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Contents

1 Intellectual Property and Innovation Audit, Valuation, and Commercialisation in Kenya 1

2 Dynamic Capabilities as a Precursor to Corporate Innovation and Competitive Advantage: The Role of Human Capital 13

3 Intellectual Property Rights, Innovation and Firm Performance in Developing Countries 25

4 Mobile Money for Financial Inclusion: The Mobile Accumulating Savings and Credit Association (M-ASCA) Model In Kenya. 37

5 Telediagnostics: An Automatic Biomedical Image Matching and Retrieval in a Multi-distributed Telecommunications Environment in Kenya 45

6 Blockchain: Building Africa Block by Block 55

7 Innovations for a Better Tomorrow: Human-Wildlife Interface in Kenya 65

8 Product-Service Systems Design for E-Waste Management: A Case Study of Waste Electrical and Electronic Equipment Centre in Nairobi County 73

9 Development and Release of New Stress Tolerant Canning Beans for Smallholder Farmers in Eastern Africa 83
Intellectual Property and Innovation Audit, Valuation, and Commercialisation in Kenya

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Abstract

The overarching argument in this paper is two-pronged. First, it is asserted that Kenya has a lot of potential for innovation, technology development, and the creation of intellectual property intensive goods, services, and works. However, there are serious weaknesses or limitations in the legal and regulatory frameworks on intellectual property and innovation valuation, and commercialisation as well as general corporate and constitutional governance. The second argument is to the extent that scholarship and practice in business and law in Kenya need to urgently focus on intellectual property audit, valuation, commercialization, securitization and taxation. This will enable innovators and all key stakeholders to benefit from the copyright, trade mark, patent, trade secret, utility model, industrial design, plant or animal breeder’s rights and other forms of intellectual property and innovation that have been developed and that need to be nurtured.

Key Words. Intellectual property, innovation valuation, commericalisation

PROLEGOMENON TO INTELLECTUAL PROPERTY AND INNOVATION AUDIT, VALUATION AND COMMERCIALISATION

Intellectual property has been regarded as the recognition, protection and promotion of the work or product of the mind; of human creativity embodied in tangible form (Sihanya, 2016a). This is done through substantive, procedural and evidentiary law on rewards, incentives as well as legal mechanisms for the enforcement or vindication of these rights in the case of infringement.

Intellectual property is broadly divided into two categories, namely, industrial property and copyright and related rights. Industrial property consists of at least ten sets of protected rights. Some IP scholars and lawyers claim that PBR or plant variety protection (PVP) is the third distinct doctrine or category of IP and that it is not part of industrial property. They do not account for animal breeder’s right (ABR). I treat ABR as significant in Kenya and Africa and, like PBR, ABR belongs to industrial property rights. And there is need for a clear legal framework on ABR.

Intellectual Property and Innovation Audit, Valuation, and Commercialisation in Kenya

Under this, there is patent, which is the certificate granted to an inventor, and the property rights of a patentee. Another protected right is the utility model (UM or petty patent) which is used to protect and promote innovations that are new and industrially applicable (GoK, 2001, section 82(2)).

Some of the utility models (UMs) that have been granted protection and registered in Kenya include detachable concrete structures, smart GPS alarm, virtual currency or requester device, and virtual currency or mobile device (Kenya Industrial Property, 2016).

The other right classified under industrial property is trade secret (TS). This is any confidential business information which provides an enterprise a competitive edge. For it to be protected, it must satisfy three criteria: first, it must be secret in the sense of not being generally known. Second, it must have commercial value because of the confidentiality or secrecy. And third, there must be an obligation to keep the information confidential (Talhiya Sheikh, 2015). Examples in Kenya include the numerous non-disclosure agreements (NDAs), non-compete agreements, and contracts in restraint of trade in the Kenyan and African sole proprietorship, firms, corporations or organizations dealing with education, training and mentoring; lawyering and litigation; manufacturing; or distribution and delivery of various goods and services. An example is the black syrup base of Coca Cola drink.

Moreover, trade mark (TM, SM, or ®) as an industrial property is a bundle of intellectual property (IP) rights granted to distinguish the goods and services of one trade mark owner, enterprise or undertaking from those of the competitors, while the unfair competition (UC) regime of industrial property is applied in act of competition contrary to fair or honest practices in industrial and commercial matters is unfair competition.

For its part, geographical indication (GI) is defined under article 22 of the TRIPs Agreement. Section 2 of the Geographical Indication Bill also defines GI stating that:

‘Geographical Indication’ in relation to goods or services, means a description or presentation used to indicate the geographical origin, in the territory of a country, or a region or locality in that territory, where a given quality, reputation or other characteristics of goods or services are exclusively or essentially attributable to geographical environment, including natural factors, human factors or both.

This is in relation to situations where indication of source is a significant factor in terms of quality or sentimental value or association generally. For example, Champagne, Chablis and Cognac are French drinks, which derive their names from their geographical origins and relate to certain quality standards (Sihanya, 2016b). Some key examples from Africa include Miombo woodlands of South Africa known for Marula fruits, penja pepper in Cameroon, Oku honey in Cameroon and Ziama-macenta coffee in Guinea. It is notable in this regard that Kenya has a lot of candidates for GI, if only it could enact a law and negotiate these in the international regime. Good examples could include Kisii Soapstone, mmazi (coconut palm, from Coastal Kenya), Kitui honey, Kamba carvings, special tea (such as those from Kericho, Nandi and Limuru) and coffee (from Mt Kenya region and the Aberdares) (Daily Nation, 2008).

Another notable industrial property right is mask work or layout design of integrated circuits. This is defined under the Washington Treaty on Intellectual Property in Respect of Integrated Circuits of 1989 as:

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4The syrup is not patented but is protected under trade secrets law. See Sabra Chartrand (2001) ‘Patents; many companies will forgo patents in an effort to safeguard their trade secrets,’ The New York Times, New York, 5/2/2001

5See section 5 of the Trade Marks Act; section 21 of the Competition Act, 2010.


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The three-dimensional disposition, however expressed, of the elements, at least one of which is an active element, and of some or all of the interconnections of an integrated circuit, or such a three-dimensional disposition prepared for an integrated circuit intended for manufacture.

A generally accepted definition of plant breeder’s rights (PBR) or Plant Variety Protection (PVP) recognises rights granted to the breeder of a new variety of plant that give the breeder exclusive control over the propagating material. Thus, PBR is exclusive rights over the commercial production and marketing of the reproductive or vegetative propagating material of the protected variety.7 In Kenya, PBR and PVP are defined under the Seeds and Plant Varieties Act 2012 at section 2 as "rights granted under section 17." For protection to be accorded, the seed or plant must be distinct, uniform and stable (DUS). In Kenya, PBR protection has been extended to products, owned by the Kenya Seed Company,8 Pioneer Hybrid, Monsanto Kenya, and Simlaw seeds.

The other recognised industrial property is industrial design (ID). This is protected on the basis of the originality of a combination of lines or colours that give rise to the appearance or look and feel of a product; ID includes graphic designs, fashion designs textile designs (GoK, 2001, Section 84) Industrial design can be used to protect shapes, configurations, patterns or ornaments. Other items which may be the subject matter of industrial design include toys, games, and electrical equipment.

The second major doctrine of IP is copyright. Broadly, copyright refers to a set of exclusive rights enjoyed by the author or creator of an original work. These include the right to reproduce (e.g. hand written, photocopy, print, scan, photograph, snapshot, downloads), distribute or adapt the work. Copyright does not protect ideas, only their expression or fixation. In most jurisdictions copyright arises upon fixation and does not need to be registered. Copyright owners have the exclusive constitutional and statutory right to exercise control over copying and other exploitation of the works for a specific period of time, after which the work is said to enter the public domain (Sihanya, 2016a).

Copyright confers two forms of rights: moral rights9 and economic rights. Moral rights consist of four categories. First, the right to be named. Second, the right to integrity. Third, the freedom from false attribution. And fourth, the right to privacy. Economic rights relate to an author’s or an entrepreneur’s right to secure economic and financial benefits from investing in a work (Sihanya, 2016a).

Innovation has been defined as a new and useful art (whether producing a physical effect or not), process, machine, manufacture or composition of matter, which is not obvious, or any new and useful improvement thereof. It is not obvious, capable of being used or applied in trade or industry and includes an alleged invention (GoK, 2001, Section 2).

There are three components of innovation. First, is the discovery aspect. Second, is creativity. And third, the inventive step (Sihanya, 2006). These three components can be viewed in two different aspects. First, as making an invention or writing of a book. Second, innovation as involving packaging or marketing strategies to exploit creativity or a technology and capture the financial and related benefits from the creativity (Sihanya, 2001).

From the 1950s, the role of innovation and technology in socio-economic development began to be recognised. With it came numerous public policy and governance issues. Article 11 of the

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7Significantly, hardly any important IP scholar or lawyer discusses animal breeder’s rights (ABR). They do not account animal breeder’s right. I treat ABR as significant in Kenya and Africa and like plant breeder’s rights (PBRs) belong to industrial property rights.

8Some of their products include duma, popo and mbuni for maize seeds; serena and seredo for sorghum seeds; as well as heroe and chozi for wheat seeds.

9Moral rights were conferred by section 7(3) of Kenya’s Copyright Act 1966 at the end of a section which otherwise dealt more exhaustively with economic rights. Section 32 of the Copyright Act 2001 exclusively addresses the “moral rights of an author.”
Constitution of Kenya 2010, among others, now protects and promotes intellectual property and innovation.

Given the contextual meaning of copyright, trade mark, patent, trade secrets and related forms of intellectual property (IP), what is the role of IP and innovation in Kenya’s industrialisation, technology transfer and capital accumulation? IP and innovation are no longer mere intellectual or technical questions. There is therefore the need for analysis of the political economy and equity regarding the interests of individuals, households, corporations, and particularly tribes and regions in Kenya (Sihanya, 2016a).

METHODOLOGY OF INTELLECTUAL PROPERTY, INNOVATION AND TRANSFER OF TECHNOLOGY IN KENYA AND AFRICA

There are no explicit formulae or methodology for IP valuation under the Constitutions, statutes, rules, regulations or national IP policies in Kenya, Uganda, Tanzania, Ghana, South Africa and Nigeria. Public discourse may be a guide to the development of an IP valuation methodology. Two examples may suffice. First, when a good, service or works are dear, many in Kenya and elsewhere often likely to say it costs "an arm and a leg (of a goat?)." Second, when anything is affordable or cheap, they say "it goes for a (copyrightable?) song."

Some jurisdictions like the US, Germany, United Kingdom and Japan have developed relevant formulae especially through litigation. The most comprehensive framework is found in patent litigation which now has the following four guidelines in the context of economic damages: lost profits, price erosion, entire market value rule, and reasonable royalty (Perry et al., 2006; Thomas et al., 2006).

In trade mark, some of the evolving formulae relate to the demand approach, and brand profitability (Dublin, 2006). This is closely related to emerging work on the generic approaches to trade mark valuation. In this line, Corbett et al. (2006) have argued thus:

Trademarkes are typically valued for one of three purposes: (1) in the context of a licensing transaction or acquisition, including as part of a business acquisition; (2) for regulatory compliance such as in transfer pricing; and (3) in the context of litigation. The economic principles behind the valuation remain essentially the same in each context.

They proceed to discuss the three main approaches in the context of trade mark licensing: the cost approach; the market approach; and the income approach. However, not much work has, however, been done, especially in Kenya, Ghana, Nigeria, South Africa, Uganda, Tanzania, and other African countries on auditing and valuation of copyright and trade secret.

Implicit Formulae on IP Valuation

Nonetheless, implicit formulae are emerging in Kenya, Nigeria, South Africa and other African states regarding the valuation of IP. The three-pronged typology developed by Corbett, Rao and Teece, are noteworthy namely, (1) IP valuation in licensing or business acquisition; (2) IP valuation for regulatory compliance – especially tax compliance; and (3) IP valuation in litigation (Corbett et al., 2006).

10It costs a lot of money.
11It is too cheap to be true.
IP Valuation in Licensing

IP valuation is increasingly becoming an important, if somewhat incidental, aspect of licensing, franchising, joint venture or strategic alliance and other forms of transactions involving innovation, creativity, IP or technology transfer in Kenya and Africa generally. Indeed, IP valuation is now playing a role in the transfer, merger or acquisition of business (interests).

Comparatively, the audit and valuation of real estate and personal property is more established than in IP. For instance, there are statutes, clearer guidelines, formulae or methodology and institutions in land valuation. However, IP transactions such as licensing, franchising and joint ventures involve various types of payments (such as royaltie). Whereas some of these valuation methods are specific to the relevant transactions, others are generic and thus regulated and analysed on the basis of cost or income analysis, or under a market model-based approach to valuation. But there are challenges involved which include estimating the actual or reasonably attributable costs in terms of the market rate for the relevant form of IP, and most transactions thus far seem to focus on copyright and trade mark.

Remarkably some asset acquisitions have given hints on the value, of the IP, if not necessarily the methodology of computing the values of IP. A case in point is the acquisition of the Kimbo, a cooking fat brand, by Bidco Co. Ltd from Unilever, who had acquired it from East Africa Industries Ltd. The trade mark acquisition helped Bidco to penetrate the Kenyan cooking oil market.

Valuation vis-a-vis Tax-Compliance and Transfer-Pricing through Imports and Exports of IP and Innovation in Kenya

Taxes on IP and innovation is becoming popular among tax administrators aiming to enhance revenue collection and to broaden the tax bracket. However, there are some challenges to this. The first is in relation to how to value the various forms of IP (especially copyright, trade mark, patent, trade secret, utility model or industrial design) for purposes of taxation. The other relates to the inadequacy in the legal framework to encompass IP related incomes. While the third relates to the perceived vindictiveness or regulatory and even state capture of the tax administrators by the competitors.

Moreover, how the tax administrator is to address the issue of transactions by related or affiliated companies within Kenya (some of which are outside Kenya) was a major challenge in the immediate post-independence period (especially in the 1960s-1980s). The main challenges have been hidden profits, repatriation of profits, limited re-investment, overpricing (or over invoicing) imports, underpricing (or under invoicing) exports, money laundering, incorporation or investing in tax heavens, and related transfer pricing as well as tax avoidance and evasion schemes (Leys, 1975; Swainson, 1980). These are still recurrent and into the 2010s.

In principle improvements in the investment climate are supposed to cover the whole range of issues from macroeconomic management, to infrastructure and skills, to the policies and institutions that most closely affect private investors. In practice the investment climate agenda has centred on narrow regulatory reform (Nyong’o, 1988). Most relate to developments in ICT.

13 See Valuation for Rating Act, Cap 266.
14 The Kenya Industrial Property Institute (KIPI) registers trade mark and other industrial property rights like patent, industrial design and technovations. Rarely as indicated earlier on KIPI review or register technology transfer transactions as it used to do as (KIPO) under the Industrial Property Act, 1989.
15 The Kenya Industrial Management Board whose acronym KIMBO became its flagship product in 1960s. See Jackson Okoth and Macharia Kamau (2013) 'Big brands that have survived the charts,' Standard Digital, Nairobi, December 18, 2016.
16 The main challenges have been expatiation of profits and limited reinvestment, hidden profits, over pricing imports, under pricing exports and relaxed transfer policy as well as tax avoidance and evasion.
online and mobile technologies or innovations that facilitate disaggregation of business. A major objective is with a view to minimising costs and tax liability, while maximizing profit.

Thus, intellectual property (IP), innovation and technology transfer (ToT) are a fast growing sector yet there are no clear rules on taxing the transactions. There has been disputation between the Kenya Revenue Authority (KRA) and one of its employees, Mr Samson Ngengi Njuguna. Mr Ngengi went to the Kenya High Court in November 2012 seeking orders to bar KRA from procuring or implementing a rental tax mapping and collection system until his efforts in developing a similar system are recognised and he is adequately compensated. The matter was later referred to arbitration (Sihanya, 2016a).

**IP Valuation in Litigation**

Disputes regarding innovation, IP and technology transfer are usually resolved through alternative dispute resolution (ADR) mechanisms or by litigation. In this regard, lawyers, magistrates, judges and even clients or innovators have developed or internalized some principles, rules, formulae and methodologies to address IP valuation. Three are key.

1. IP valuation for purposes of injunctions - Injunctions are usually issued on the principle that damages would not be sufficient. Thus, some form of valuation or assessment must be done to determine whether or not an injunction should be issued.

2. IP valuation for assessing damages - Damages are usually awarded on the basis of the actual loss suffered by the claimant. In the case of IP, damages would be issued to compensate the owner for the actual loss suffered due to the infringement. The damages may also be integrated to get the innovator or IP owner to where they would have been financially or economically had the infringement not occurred. Damages may also be awarded in some cases as a punitive measure to deter the infringement or prospective infringement of an IP right.

3. IP valuation in the account of profits - In an action for account of profits, the infringer is required to give a statement of the income received and costs incurred. In this case reasonable profits from the relevant IP are computed and turned over to the IP owner or plaintiff.

There are arguments and perceptions that accounting for profits may be a higher than compensatory damages partly because IP infringement has greater focus or expertise on commercializing the IP or innovation.

**INTER-MULTI-TRANSDISCIPLINARY RESEARCH METHODOLOGY ON INTELLECTUAL PROPERTY, INNOVATION AND TRANSFER OF TECHNOLOGY**

Interdisciplinary research is the study or research that draws from two or more disciplines in order to gain a more or well developed perspective regarding a certain topic or field. It has been defined as "the product of a set of social forces of normalization and education, reward and

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http://uonresearch.org/irs
punishment, through which the academic’s head gets constructed, and the academic becomes the kind of academic that he or she is.” (Balkin, 1996).

IP is an interdisciplinary field as it covers all sectors of the economy including the legal, business, medical, agricultural, industrial, and education fields. Moreover, the arts, humanities and social sciences are sites of innovation or creativity as well as contributors to the analysis, debates, prescription, and reform of innovation policies. There are important interdisciplinary contributions in literature, sociology, anthropology, cultural studies, political science, history and economics.

It is impossible to think of intellectual property rights in isolation from the outputs of innovation and creativity. IP legislation embodies the outcome of political debate between cultural, industrial and commercial interests and IP specialists. Intellectual property litigation locates IP law at the cutting edge of science, technology, and the arts. Intellectual property rights pervade global social and economic life. International governments’ technology transfer and enterprise agendas show they consider interdisciplinary IP education and research to be vital for continued economic growth.

Various authors observe and reflect upon the impact of intellectual property law and policy for society and culture more broadly. No longer an arcane and technical area of the law best left to legal specialists, intellectual property law has evolved into a site of contention over what it means to think, to create, and to participate in culture and in society.

ROLE OF CAPITAL FORMATION AND ACCUMULATION FROM INNOVATION IN KENYA

Capital formation and capital accumulation includes assets that are deployed or invested in trade or commerce, manufacturing, and service delivery. Significantly, the world is becoming a technological hub and that income gains are driven by accumulation of capital rather than pioneering of inventions (alone) (Mankiw et al., 1992). Therefore capital formation and accumulation is a crucial aspect to the improvement of our Kenyan economy.

Innovations can be used to promote and improve local and foreign investments and also Kenya’s growth. Calestous Juma and Lee Yee-Cheong highlighted the important role that innovation and innovation policy plays in development (Juma and Yee-Cheong, 2005). The Government both at national and county level should encourage capital accumulation and growth by developing policies that adhere to a common set of principles such as competitive pressures, free flow of information, trade in ideas and technologies, and a focus on shifting norms and culture. By doing so, they will be creating a favourable environment for inventors and innovators to practice their craft. A conducive business environment facilitates capital accumulation and innovation. In order to create a conducive business environment there is need for the establishment of growth enhancing governance innovations laws and policies.

Over a long period of time large firms that are well financed by investors have had a competitive edge over micro small and medium enterprises (MSMEs) firms and solo inventors and innovators. However, MSMEs have become more engaged in the commercialization and development of innovations. They play a key role when it comes to capital formation and accumulation from innovations and inventions (European Patent Office, 2017). They develop and commercialize innovations, they adopt innovations developed by other organizations, and they provide ideas and inputs to ideas generation that are exploited by large firms, universities and research organizations and other small firms.

The Kenya Government’s 2016 report on Micro, Small and Medium Enterprises (MSMEs) Survey indicated that close to 400 thousand MSMEs did not last up to the second year in the previous five years. This raises concern over sustainability in this critical area. The report further indicated that close to 2.2 million MSMEs had closed in the previous five years, 2016 inclusive.
The report further found that a significant 46 per cent of the MSMEs surveyed died in their first year of establishment. The 2016 National MSME Survey sought to provide comprehensive data, at national and county levels, on the characteristics, operations, dynamics and evolving nature of micro, small, and medium-scale enterprises in Kenya (KNBS, 2016).

Kenya has made some steps in developing a comprehensive innovation policy that allows for an even playing ground for large firms and MSMEs in innovation and inventions. However, there is a lot of room for improvement, especially in terms of implementation. For example, the relationship between research institutions and industry has remained disjointed (Ndemo, 2015). There is also the need to protect and promote small or sole inventors and innovators from having their works stolen by large firms or already established corporations who have the financial muscle.

One of the major reasons why majority of small or sole start up inventors and innovators fail in Kenya is because they seek investments or grants too early so that they can be able to finance their operations. They then end up giving a large percentage of their businesses to investors who finance them who end up taking control of the businesses.

The national IP regime and policy should be modeled to provide for the protection of these small or sole inventors and innovators by having their works legally owned and protected. However, the SMEs and sole inventors have faced numerous challenges including the lack of financial power to advance their research on these inventions and innovations. The big or already established firms take advantage of such challenges by offering to pay small inventors and innovators an insignificant fee while they themselves gain the rights to these innovations developing them further and making huge profits (McGuirk et al., 2015).

**ROLE OF UNIVERSITIES AND RESEARCH INSTITUTIONS IN CAPITAL FORMATION AND ACCUMULATION FROM INNOVATION IN KENYA**

Universities historically focused on teaching and academic research. New universities merely copied the programmes, curricula and syllabi of their predecessors. Thus many Kenyan universities have merely copied the University of Nairobi (UoN), the oldest and largest in Kenya. Some had a lot of promise and had the opportunity to focus on niche fields for example: Moi University (ICT and technology or information technology generally), Kenyatta University (education, literature and cultural studies), Egerton University (agriculture), Jomo Kenyatta University of Agriculture and Technology (JKUAT) (agriculture and technology), and Strathmore University (accounting and business; ICT).

Some universities are now engaged in commercializing the research findings. Some Kenyan public and private universities play a leading role in advancing the frontiers of science, technology, innovation and cultural creativity. There is a need to establish and strengthen innovation, transfer of technology and structures for IP administration in Kenyan universities to coordinate the development, commercialization and dissemination of innovation within academia, industry and public spaces (Sihanya, 2016a).

Universities play a major role in research and development (R&D). Their role and mandate in national development is increasingly becoming important. The primary and traditional role of universities was to transmit skills, knowledge, attitude, values and innovation (SKAVI) especially through education, training, research, innovation and mentoring (ETRIM). Over the years, the importance of research and dissemination of research findings or outreach in the Kenyan and African society has been underscored. Through research, and the research results or findings, universities are expected to contribute to the improvement of the quality of life and to social and technological change.

The University of Nairobi has embarked on a business incubation project and related projects with the National Government agencies and private corporations as well as state departments.
to help in the development, dissemination and utilization of science, technology and innovation (STI).  There are concerns regarding application, commercialization and efficient utilization of STI that has been or is being developed. There are also concerns that innovations and creativity in the arts, humanities and social sciences should be encouraged and nurtured. These should get appropriate support even as the relevant agencies also improve support for patentable technologies, inventions and innovations.  

In the medium to long term, this calls for institutional (re)design in at least three ways. First, universities should enhance practical and income orientation in their programmes. They should enrich or move beyond the privately sponsored Module II or direct paying student model that began in the late 1990s. While this model has provided opportunity to thousands of student and earned universities a lot of money, it has weaknesses. These include focus on teaching or training using already generated knowledge, some of which is dated. My argument is that all students who qualify for university or college education and training should be given adequate concessionary and long term loans. They should pursue degrees or diploma and even doctoral programmes. And university staff should be compensated and remunerated appropriately including in terms of salaries, allowances and research grants, rather than the basis of participation in module II where the payment to staff has always delayed, declined and even collapsed in most universities anyway.

There is also general complacency among some university managers whereby teaching or training units focus mere clerical and accounting work involving collecting student fees rather than pro-active research and development activities such as cutting edge research or job focused post graduate training based on a needs assessing of the academy, the national and county government, industries and civil society organizations.

Second, some scholars like the Kenya School of Government’s Prof Calestous Juma has suggested that the relevant Government Ministries, Departments, and Agencies (MDAs) be converted into universities (Juma, 2016). The third model is probably more focused centres and institutes.

SUMMARY OF FINDINGS, CONCLUSION AND RECOMMENDATIONS OF IP AUDIT, VALUATION, COMMERCIALIZATION, SECURISITATION AND TAXATION IN KENYA AND AFRICA

The main objective of this article was to analyse the status and trends in IP valuation in Kenya and relevant African countries. The overarching argument was that the scholarship and practice in business and law in Kenya needs to focus needs to focus in intellectual property audit, valuation, commercialisation, securitisation and taxation. Much have been done to ensure the audit, valuation, commercialisation, securitisation and taxation of IP and innovation in Kenya and generally in Africa.

My overarching argument in this article is that the various statutes and regulations that govern IP, Kenya lack the legal, institutional and structural mechanisms to equitably and efficiently implement the audit, valuation, commercialisation, securitisation and taxation of IP and innovation. There is need for the National Government to work with the 47 County Governments, the Kenya Industrial Property Institute (KIPI), Kenya Copyright Board (KECOBO), Kenya Plant Health 

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23 A challenge is that universities develop appropriate programs with the relevant agencies of the National Government and the relevant 47 County Governments.

24 There is a running debate in which some government officials express preference for STI in comparison to the arts, humanities and social sciences. Deputy President William Ruto expressed such sentiments while serving as Minister for Higher Education in the Grand Coalition Government. “He has not retracted. Cf. BA. Ogot (2009) “Rereading the history and histography of epistemic domination and resistance in Africa,” 52.01 African Studies Review 1-22.
Intellectual Property and Innovation Audit, Valuation, and Commercialisation in Kenya

Inspectorate Service (KEPHIS), Kenya Revenue Authority (KRA), Kenya Bureau of Standards (KEBS), Anti-Counterfeit Agency (ACA) and the Industrial Property Tribunal.

There is need to restructure and operationalise institutions that have been proposed before, such as a Kenya Copyright Tribunal in place of the Competent Authority. There is also need to harmonize and coordinate the work of the numerous stakeholders in the academy, industry, informal sector and civil society organisation.

Second, the Government, the private sector as well as educational institutions have not invested much in developing and promoting research and development. Third, the taxation of IP, innovation and transfer of technology transactions are of great interest to most governments only for the purpose of broadening the tax base and increasing tax income. This is done without similar level of investment on IP and innovation with regards to audit, valuation and commercialization and securitization.

Valuation, commercialization and application of IP and innovation should therefore be addressed at national level within the various disciplines including the legal, business, medical, agricultural, industrial, and education field. This will help achieve sustainable development goals (SGDs) and Vision 2030 which recognize and emphasize on the role of research and development (R&D), science and technology and innovation in improving the economy and human development.

Reform requires serious consideration of at least three important phenomena. First, establishing and reviewing the extant situation regarding IP audit assignments, valuation, and commercialization. Second, introducing or establishing new norms, institutions, administrative procedures or structural relations where none existed to effectively secure IP audit, valuation, commercialization and taxation. This includes multi, trans and inter-disciplinarity in skilling, re-skilling and multi skilling. And third, strengthening extant progressive phenomena in intellectual property and innovation audit, valuation and commercialisation in Kenya.

There is urgent need for at least five reforms in audit, valuation, commercialisation, securitisation and taxation in Kenya. First, the review of constitutional provisions on constitutionalising IP protection, promotion and administration in a view to enact appropriate legislation, registration and policies to implement and enforce IP audit. Second, clarification and elaboration of administrative rules, regulations and procedures to promote IP audit, valuation, securitization and commercialisation of the respective intellectual property (IP) doctrine.

Third, establishment or strengthening of innovation, intellectual property (IP) and transfer of technology (ToT) administration systems to verify and ensure that commercialisation and securitization of IP. Fourth, review of the juridical and regulatory framework with emphasis on administrative or procedural aspects of IP auditing and securitisation and commercialization of IP. And fifth, review of the architecture or infrastructure of IP valuation and audit, including commercialisation and securitisation.

These proposed reforms are not exhaustive but just the starting point of what should be done in terms of research and implementation in Kenya in order to ensure that there is equity and appropriate or adequate promotion and protection of intellectual property audit, valuation, commercialisation, securitisation and taxation in Kenya.

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Dynamic Capabilities as a Precursor to Corporate Innovation and Competitive Advantage: The Role of Human Capital

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Abstract

This paper presents a critical review of literature on the relationship between dynamic capabilities and innovation, and between innovation and competitive advantage of firms. It further explores the effect that human capital has on these relationships. Theories of dynamic capabilities, resource-based view and resource advantage theory were used to support the literature provided for in the study.

Relevance to innovation. The literature presented shows that dynamic capabilities supports innovation as the business environment changes and provides the foundation of firm-level competitive advantage. Various empirical studies highlighted demonstrate that to attain innovative performance, firms must be able to mobilize their resources and capabilities and dynamically align them with the changing environmental opportunities and customer needs.

Key Words. Dynamic Capabilities, Innovation, Competitive Advantage, Human Capital.

INTRODUCTION

Research on dynamic capabilities has been described as a promising perspective of scholarship in strategic management (Teece, 2014). It supports evolutionary fitness which has to do more with innovation and continuously doing the right things as the business environment changes (Teece, 2009). Practitioners and researchers can use the framework to determine the basis of companies’ value creation and establishment of sustainable competitive advantage. This can no longer be achieved through cost control, reduction in inventories, quality improvement and use of best practices. Business environments with global competition, driven by robust innovation were assumed for the dynamic capabilities framework. Dynamic capabilities involve building and orchestrating resources to perform various tasks in an organization.

Strategic capabilities can be achieved primarily through valuable assets such as knowledge resources which can form distinctive configurations (Hsu and Sabherwal, 2012). Within an organization, an important form of knowledge is inherent in human capital (Hitt et al., 2001). For example, employees have been recognized to play important duties in the development and maintenance of a firm’s competitive advantage (Delery and Shaw, 2001). In addition, companies have a high possibility of benefiting from knowledge and competences specific to them to sustain competitive advantage if they remained where they are developed (Hitt et al., 2001). To be effective in achieving advantage dynamic capabilities should be used in support of successful strategies that
Dynamic Capabilities as a Precursor to Corporate Innovation and Competitive Advantage: The Role of Human Capital

Figure 1: Relationship between Dynamic Capabilities, Innovation and Competitive Advantage of Firms and the Influence of Human Capital

are consistent, coherent and can accommodate innovation. The roots of the innovation construct can be found in the work of Schumpeter (1952). He argued that innovation does not have to be created from new knowledge but can be created from an organization’s unused knowledge (Hébert and Link, 2006).

Understanding of a companies’ advantage over its rivals has been influenced by the dynamic capabilities framework. Some of the approaches of competitive advantage identified by various management scholars include the firm’s management decisions, activities and processes that firm’s use in pursuit of new market opportunities in order to establish a superior market position (Eisenhardt and Sull, 2001). The relationship between dynamic capabilities, innovation and competitive advantage can be modeled as shown in Figure 1. Within the figure it is posited that human capital plays a key role in the strength of the relationships. A description of each of these variables and their relationships as found in the literature, are presented in the sections that follow.

DYNAMIC CAPABILITIES

Dynamic capabilities was defined by Teece et al., (1997) as the integration, building and configuration of a company’s resources, competences that are external and internal to the firm to deal with rapidly changing environment. They are influenced by companies’ structures, processes and systems for their trading activities and are vested in their top management team (Teece, 2007). In order to stay ahead of competition, a company’s future can be determined by entrepreneurial managers through sensing, seizing, augmentation of knowledge resources, transformation of organizational regulatory and institutional structures and protecting them with intellectual property rights (Teece, 2007).

The roles of entrepreneurial management entrenched in dynamic capabilities involves recognizing problems and trends, directing, reconfiguring, renewing resources and reshaping organizational structure, systems and processes to create and address technological and business opportunities while remaining aligned to customer needs and preferences. Earlier, faster and more astute application of dynamic capabilities by firms should lead to competitive advantage over others (Eisenhardt and Martin, 2000). Wang and Ahmed (2007) grouped dynamic capabilities into three main components namely: innovative, absorptive and adaptive capabilities. To capitalize on new markets opportunities, adaptive capabilities stresses on a company’s capacity to adapt in a prompt manner through flexible use of its assets. The significance of acquisition of external

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information integrated with internal information is recognized by absorptive capabilities to be useful within a company for commercial activities.

Innovative capability involves a firm’s ability to link the advantage it has in the market with its inherent innovative behavior by developing new markets and products. The three main components as established in the dynamic capabilities literature are similar in more than a few industries even though it may also be developed by companies from their unique beginnings and paths (Mota and de Castro, 2004).

**INNOVATION**

Innovation is a key source of competitive advantage in firms. Creation of new ideas is fundamental to the process of developing innovation. These come from within and outside the firm (Hyland, Marceau, and Sloan, 2006). It is also driven by internal factors such as firm’s employees (Zhou, Hong and Liu, 2013) and research and development investments (Amara and Landry, 2005). According to Hall (2009), Organization for Economic, Cooperation and Development (OECD) studies have provided rules which classify innovation into five groups namely: marketing innovation; service innovation; process innovation; management innovation and product innovation.

Innovations of services and products are those that result in significantly improved or new products and services (Camisón and Monfort-Mir, 2012). Innovation in processes includes all operational tasks to improve and enhance quality of offerings through provision of more cost effective methods of delivery (O’Sullivan and Dooley, 2009). Innovation in management is the significant improvement or new methods of management of external relationships, systems, structures and organized functions (Hall, 2009). Innovation in marketing refers to new introduced marketing techniques and methods such as changed and improved pricing, design of products and promotional strategies (Camisón and Monfort-Mir, 2012).

Global competition is today often technologically intensive. As a result, innovation in technology can lead to increased competitive advantage. Companies applying innovation in technology can speedily act on new product and service offerings as well as reduce time taken to develop products. Further, when competition in technology is intensified, it can be a global source of competitive advantage if companies have more importantly reinforced, protected and recognized their technological capabilities (Guan, 2007). Innovation in processes can be enabled by new technological adoption, for example information technology. Its implementation is successful if there are improvements in organization routines and efficient utilization of new systems.

**COMPETITIVE ADVANTAGE**

Gaining competitive advantage has been eagerly pursued by researchers in strategic management and continues to remain difficult to achieve (Helfat and Peteraf, 2009). D’Aveni et al.,(2010) provided that only short-term gains are achievable. Competitive advantage refers to the execution of a strategy different from rivals in order to provide superior products and services, capitalize on new market opportunities, counteract competitors’s threats and reduce costs. The term is used reciprocally with performance but the two are conceptualized differently (Powell, 2001). Performance is envisioned to be payments accrued by a company after execution of its strategies. A company which creates greater economic worth will have achieved competitive advantage over its rivals (Peteraf and Barney, 2003). Firms can have a cost effective competitive advantage by providing offerings with greater worth at a lower cost than their rivals (Newbert, 2008).

Thus, firm managers’ need to exploit their distinct resources, competencies, capabilities while concentrating their efforts on innovation, are receptive to customer needs and provide quality products and services to attain a market position superior to its competitors. It is also imperative for firms to generate greater customer value and enter market segments by constantly innovating.
their offerings and looking for new market opportunities in order to achieve higher financial earnings than competition (Hill and Jones, 2004). Hence, to sustain competitive advantage, firms’ must have the capacity to maintain their innovation for longer periods (Miles et al., 2003).

Many scholars have measured competitive advantage using public archived information and statistics. Some of the researchers have found it difficult to obtain financial data for organizations and opt for non financial data. This is supported by a study done by (Spanos and Lioukas, 2001). Li and Liu (2014) measured competitive advantage using financial and non financial measures such as higher profit growth margins, higher sales growth, lower cost of operations, superior quality products and services, bigger market share and increased profitable old and new customers (Chang, 2011).

**HUMAN CAPITAL**

In the field of strategic management, human capital has been recognized as an important resource which can be a source of competitive advantage. Coff et al., (2011) defined human capital from an individual perspective as an individual’s stock of knowledge, skills, and abilities. From the firm’s level, they defined it as an aggregation of employee skills. Crook et al., (2011) defined it as the knowledge, skills and abilities expressed in a person. The translation accepted by (Kor and Leblebici, 2005) is that contrary to financial and physical capital, human capital is the skills, health and knowledge that is inseparable from people owning them.

In a company, the accumulation of human resource comes from selecting, developing and deploying employees (Koch and McGrath, 1996). Therefore, companies need to seek externally from the job market, individuals that provide assurance to become industrious employees (Hatch and Dyer, 2004). However, being industrious may not be certain. Companies need to develop their employees in order to improve their productivity so to be able to offer quality products and services and subsequently improve performance, hence competitive advantage.

Sustainable competitive advantage is contributed by human capital due to its intangibility, complexity and difficult to copy by competition. Thus, for the full potential of human capital to be realized, hiring, development and deployment must be done well. Further human resource with better education will be more productive (Hitt et al., 2001). Companies also need to prevent competitors from quickly seizing the value of their human capital (Hatch and Dyer, 2004). Education levels acts as a basis of defining the level of an employee’ cognitive skills such as their motivation to achieve and their capacity to absorb knowledge.

Efficiency and adaptation to innovation in a firm can be assisted by highly talented and gifted employees (Mahsun, et al., 2011). Education will not lead to competitive advantage even when it increases employees’ acquisition and employment of specific skills and knowledge, if workers with related education are obtainable or easily acquired by competitors. Companies with high turnover of human capital significantly perform lesser than their rivals. Firms must therefore develop and implement strategies to retain employees such as provision of better compensation.

**DYNAMIC CAPABILITIES, HUMAN CAPITAL AND INNOVATION FIRM**

Teece, Picano and Shuen (1997) described dynamic capabilities as competences and company’s ability to react quickly to changes in the external environment by producing unique products and processes. Sensing, seizing and transforming company capabilities were identified to be essential to sustain innovation. To achieve innovative performance, organizations must mobilize their resources and capabilities to dynamically align them with changing environmental opportunities (Liao et al., 2009). An empirical study carried out by Zheng et al., (2011) showed significant relationships between dynamic capabilities, innovation and performance. Similarly, Danneels
An essential valuable asset used to achieve fundamental competences that allows firms to sustain their advantage over rivals is human capital. Firms are therefore expected to invest further in the selection, acquisition, retention and training to increase the value of its human capital. Michie and Sheehan (2003) who investigated grouped systems of human resource and their association between product and process innovation discovered that companies that recruited and selected well, managed and rewarded performance, trained their employees and provided versatile job duties had a higher likelihood to innovate than those who did not. Similarly, they had a higher likelihood to introduce innovation in a process than those companies that did not have work place innovation practices.

Thus, human resource systems and innovation strongly complemented each other. Shipton et al., (2006) provided that most innovative enterprises train more. This was also identified by Lau and Ngo, (2004).

INNOVATION, HUMAN CAPITAL AND COMPETITIVE ADVANTAGE

To strengthen efficiency and competitiveness, innovation has been continuously recognized by companies for being responsible for the achievement of a firm’s competitive advantage (Baregheh et al., 2012). Major challenges being faced by companies today are on how to consolidate diverse categories of innovations in order to achieve competitive advantage. Empirical research by Tidd et al., (2006) noted that there is a strong relationship between market performance and the development of new products to maintain market share. Guo et al., (2013) investigated the role of top management and human capital on business model innovation. Through a survey of 146 Chinese firms, they found out that entrepreneurship and management skills of top management linked strongly to business model innovation, a precursor to competitive advantage.

Awino (2016) sought to determine whether innovation had an impact on firm performance. He carried out a survey of 55 publicly listed companies in the Nairobi Stock Exchange. He established that the relationship between innovation and performance was positive and significant and that organizational innovation was achieved through employees’ engagement. All these
studies suggest that although innovation can lead to a firm’s competitive advantage and superior performance, it is predicated on the human capital either through the management actions or employees engagement. Innovation alone, therefore, may not be a sufficient condition for attaining superior competitive advantage.

DISCUSSION

The division of the philosophical areas of two seminal papers by Teece et al., (1997) and Eisenhard and Martin (2000) led to the social construction of dynamic capabilities theory (Di Stefano et al., 2010). The scholars differed on the definition of terms, assumptions, central relationships between variables, applicable boundary conditions as well as how firms can use dynamic capabilities to attain and maintain competitive advantage. Further, questions have arisen about its coherence and validity explicitly on its failure to attain concurrence on key construct elements (Ambrosini and Bowman, 2009).

On applicable boundary conditions, Teece et al., (1997) found dynamic capabilities approach relevant and suitable in a Schumpeterian world where organizations seek to attain competitive edge over others through new types of innovation. On the contrary, Eisenhardt et al., (2000) found it relevant in high velocity markets, is homogenous and therefore a limited source of competitive advantage (Peteraf, Di Stefano and Verona, 2013). The opinion of the author on the critical differences of the two scholars is that organizations can use dynamic capabilities to attain a competitive edge over others. Organizations operate in a fast and rapidly changing business environment, often global in scope and therefore require unique, rare, and difficult to imitate and replicate dynamic capabilities.

These can only be acquired through creation, protection, renewal, transformation and upgrade of the firm’s assets and resources to adapt and respond to changing customer needs fast and proficient as the environment changes. Through this, managers of organizations will avoid being complacent with status quo as long as they are competing in markets that are perfect. However, in many ways both scholars emphasized on the importance of organizational procedures and the crucial roles played by managers in decision making which affect organizational processes and systems. Top management who are visionary can direct a firm’s processes in order to shape and create dynamic capabilities.

Studies supporting this argument include McKelvie and Davidsson (2009) whose study found that improvement to the technological resources within the firm is positively related to new product development. A manager’s ability to sense, seize opportunities and maintain competitive advantage by combining, enhancing, reconfiguring and protecting a firm’s tangible and intangible resource base is different and not likely to be found in one manager (Teece, 2007). Therefore the chief executive officer of a firm must create teamwork among his top managers. Dynamic capabilities framework has been criticized for challenges in its measurability and that many of its aspects are unverifiable. Examples of methodologies used to measure it include interviews, case studies, questionnaires and longitudinal studies. Interviews were carried out by (Bruni and Verona, 2009) from companies that sold pharmaceutical drugs in order to establish the roles and process played by dynamic marketing capabilities in developing new drugs.

Questionnaires were filled by the creators and the chief executive officers of various firms to examine the roots and growth of dynamic capabilities in new firms (McKelvie and Davidson, 2009). In the history of management literature, the resource based view has been recognized as one of the most authoritative and highly quoted theories (Kraaijenbrink, Spender and Groen, 2010). It provides an explanation for the source of sustainable competitive advantage from the inside of a firm. It argues that competitive advantage can only be attained by firms’ through acquisition and control of rare, valuable and difficult to imitate and substitute (VRIN) resources.
and capabilities. Further, companies must also have the ability to assimilate and use them (Barney, 2002). Its development supplements the theory of industrial organization (IO).

While industrial organization look at the external sources of a company’s competitive advantage, the resource based view looks at the internal sources of competitive advantage from within a firm. The methodology used in studies done on the theory have been mainly variance approach where a group of resources and capabilities were categorized as predictor variables and sustainable competitive advantage as the response variable. Researchers have critiqued the theory on its lack of managerial implications; limited applicability and unachievable sustainable competitive advantage (Foss et al, 2008). It is therefore essential to extend research methodologies on process approaches (Groen et al., 2008).

Mixing both perspectives can be useful to researchers to create an understanding on the types of capabilities and resources required to achieve competitive advantage and the reasons for better performance by some firms compared to others (Holcomb et al., 2009). The theory has had some methodological challenges which have been difficult to measure empirically. Molloy et al., (2011) for example noted the theoretical disconnect between the theory and measurement of intangibles that leaves central questions in the research unanswered, undermines and constricts the success and fruitfulness of future research. He noted a lack of mixed method approaches and raised concerns in which quantitative and qualitative methods were combined. Foss (2011) noted that scholars are increasingly familiarizing themselves with various statistical methods that can handle these multilevel issues. However studies have been limited. Resource-advantage theory is important for this study as its central proposition is competition (Magnusson et al., 2009). It puts emphasis on companies pulling together their tangible and intangible assets to attain competitive advantage which results to a company’s superior financial performance (Hughes and Morgan, 2007).

It also emphasizes on the importance of market segmentation; acquisition of heterogeneous assets by a company to attain superior market position. The theory evolved from the resource based view, industrial-organization economics and the transaction cost economic theories. Each firm in the marketplace will have a unique set of resources such as very knowledgeable workforce, efficient production methods, highly capable and knowledgeable management Therefore, firms compete for resources that will yield attainment of superior market place positions for some of the market segments hence superior financial performance (Griffith and Yalcinkaya 2010). The theory stresses that resources are tangible and intangible assets that assists companies to be efficient and effective in the production of product and services that can yield benefits for various markets (Hunt, 2000).

It categorizes resources into seven categories; human, financial, physical, organizational, relational, legal and information resources. Financial resources facilitate new product and service development and company’s expansion to new markets (Li and Li, 2008). Human resources stimulate the use of other resources and are therefore considered the most important (Roth et al., 2009). Physical resources provide an interacting environment with customers such as ambience. Legal resources include licenses, trademarks; copy rights and protects a firm’s competitive aspects of its offering (Hunt, 2000). Information resources comprises of a company’s product, service, system, production process, customer, supplier and competitor information.

Organization resources comprises of a company’s capabilities, policies and culture. Relational resources comprises of a company’s suppliers, competitors and customers and its relationship with them (Hunt, 2000). Assets possessed by a company do not guarantee any benefits. The benefits are acquired if they are able to generate differentiated offerings that are beneficial to customers. Empirical studies that have used this theory include Yeo and Delami (2015) whose study found that a positive relationship exists between the upper and middle level management’s personal preference for innovation and the adoption of a proactive strategy.
CONCLUSION

This paper has presented a critical review of literature on the influence of human capital on the relationships between dynamic capabilities, innovation and competitive advantage as outlined in the conceptual model (Figure 1). The literature reviewed supports that earlier, faster and more astute application of dynamic capabilities by firms can lead to competitive advantage. It emphasizes that firms’ with strong dynamic capabilities are highly entrepreneurial and embraces innovation through provision of its unique offerings.

It recognizes the important role of the chief executive officer and management in decision making and defining its strategic actions. Management must have and demonstrate entrepreneurial leadership through instituting actions and reforms in organization that competition will find it difficult to replicate. The chief executive officer of a firm must create teamwork among his top managers as a manager’s ability to sense, seize opportunities in the market in order to remain competitive is different and not likely to be found in one manager. The literature also identified resources such as human capital as the most important valuable asset that enable firms to achieve and maintain its competitiveness as they are intangible, socially complex and difficult to imitate.

Firms who have a high experienced and knowledgeable workforce will have the capability to identify unique company assets, align and modify their functions to meet the changing customer needs and to better understand their environment. Training function was noted to be significant for the production of greater innovation levels, creation of management capabilities and organizational culture that sustain innovation through improvement of knowledge and skills needed at a personal level.

Literature also identified innovation to be also a key source of competitive advantage and are interconnected. Innovation was categorized into product, process, marketing, management and technological innovations all playing significant key roles in organization’s achievement of its competitive advantage. It also noted that the term competitive advantage is used reciprocally with performance but the two are conceived differently. The theoretical foundations used in the study were resource based view, resource advantage theory and dynamic capabilities theory and are related.

REFERENCES


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Intellectual Property Rights, Innovation and Firm Performance in Developing Countries: Firm Level Evidence from Kenya

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Abstract
The study investigated the determinants of Intellectual property Rights (IPR) and its impact on a firm’s innovativeness and financial performance in Kenya. The results revealed that, Intellectual Property Rights notably influence a firm’s decision to invest in Research and Development (R&D). Further, the results suggested that IPR generally enhanced a firm’s value added. Nonetheless, no significant association between IPR and product innovation was found even though there was a significant weak correlation between patented knowledge and product/service innovation. The positive role of IPR on R&D activities was significantly determined by a firm ownership and was predominant in the manufacturing sector.

Relevance to innovation. This paper presents a micro econometric analysis method which is useful in assessing whether innovation efforts by Kenyan firms in the manufacturing and service sectors have led to creation/introduction of new products or services in Kenya. Further, this paper contributes to policy discourse in the context of a developing country by empirically investigating intellectual property rights as an enabling environment for innovation. Additionally, the paper presents policy recommendations which are critical in the transformation of Kenya’s economy from a factor-driven economy to an innovation-driven economy.

Key Words. Intellectual property Rights, R&D intensity, product/service innovation, Value added.

INTRODUCTION
In the modern competitive global markets, creativity, inventions and innovations are the most crucial ingredients of business survival and economic growth (Ngo and O’cass, 2013). To remain competitive, firms are heavily investing in knowledge inputs of production like innovations, creativity and inventions and other kinds of intellectual assets (Killing, 2012). Intellectual properties are key drivers to the development of a brand value, creation of jobs and overall firm productivity (Miller et al., 2015; Kim et al., 2012; Holzknecht, 2012; Shapiro and Pham, 2007).

Jones and Tilley (2003) allude that IPR has become a crucial input in the innovation process since intellectual property and the patented knowledge spread in and out of the firm occasionally. Chesbrough et al. (2006) as cited in Lichtenthaler (2008) postulate that IPR management plays a vital role in managing open innovation collaborative platforms. Effective IPR protection creates
Table 1: Composition of Innovation Spending by Kenyan Firms 2008-2014

<table>
<thead>
<tr>
<th></th>
<th>Sector</th>
<th>Firm Size</th>
<th>SMEs</th>
<th>Large</th>
</tr>
</thead>
<tbody>
<tr>
<td>In house R&amp;D</td>
<td>Overall 39%</td>
<td>Manufacturing 16% Service 23% SMEs 29% Large 10%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Out sourced R&amp;D</td>
<td>20%</td>
<td>7%</td>
<td>13%</td>
<td>13%</td>
</tr>
<tr>
<td>Acquisition of</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>machinery and hardware</td>
<td>54%</td>
<td>24%</td>
<td>34%</td>
<td>41%</td>
</tr>
<tr>
<td>Acquisition of software</td>
<td>43%</td>
<td>15%</td>
<td>28%</td>
<td>31%</td>
</tr>
<tr>
<td>Acquisition of other external knowledge</td>
<td>26%</td>
<td>8%</td>
<td>13%</td>
<td>19%</td>
</tr>
<tr>
<td>Training 54%</td>
<td>21%</td>
<td>33%</td>
<td>38%</td>
<td>16%</td>
</tr>
<tr>
<td>Introduction of</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>innovation to the market</td>
<td>41%</td>
<td>18%</td>
<td>23%</td>
<td>27%</td>
</tr>
<tr>
<td>Design 43%</td>
<td>21%</td>
<td>22%</td>
<td>28%</td>
<td>15%</td>
</tr>
</tbody>
</table>

Source: Author’s own explanation from first and second community innovation surveys by MoEST & KNBS, 2012; 2015.

an environment for smooth transfers of technology through licenses (Chesbrough et al., 2014; Simard and West, 2006).

Reviewed classical and modern literature reveal that, any tool or system that sustain open innovation must support and enhance a comprehensive IPR, encourage and enable stakeholders to set a clear IPR policy (Lee et al., 2010; Chesbrough and Ghafele, 2014). A comprehensive IPR protection policy and licensing plan is essential in ensuring that patented knowledge is not misused and at the same time enabling technology diffusion in and out of the firm frequently (Chesbrough et al., 2014; WIPO, 2015; Fontana et al., 2006).

Innovation is defined in this paper just as in Griffith et al., (2006) that is “the introduction of new-to-the-firm ideas and methods into a workplace which includes imitations”. A firm’s effort to innovate is mostly indicated by R&D spending per employee (Bain and Kleinknecht, 2016). The output of knowledge investments are mostly indicated by four categorical variables associated to product, organizational, process and marketing innovation as well as two variables which are continuous and associated to the contributions in value added related to innovations and intellectual property application (Blasco, 2010; Brockhoff, et al., 2013). Table 1 shows the efforts of Kenyan firms to innovate by spending on R&D.

Information captured in table 1 was contained in the first and the second innovation surveys of 2012 and 2015 respectively which covered a total of 534 firms in the services and manufacturing sectors. Table 1 reveals that, within the time period 2008 – 2014, there was a moderate effort to invest in R&D. The community innovation surveys indicated that 39% of all firms were engaged in in-house R&D which entailed innovative works aimed at increasing the stock of knowledge within an enterprise. 20% of all firms spent on outsourced R&D which comprised of all innovative ideas purchased from other companies including private and public research organizations. 54% and 43% of all the firms spent on acquisition of advanced machinery, equipments and software respectively meant for producing more improved products and services.

Further the surveys indicated that 54% of firms invested in training and retraining their employees. 41% of all firms were engaged in activities like launch advertising and market research that facilitate introduction of latest or considerably improved goods or services in the market. 26% of the firms were engaged in acquisition of external knowledge like licensing of patents and non patented inventions from other organizations. 43% of all firms reported to have spent on designing and improving the appearance of an improved product. A direct comparison between R&D spending across the sectors and firm size revealed that firms in the service sector and small and medium firms(with less than 200 employees) spent more on R&D in the period of study.
Table 2: Intellectual Property Rights by Kenyan Firms: 2008-2014

<table>
<thead>
<tr>
<th></th>
<th>All Firms</th>
<th>SME</th>
<th>Large</th>
<th>Manufacturing</th>
<th>Service</th>
</tr>
</thead>
<tbody>
<tr>
<td>Secured a patent in Kenya</td>
<td>12% 7% 5% 5% 7%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Applied for a patent outside Kenya</td>
<td>4% 3% 1% 2% 2%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Registered an industrial design</td>
<td>10% 6% 4% 5% 5%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Registered a trade mark</td>
<td>20% 12% 8% 11% 9%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Claimed a copyright</td>
<td>9% 4% 6% 3% 5%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Own IPR = 27%, Non IPR Owner = 73%

Source: Author’s own explanation from first and second community innovation surveys by MoEST & KNBS 2012, 2015.

compared to manufacturing firms and large firms respectively.

R&D spending involves spending on intangible assets which include intellectual properties. Intellectual properties refer to conception of the brainpower that includes inventions and innovations (WIPO, 2004). Intellectual property is categorized into two major classifications. The first category is the industrial property that comprises inventions, industrial designs, patents, utility models and trademarks. The second category is copyright that comprises artistic and literary works for instance novels, music, poems, drawings, plays, architectural designs and films (WIPO, 2004).

Kenya has invested in protecting its property rights through legislation and policy directive. Protection and administration of property rights in Kenya is managed by Kenya Industrial Property Institute (KIPI) which is a public institute under the Ministry of Industry, Trade and Cooperatives. One of the mandates of KIPI is to ensure the promotion of inventive and innovative activities in Kenya. The second role is to enhance technology acquisition and diffusion through the grant, regulation and protection of rationalization models, patents, industrial designs and utility models (MoEST and KNBS, 2015). Table 2 shows ownership of intellectual properties rights by Kenyan firms between the years 2008-2014.

Community innovation surveys revealed that only 27% of the firms owned at least one of the five IPR (as shown by table 2) between the years 2008-2014. 12% of all firms secured a patent in Kenya, while 4% secured a patent outside Kenya. 10% of the firms registered for an industrial design, 20% and 9% of all firms registered a trade mark and a copyright respectively. A direct comparison between IPR rights across firms revealed that IPR ownership was slightly concentrated among the small and medium enterprises. Comparison between manufacturing and service sector did not show any significant pattern in terms of IPR rights.

Empirical evidence from developed and developing countries (Hussain and Terziovski, 2016; Tanaka and Iwaisako, 2014) has shown that strengthening IPR promotes innovation which translates to a better firm performance. Chen and Puttitanum (2005), using a panel data from 64 developing countries, found a positive link between IPR and Innovation and economic development. A study by Oloukoili and Senou (2016) examined the relationship connecting intellectual property rights, innovation and added value in six African countries among them Kenya. Their results revealed the effect of IPR on value added and growth was vague.

The emerging debate from the survey of literature indicates that intellectual property rights can be formal or informal whereby firms choose to disclose their patents or keep it a secret. Empirical Studies for instance by Hall et.al (2014) have shown that the type of IPR (formal or informal) impacts the value added, innovation and growth differently. Modern literature for instance by marine et al. (2007) postulates that intellectual property rights enables a firm to have total control over the profitable exploitation of innovations. It is expected that this control may encourage further innovations. However, this control may become a deterrent to the diffusion of technology and consequent innovation.
Table 3: Variable Description and Measurement

<table>
<thead>
<tr>
<th>Variable</th>
<th>Symbol</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Firm Age</td>
<td>FA</td>
<td>The number of years an establishment has been inexistence</td>
</tr>
<tr>
<td>Employment Level</td>
<td>EL</td>
<td>All Skilled workers permanent and contractual</td>
</tr>
<tr>
<td>R&amp;D Intensity</td>
<td>RDI</td>
<td>Firm spending on R&amp;D to employment Level ratio</td>
</tr>
<tr>
<td>Value added per employee</td>
<td>VA</td>
<td>Gross proceeds from sales of goods and services less value added tax and other levy paid by the firms per year divided by the number of employees.</td>
</tr>
<tr>
<td>Intellectual Property Rights</td>
<td>IPR</td>
<td>1 If a firm owns an IP and 0 if otherwise</td>
</tr>
<tr>
<td>R&amp;D Spending</td>
<td>RDS</td>
<td>1 if a firm invest on R&amp;D 0 if otherwise</td>
</tr>
<tr>
<td>Financial capital</td>
<td>FC</td>
<td>The value of tangible assets bought by a firm (Machinery, software etc)</td>
</tr>
<tr>
<td>Firm size</td>
<td>FS</td>
<td>1 If more than 200 employees 0 if otherwise</td>
</tr>
<tr>
<td>Product/Service innovation</td>
<td>INNOV</td>
<td>1 if a firm introduced a new or significantly improved product/service into the Market 0 if otherwise.</td>
</tr>
<tr>
<td>Firm Ownership</td>
<td>FO</td>
<td>1 if a firm is a part of a bigger group of firms 0 if otherwise</td>
</tr>
<tr>
<td>Sector Dummy</td>
<td>SD</td>
<td>1 if a manufacturing firm 0 if otherwise</td>
</tr>
<tr>
<td>Location Dummy</td>
<td>FL</td>
<td>1 if located in the capital city 0 of otherwise</td>
</tr>
<tr>
<td>Survey Dummy</td>
<td>SVY</td>
<td>1 if the first innovation survey 0 if the second innovation survey</td>
</tr>
</tbody>
</table>

After reviewing the terms of the debate in the conventional and modern theoretical and empirical literature, this paper explore empirically the impact of IPR on innovation and firm performance in the context of developing country like Kenya where by this discourse has not been adequately investigated empirically using firm level data. The rest of the paper is organized as follow: section two presents the methodology and data sources, section three discuses the results of this study while section four presents conclusions and policy implications of the study.

**METHODOLOGY AND DATA SOURCES**

**Nature of Data sources**

There is no real panel data on innovation in Kenya due to the nature of community innovations sampling. This paper utilized data from the first and the second community innovation surveys of 2012 and 2015 respectively which covered a total of 534 firms. The kind of variables to extract and data analysis depends on the quality of innovation surveys (Hall and Sena 2011, Blasco, 2010; Ndicu and Wacuka, 2017). From the community innovation surveys and empirical literature for example by Griffith et al. (2006) and Hall et al. (2014), five continuous variables, and nine categorical variables were extracted and the variable type, its symbol and description were summarized by Table 3.
THE ECONOMETRIC MODEL

The augmented Crépon, Duguet, and Mairessec (CDM) (1998) system of equations model was used as the estimation technique just as they did Griffith et al. (2006) and Hall and Sena (2011). The initial step is to estimate the decision to spend on R&D and the intensity of R&D investment. Firms decide whether to spend their resources producing goods and services or producing ideas (innovate). Therefore, decision to invest in R&D is a latent variable, \( r_d^i \), as shown by Equation (1-2) which is a generalized Tobit.

\[
\begin{align*}
    r_d^i &= \begin{cases} 
    1 & \text{if } r_d^i = w_i \alpha + u_i > 0 \\ 
    0 & \text{if } r_d^i = w_i \alpha + u_i \leq 0 
    \end{cases} \\
\end{align*}
\]

Where \( r_d^i \) is a latent variable, which is one for a firm that invests on R&D and zero for a firm that does not invest on R&D. Where \( X_i \) is a vector of determinants of R&D choice and R&D intensity, \( \beta \) is a vector of parameters to be estimated and \( u_i \) is a random error term. The second step involves the estimation of the probability of a firm to innovate and own IPR as shown by equation 2 and 3 respectively. Equation (3) helps to determine the impact of R&D intensity on product/service innovation or imitation.

\[
\begin{align*}
    INNV_i &= \pi_1 r_d^i + \theta_1 x_1^i + d_s + d_r + \epsilon_i^1 \\
\end{align*}
\]

Where \( INNV_i \) is a dummy variable which indicate innovation measurement with 1 if a firm introduced a new product or service into the market and 0 if otherwise. \( r_d^i \) is the predicted value of R&D intensity. Predicted values of R&D intensity were used to control for the endogenous nature of product/service innovation and R&D intensity. \( x_1^i \) is a vector of other variables that affect firms’ tendency to innovate, \( d_s \) and \( d_r \) are industry and region dummies and \( \epsilon_i^1 \) is the residual. The impact of intellectual property rights to a firm was modeled by Equation (4).

\[
\begin{align*}
    IPR_i &= \pi_2 r_d^i + \theta_2 x_2^i + d_s + d_r + \epsilon_i^2 \\
\end{align*}
\]

Where \( IPR_i \) is a dummy variable taking the value of 1 for firms that own IPR and 0 for firms that do not. \( r_d^i \) is the predicted value of R&D intensity. \( x_2^i \) is a vector of variables that affect firms’ propensity to own IPR. \( d_s \) and \( d_r \) are industry and region dummies and the are the residuals. \( \pi_2 \) and \( \theta_2 \) are parameters to be estimated. Equations (3) and (4) are estimated simultaneously as a bivariate probit system, assuming that the two disturbances are correlated. The final step is the estimation a Cobb-Douglas stochastic production function Equation (5). This enables observation of the impact of the two innovation output (product/service innovation and IPR rights) on a firms’ value added per employee.

\[
\begin{align*}
    Q_i &= A + \alpha_k k_i + \alpha_l l_i + \delta_1 INNV_i^* IPR_i^* + d_s + d_r + v_i \\
\end{align*}
\]

Equation (5) has innovation outputs from the previous stage (Product innovation and IPR Rights) included in the regression model together with logs of capital, labour and Value added sector. Survey and regional dummies are included to control individual heterogeneity that may influence the output.

RESULTS AND DISCUSSION

Table 4 shows the sample selection estimates which are crucial in determining factors that influence R&D activities (spending and intensity). Rho = 0.7, which is the correlation between the two
Table 4: Table Sample selection Estimates - Investment in R&D and R&D intensity

<table>
<thead>
<tr>
<th>Independent</th>
<th>Invest in R&amp;D (1/0)</th>
<th>R&amp;D Intensity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Value added</td>
<td>-0.0659</td>
<td>0.1500**</td>
</tr>
<tr>
<td></td>
<td>(0.0808)</td>
<td>(0.075)</td>
</tr>
<tr>
<td>Product/service Innov.</td>
<td>0.6219**</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.1594)</td>
<td></td>
</tr>
<tr>
<td>IP ownership</td>
<td>0.5831**</td>
<td>0.0416</td>
</tr>
<tr>
<td></td>
<td>(0.179)</td>
<td>(0.2233)</td>
</tr>
<tr>
<td>Foreign ownership</td>
<td>0.4524**</td>
<td>0.0379*</td>
</tr>
<tr>
<td></td>
<td>(0.1679)</td>
<td>(0.1813)</td>
</tr>
<tr>
<td>Firm Size</td>
<td>0.2549</td>
<td>-0.3116</td>
</tr>
<tr>
<td></td>
<td>(0.2309)</td>
<td>(0.2224)</td>
</tr>
<tr>
<td>Employment Level</td>
<td>-0.0102</td>
<td>-0.0221*</td>
</tr>
<tr>
<td></td>
<td>(0.0201)</td>
<td>(0.0246)</td>
</tr>
<tr>
<td>Firm Age</td>
<td>-0.0026</td>
<td>-0.0027</td>
</tr>
<tr>
<td></td>
<td>(0.0041)</td>
<td>(0.0041)</td>
</tr>
<tr>
<td>Location Dummy</td>
<td>-0.1101</td>
<td>0.1917</td>
</tr>
<tr>
<td></td>
<td>(0.1652)</td>
<td>(0.1631)</td>
</tr>
<tr>
<td>Sector Dummy</td>
<td>0.3379**</td>
<td>-0.1028</td>
</tr>
<tr>
<td></td>
<td>(0.1757)</td>
<td>(0.1954)</td>
</tr>
</tbody>
</table>

Mills Lambda 2.1225 (0.3789); Rho 0.6583; Sigma 0.8739; Pro>\(\text{Chi}^2\) 0.0019

Note ** and * represents \(\rho < 0.05\) and \(\rho < 0.1\) respectively.

residuals, is quite significant. Further, the overall significance of the model of \(\text{Pro}>\chi^2 = 0.0019\) makes the sample selection model Equation (1) and estimates useful in determination of factors influencing R&D activities.

The sample selection estimates revealed that if a firm had introduced a new product or service in the market, then it was likely to invest in R&D activities. Further IPR ownership positively influenced a firm’s decision to invest in R&D. The results also reveal that those firms that were a part of a large group of firms (subsidiary) were likely to invest in Research and Development. The results also revealed that, value added was the only significant determinant of R&D spending per employee by firms that invested on R&D. Additionally, the results revealed R&D spending per employee to some extent was influenced by a firm ownership (being part of a larger group). However the number employees in a firm reduced the tendency of a R&D spending per employee. Firm age and size as well the survey and location dummy did not matter to a firm’s R&D choice and Intensity.

Table 5 shows the estimates of multivariate probit with selection estimates of product innovation and IPR rights. Product /service innovation/ imitation and IPR rights are the expected R&D intensity outcomes.

Correlation test also reported by Table 5, revealed a very weak positive correlation between IPR ownership and product/service innovation and a very weak positive correlation between IP rights and R&D Intensity. Correlation results also revealed a very weak correlation between product/service innovation and R&D Intensity. Probit regression with selection results revealed that a firm being a part of a larger group increased the possibility of that firm owning an IPR. The sector dummy included in the probit regression was significant revealing that IPR ownership was predominated in the manufacturing sector as opposed to the service sectors. Moreover, R&D intensity did not have a significant impact on product/service innovation or imitation.

The results of this study indicated that only financial inputs had a significant impact on
Table 5: Multivariate probit estimates of product/service innovation or imitation and intellectual property rights

<table>
<thead>
<tr>
<th></th>
<th>Product Innovation</th>
<th>IPR Ownership</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location Dummy</td>
<td>0.3995</td>
<td>0.4683</td>
</tr>
<tr>
<td></td>
<td>(0.3004)</td>
<td>(0.2805)</td>
</tr>
<tr>
<td>Sector Dummy</td>
<td>0.4179</td>
<td>0.6756**</td>
</tr>
<tr>
<td></td>
<td>(0.2966)</td>
<td>(0.2816)</td>
</tr>
<tr>
<td>Firm Age</td>
<td>-0.0091</td>
<td>-0.0024</td>
</tr>
<tr>
<td></td>
<td>(0.0068)</td>
<td>(0.0071)</td>
</tr>
<tr>
<td>Employment level</td>
<td>0.0015</td>
<td>0.001</td>
</tr>
<tr>
<td></td>
<td>(0.0002)</td>
<td>(0.0006)</td>
</tr>
<tr>
<td>R&amp;D Intensity</td>
<td>-0.0122</td>
<td>0.0979</td>
</tr>
<tr>
<td></td>
<td>(0.1569)</td>
<td>(0.0652)</td>
</tr>
<tr>
<td>value added</td>
<td>0.1544**</td>
<td>-0.0998</td>
</tr>
<tr>
<td></td>
<td>(0.135)</td>
<td>(0.0122)</td>
</tr>
<tr>
<td>Foreign ownership</td>
<td>-0.3649</td>
<td>0.4787**</td>
</tr>
<tr>
<td></td>
<td>(0.2822)</td>
<td>(0.2719)</td>
</tr>
<tr>
<td>Size</td>
<td>0.311</td>
<td>-0.4994</td>
</tr>
<tr>
<td></td>
<td>(0.2901)</td>
<td>(0.4196)</td>
</tr>
<tr>
<td>IP ownership</td>
<td>0.4303</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.02869)</td>
<td></td>
</tr>
<tr>
<td>Product/service Innovation</td>
<td></td>
<td>0.4407</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.291)</td>
</tr>
</tbody>
</table>

Corr (IP rights, Product/service Innov) 0.2657** (0.0000)
Corr (IP rights, R&D Intensity) 0.2121** (0.0000)
Corr (Product/service Innov, R&D Intensity) 0.2417** (0.0000)

Note ** and * represents $p < 0.05$ and $p < 0.1$ respectively. Method of estimation is MLE, the figures in parentheses is robust standard errors.

innovation. Further, the results of this study pointed out that variables associated to firm characteristics like firm age and size, variables relating human capital like employment did not have any impact to a firm’s product or service innovation and its IPR ownership. Survey and regional dummies included to control for individual heterogeneity that may influence the output were also not significant.

Nonetheless, the results did not reveal any significant relationship between product innovation and IPR ownership. It was not clear if IPR ownership resulted to further innovations or not. It was also not comprehensible if the monopoly powers that comes with IPR ownership hindered the diffusion of patented knowledge in and out of a firm or not.

To determine the impact of the two innovation outputs (product innovation and IPR ownership) on value added per employee, the two innovation outputs were included in the stochastic frontier estimation and the estimates are shown by Table 6. The estimates of the stochastic frontier revealed all the inputs had a positive impact on value added per employee implying that product innovators and IPR owners profitably benefitted from their R&D activities. The results also revealed that IPR ownership had much more impact on value added as compared to product/service innovation. Generally, the results indicated that on average the marginal impact of the two innovation outputs on value added per employee was between twenty and forty percent as shown by Table 6.
CONCLUSION AND POLICY IMPLICATION

Modern global markets have moved to the next production frontier which involves innovation based production. To survive in the competitive markets, firms are moving towards science, innovation and technology based production. Kenya as an emerging economy has not been left behind and has made tremendous efforts to catch up with innovation and technology frontier. Kenya has done this through resource allocation, regulation and legislation.

This study sought to find out the impact of these innovation efforts on the productivity of Kenyan firms both in the manufacturing and in the service sectors. Econometric analysis of the community innovation surveys data in Kenya revealed generally a slow uptake of R&D activities by the Kenyan firms. The results of this study revealed that the few product or service innovations/imitations under the period of study were largely dependent on financial capital as opposed to creativity, inventions and innovations.

The results also revealed only 27% of Kenyan firms owned formal IPR in time period between 2008-2014. Further, the results revealed that IPR ownership was significantly influenced by the firm’s ownership and was predominant in the manufacturing sector. This study found no link between IPR rights and product innovation and it was therefore not clear if IPR rights resulted into further innovations or if the monopoly that comes with IPR rights hindered further innovations. However, the results revealed that the two innovation outcomes, that is product or service innovation/imitation and IPR ownership generally enhance the value added per employee of a firm.

The results of this paper reveal that innovation outcomes of IPR rights and product or service innovation or imitation were predominant in the manufacturing sector. On the basis of this result, this study recommends policy debates and arguments that focus on strengthening and expounding intellectual property and R&D laws that are essential to Kenya’s economic progress and international competitiveness. R&D activities in developing countries like Kenya is usually a case of catch up with imitation developed economies. In developing economies the Government’s Science, Technology and Innovation (ST&I) policies largely determines the success of R&D activities in that particular country (Vivarelli, 2014). This paper recommends a more collaborative investment in Science, Technology and Innovation among the government, researchers and development partners. This is essential since Science, Technology and Innovation is critical in the transformation of Kenya’s economy from a factor-driven economy to an innovation-driven economy.

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Mobile Money for Financial Inclusion: The Mobile Accumulating Savings and Credit Association (M-ASCA) Model In Kenya.

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Abstract

The Kenyan informal sector is characterized by an ecosystem of self made informal savings and credit groups as well as informal money lenders that target the unbanked and marginalized populations. M-ASCA aims at mitigating challenges and conveniently addressing financial needs of the unbanked populations in Kenya. The platform virtualizes all the savings and credit processes making it possible for anyone interested to join from any part of the country including friends and relatives, conveniently save anytime and any amount, use their networks as guarantors from anywhere besides accessing loans at affordable rates on phone. All operations are phone based.

Relevance to innovation. The M-ASCA model was conceptualized to fill in the gap created by the elusive financial products targeting the unbanked. M-ASCA is purely electronic; people sign themselves on the platform and invite their friends and networks from wherever they are. They form virtual groups and guarantee loans for one another via the platform acting as social collateral. The System is integrated with mobile money wallets from main providers and members remit funds via the platform anytime conveniently and no wasting time in meetings. The interest rates are low since it is welfare based. M-ASCA targets all Kenyans to support each other.

Key Words. Informal sector, affordable credit, convenient savings channels, M-ASCA.

INTRODUCTION

Mobile money systems have transformed the execution of monetary transactions in Kenya. As of September 2015 (CA, 2015) 28.7 million subscribers were active in various forms of mobile money transactions among them money transfers, mobile banking, payment systems or other forms. Consequently populations excluded from formal financial services in Kenya have had a chance of participating, with financial service providers extending their services to the segments through agency networks whose number stood at 135,724 as of September 2015. Further mobile phone subscribers increased from 36.1 in 2014 to 37.8 % in 2015 (CCK, 2015).

Driving the exponential transformation is the acute lack of formal financial services particularly in rural areas, in addition mobile money products on offer have been designed to address needs that target poor and marginalized populations. For this reason even populations that were in urban areas but excluded from existing financial services due to unsuitable models (Mulwa &
Mobile Money for Financial Inclusion: The Mobile Accumulating Savings and Credit Association (M-ASCA) Model In Kenya.

Ndati, 2013) have found mobile money systems friendly and accommodative of their specific needs. Such needs include convenience of operating hours, amounts of transactions, any time anywhere access, privacy, intermediation among others.

THE M-ASCA MODEL

The M-ASCA model is an indiscriminate mobile phone based accumulating savings and credit application that aims at bringing community members together in order to improve their livelihoods. Operating as a Community Based Organization, named Mobile ASCA, The organization targets every adult Kenyan irrespective of their background (youths, women, small scale business people, the unemployed, private institutions etc) interested in saving in order to access capital for investment, business start ups, old age savings or any other viable need. An end to end electronic system members register themselves from any part of the country, integrated with local virtual platforms of major Mobile service providers they save conveniently to the association even late in the night and in convenient amounts accumulating savings little by little, apply for loans via the platform and request to be guaranteed and get guaranteed on phone, get disbursements to M-ASCA phone based accounts, check balances and exit from the system among other functionalities.

A pure electronic process allows people with irregular income to submit small amounts little by little; it also provides access to marginalized populations nurturing a saving culture as well as ensuring financial inclusion. It fosters transparency and streamlines the informal sector by providing affordable credit to those who do not have access to traditional financial services for their self-sustaining business activities.

PROBLEM STATEMENT

Kenya is categorized as a very poor country with large populations living in extreme poverty (Institute for security studies, 2015). According to world bank report (2015), 46% of Kenyans live in absolute poverty. These people have no means of meeting basic human needs and lead dehumanizing lives according to universal norms of human dignity which include starvation, lack of shelter and are likely to result to immoral activities for survival. Consequently the unemployment rate in Kenya stands at 40% (Trading Economics, 2014) meaning that existing affordable savings services in the form of SACCOs (Savings and credit cooperative societies) are not available for these people.

Sub-Saharan Africa is regarded as having a thriving informal sector with numerous small businesses that require little capital injection to get them started and sustained. In addition Prahalad (2006) is of the view that though the poor are of limited means, taken as an aggregate constitute a viable business volume. Unfortunately proprietors of these small ventures are continually frustrated by the legislative system and consequently the populations in these areas are excluded from essential services because of their meager resources, are sparsely populated and usually reside in rural areas that lack basic infrastructure (SIDA review, 2010).

Instituted support systems to these populations will encourage entrepreneurship, bolster incomes and see living conditions improved through access to growing incomes. Mobile money systems have demonstrated the possibility of extending mainstream financial services to marginalized populations and in effect deepening financial services to the unbanked populations. While the government of the day is alive to this concern through initiatives like the Uwezo, women and the youth funds, more sustainable models of financing the entrepreneurial sector are necessary. The M-ASCA model is designed to conveniently nurture a saving culture amongst the lesser off segments creating a sustainable and self-sustaining model for affordable credit.
OBJECTIVES
The purpose of this paper is to underscore the gaps exhibited by financial inclusion models targeting the lesser off segments and demonstrate how the M-ASCA model in Kenya fills this gap.

The specific objectives are:

(a) Analyze in detail the existing financial inclusion models targeting the poor and marginalized populations in Kenya.
(b) Highlight critical areas in need of interventions for financial inclusion of the lesser off segments in Kenya.
(c) Demonstrate how the M-ASCA model in Kenya is designed to address the specific needs of the lesser off segments in society.

LITERATURE REVIEW
Microfinance, the provisions of financial services to the low-income households and micro and small enterprises (MSEs), provide an enormous potential to support the economic activities of the poor and thus contribute to poverty alleviation (George Omino CBK, 2005). Widespread experiences and research have shown the importance of savings and credit facilities for the poor and MSEs. This puts emphasis on the sound development of microfinance institutions as vital ingredients for investment, employment and economic growth. The potential of using institutional credit and other financial services for poverty alleviation in Kenya is quite significant.

About 18 million people, or 60% of the population, are poor and mostly out of the scope of formal banking services. According to the National Micro and Small Enterprise Baseline Survey of 1999, there are close to 1.3 million MSEs employing nearly 2.3 million people or 20% of the country’s total employment and contributing 18% of overall GDP and 25% of non-agricultural GDP. Despite this important contribution, only 10.4% of the MSEs receive credit and other financial services. The formal banking sector in Kenya over the years has regarded the informal sector as risky and not commercially viable.

According to the Poverty Reduction Strategy Paper (PRSP) of 1999, a large number of Kenyans derive their livelihood from the MSEs. Therefore, development of this sector represents an important means of creating employment, promoting growth, and reducing poverty in the long-term. However, in spite of the importance of this sector, experience shows that provision and delivery of credit and other financial services to the sector by formal financial institutions, such as commercial banks has been below expectation. This means that it is difficult for the poor to climb out of poverty due to lack of finance for their productive activities. Therefore, new, innovative, and pro-poor modes of financing low-income households and MSEs based on sound operating principles need to be developed.

Mobile money has been proposed as a promising trajectory in the effort to address financial inclusion of the poor and marginalized (Mulwa and Ndeti 2013). Traditional lending methods have not been able to address the needs of the unbanked in Kenya. These populations are of irregular and meagre income, work long hours and have several competing needs. There is therefore need for a well thought out model to address their financial needs.

EXISTING MICRO FINANCE MODELS
The fallback to entrepreneurship by majority of Kenyans as a solution to lack of formal employment calls for affordable convenient and reliable financial sources for startup capital. Safe the government initiatives of Uwezo, women and youth funds which need to be supplemented, various models have sprung up to cash on these vulnerable sector. Among these are shylocks and MFIs whose interest in not regulated as opposed to that of banks. MFIs particularly that lend money to groups of people in the informal sector have proven unfriendly due to their mode of execution.
Members are required to be in groups of 10-15 and residing at the same geographical area. These members act as guarantors for loans given to each one of them. Since these members only come together simply as a requirement of the MFI, many take loans and default, leaving the burden to the others. In addition members recover defaulted loans from sale of household items which is straining to extended family members including children.

Shylocks on the other hand are out of reach as they charge scissor interest rates on their loans are unsustainable and leave borrowers poorer (Martina & Ndeti 2013). Besides MFIs, two other significant informal financial services dominating the informal sector are the Rotating Savings and Credit Associations (ROSCA also known as merry go round) and Accumulating Savings and Credit (ASCAs) (FSD Kenya 2009)). These are similar to each other in the sense that they are both voluntary and independent groups with their own rules and no outside organization with control over them. The central difference between ASCAs and ROSCAs is that each time a ROSCA group meets and savings are collected, the whole pot is then immediately in the same meeting redistributed to one or several members of the groups. On the other hand ASCAs do not give the funds to anyone, but lend the funds to willing borrowers with interest. The interest paid on the loans will then accumulate in the group fund. At the end of the year ASCA members often divide part of the profits (from interest payment) to the members.

However, these two models have several challenges (Johnson et. al (2002) for 1999 and 2001; DFS for 2007) which include 1) Costs consisting of erroneous charges, low interest on savings and high interest rates on loans 2) on demand contributions and payments, time and effort to attend meetings, time and effort to do transactions 3) risk /trust, fraud, theft and paying for loans on behalf of defaulters 5) communication which is not efficient and 6) management as well as powerful individuals taking advantage of members. These challenges are mainly because these two models are used by the very bottom of the pyramid that are largely illiterate.

In addition these existing models face challenges in the recovery system for defaulters, increased borrowing capacity, and growth of savings forcing members to borrow loans they do not need yet the interests are very high. Though these challenges may be a serious challenge to financial inclusion considering that these models are the only options for the lesser off in society, a streamlined execution process and management of the models could ensure affordable and sustainable source of credit for the Small and Medium sector in Kenya compared to the other Informal micro finance formations.

According to FSD Kenya (2009), a total volume of some Kshs 65 billion (close to US$1bn) is intermediated through ROSCAs and ASCAs on an annual basis. Given this, there is a justification for arguing that efforts could be directed to improving the internal organization of these groups to reduce the risk of losses through this highly prevalent form of financial intermediation. Understanding lesser off segments and designing appropriate financial inclusion channels that take into consideration the characteristics, capabilities and needs of these people will go a long way in providing a permanent solution to financial exclusion in Kenya.

**DESCRIPTION OF THE M-ASCA MODEL**

M-ASCA targets those excluded from formal financial services and henceforth exposed to the informal financial sector characterized by exorbitant interest rates for credit and poor management of group activities. The targeted segments engage in small businesses, with equally small margins of profit as a result of saturation of similar activities and limited capacity for alternatives. M-ASCA mobile money enables the organization to serve its members in the entire country, breaking infrastructural and other logistical barriers as well as geographical limitations, and by minimizing the costs of operations such as cutting down on agents and facilities being set up all over the country. This does away with over reliance on agents and enables members to directly access services via their phones. The services are all inclusive from self-registration to loan application,
saving money, request for guarantors, guaranteeing members, checking balances, statements and loan repayments among others.

The model is deliberately designed to eliminate wasting crucial time for members in meetings at the expense of working choosing to empower them to take charge of the management of their financial affairs. The model also avoids tying members to a circle of friends and anyone anywhere can be an M-ASCA member and a guarantor can be anyone in any part of the country. It encourages people to know each other and socialize from wherever they are.

The model is in cognizance of the fact that convenience is critical in nurturing the saving culture of lesser off segments. Though there is a viable economic ecosystem at the base of the pyramid, saving is one among many competing needs, hence the need to avail opportunities for saving close to sources of income and as conveniently as possible. Supported by the M-Pesa and Equitel network of outlets (with over 40,000 and 20,000 agents across the country consecutively) the design puts into consideration the fact that people in the informal sector may not have regular income but access some money anyway, it is necessary to tap this resource at the earliest opportunity. The M-ASCA model allows members to save any amount; as little as Ksh 50, which the system can accept anytime and as many times as one wishes in a day. It also allows them to repay loan installments bit by bit anytime within the month as long as by the end of the month the whole installment has been paid.

M-ASCA recognizes the different social support structures in the country and factors in group saving, where members of a family or an organized group like chamas2 come together and save into a common kitty here referred to as “super guarantor”. Members of the group get guaranteed from the common kitty, and any money leaving the common kitty (super guarantor) must be confirmed by the signatories. The system also helps in mobilizing savings either through the temporary account or the loan savings account. This is made possible by the USSD (unstructured supplementary service data) based platform. The design is considerate of the heterogeneous demographics and hence simplified to make it easy to use, enabling members to follow a step by step procedure that allows them to navigate services offered by the association.

M-ASCA stands out because the registration of members is electronic, this escalates uptake as documentation required from the target segments sometimes becomes a barrier to uptake of these services. Members also have the option of making contributions or repayments in bits as their income dictates giving them an opportunity to conveniently plan their financial affairs.

Guarantor system encourages recruitment of friends and relatives and in the process incorporates majority of the unbanked populations into the formal system and consequently ripping the benefits as well as scaling the product. The model is affordable, interest rates are low and considerate to the hardships Kenyans go through. Kenyans get value for saving. Discriminated populations in terms of unemployment, women and youth for lack of collateral enjoy credit with themselves as the guarantors and their networks across geographies.
Mobile Money for Financial Inclusion: The Mobile Accumulating Savings and Credit Association (M-ASCA) Model In Kenya.

The product has the potential of creating a unified Kenya as the guarantor system is universal anyone anywhere is capable of guaranteeing the other. Membership does not need to seize when one relocates or is away from friends.

CONCLUSION

The analysis has clearly demonstrated the importance of the informal financial service sector. Through the informal financial sector 35% of the population, who would otherwise be excluded, have access to financial services. Informal groups also serve poorer clients compared to semi-formal and formal service providers as well as many small scale farmers that SACCOs may not be interested in serving.

There is justification for a consulted effort to engage directly with informal groups in a bid to improve their operations in ways that will deliver higher quality services to some of the poorest people who currently lack access. Engaging with informal groups has clearly been demonstrated to be problematic. This analysis further illuminates that these groups face many challenges, in terms of payments, management and governance of the groups, mismanagement of funds and theft. Approaches to working with these groups must therefore consider how to deal with this tension and allow for this negotiability by enabling groups to serve their member’s needs effectively and respond to emergencies. Working with groups on the basis of their own savings alleviates the need for rigid external performance assessment but may be done in ways that improve their transparency and accountability and hence effectiveness for users. Given their importance in overall access and the evidence of how much savings they mobilize, it is appropriate to consider how their services might be improved, especially in the light that many of these groups are not well organized.

The M-ASCA model comes in handy to streamline the management of the operations of the service through the strategic partnerships that would address the challenges cited by designing a universal savings and credit product that goes beyond to address barriers of socio-demographic factors of age, geographical location, education and gender. The M-ASCA model is also appropriate as it does not fall under the regulations governing deposit taking Micro finance Institutions whose capital and other set up requirements are far beyond the capability of members and incompatible with the simplistic cost cutting measures the M-ASCA model adopts to ensure access. According to the Micro Finance Amendment Act (2013) informally constituted MFIs like Rotating Savings and Credit Associations (ROSCAs), club pools, financial services associations (FSAs) or Accumulating Savings and Credit Associations (ASCAs) should not be supervised by an external agency of the Government. Donors, commercial banks, and government agencies from which they obtain funds or that support them should carry out due diligence and make informed decisions about them.

The mobile money payment system in Kenya has proven to be a reliable and sound method of tracking funds and providing the accountability required in the management of public funds (Alliance for Financial Inclusion, 2010). The M-ASCA model is thus a reliable model capable of overcoming the challenges encountered in the operations of various informal Micro Finance Institutions effectively transforming the lives of over 16 million Kenyans who depend on the informal financial sector for credit.

Recognition

M-ASCA is a copyright under the Copyright Board of Kenya as well as a Trademark
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|---------------------------------------------------------------|
Telediagnosics: An Automatic Biomedical Image Matching and Retrieval in a Multi-distributed Telecommunications Environment in Kenya

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Abstract
Diagnostic images are progressively being used within healthcare institutions for diagnosis, treatment guidance planning and disease progression monitoring. Effective management of medical cases can be costly and requires reliable patient diagnosis performed by a trained physician. As a rule of thumb, the identification of an image involves matching of features extracted from the image with a pre stored original pattern. The study uses a computerized method of segmentation and classification of medical images using artificial intelligence algorithms such as fuzzy logics to automatically match and compute similarity indexes for biomedical images sourced from digital sources such as digital microscopes.

Relevance to innovation. A new innovative process design integrated into a clinically testable telemedicine tool assembled from existing resources with a view to addressing the Kenya ehealth strategy anchored on Vision 2030.

Key Words. Artificial intelligence, biomedical images, pattern matching, telediagnosics, telemedicine

INTRODUCTION
Not so well equipped medical centers that operate seldom have the expected medical practitioners that can run them. It therefore becomes quite obvious that whenever an outbreak of a disease occurs, doctors are flown to the affected parts of the county on emergency mode. It is also notable that there are quite very few referral hospitals across the country and area concentrated in urban centers. This implies that rural areas have lesser number of good doctors and therefore this leaves a greater population percentage in the countryside with less specialist services. As per the ehealth strategy report 2011-2017, 80% of clinicians serve 20% of the population and the world health organization 2016 report on telehealth programs in Kenya indicates that, the questions on teleradiology, teledermatology, telepathology, telepsychiatry and remote patient monitoring were never answered by Kenya government as per Table 1.
Telediagnostic: An Automatic Biomedical Image Matching and Retrieval in a Multi-distributed Telecommunications Environment in Kenya

Table 1: Telehealth Programmes Country Overview: Telemedicine Response by Kenya by World health Organization, 2016

<table>
<thead>
<tr>
<th>Health system level</th>
<th>Programme type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teleradiology</td>
<td>Local</td>
</tr>
<tr>
<td>Teledermatology</td>
<td>NA</td>
</tr>
<tr>
<td>Telepsychiatry</td>
<td>NA</td>
</tr>
<tr>
<td>Telepathology</td>
<td>NA</td>
</tr>
<tr>
<td>Remote patient monitoring</td>
<td>NA</td>
</tr>
</tbody>
</table>

Legend

U – Indicates question was unanswered

Local or peripheral level – health posts, health centers providing basic level of care
Informal – use of ICT for health purposes in the absence of formal processes and policies

MAIN OBJECTIVE

The main objective was to develop and demonstrate a testable prototype of a biomedical image pattern matching tool using artificial intelligence techniques that could efficiently retrieve, match and predict similarity of biomedical visual images from digital sources such as USB microscope or digital microscopes as input devices. Then use multimodal database techniques of the captured specimen images of a patient blood, stool, or skin samples for diagnosis based on artificial intelligence algorithms.

The main objective was realized through the following sub-objectives:

1. Utilization of existing technologies such as the Global System for Mobile Communication (GSM) network and internet to deliver efficient and effective telediagnostic tool that was used to test sample image specimen.
2. Evaluation of various digital image compression techniques or image formats for optimum medical images transmission and storage mechanisms. Whilst checking if the image compression algorithm has an effect on distortion levels.

LITERATURE REVIEW

Since its inception, mobile phones have become indispensable in people’s daily life for communication, data capture and media exchange. Providing multimedia capabilities has been one of the biggest improvements in mobile telephony and with various camera phones providing multimedia capturing, browsing, editing, and sharing. The coming of third generation (3G), 4G and 5G networks with fiber optics networks are all engineered for faster and more reliable internet access throughputs.

We intend to tap on such high end technology solve or lessen some of the human burdens such as on time diagnostics of simple ailments. This study and by far such inventions could be used to provide speedy information to gather statistics on diseases. Computer scientists have a duty to champion the domain knowledge by collaborating with various domain experts such medicine, agriculture, and biology. Early and accurate diagnosis of the nature of parasites has always been made with a microscope, which is essential and crucial for appropriate choice of remedial drugs.

As similar research has been conducted by the University of California, Berkeley where they developed a mobile telephone with an inbuilt microscope. The device is a sophisticated mobile microscope with an advanced digital camera to capture microphotographs of the blood smear. The captured image is sent to specialists for observation. It is the intention of this project transmits the digitized image to a pattern matching application for automatic diagnosis. Figure 1, is an image grab from a Nokia mobile phone turned into microscope.

http://uonresearch.org/irs
The device will enable health workers in remote, rural areas to take high resolution images of a patient’s blood cells using a cell-phone camera, and then transmit the photos for diagnosis online as per University of California, Berkeley study.

The computerized biomedical tool advanced by this research will processes the information contained in the image data and create an abstraction of its content in terms of visual attributes. Subsequent analysis and retrievals of the image will be dealt with solely as abstraction rather than with the image itself. Any image inserted into the database is analyzed and a compact representation of its content is stored in a feature vector or signature location.

Using artificial intelligence (AI) techniques, the signature of the image in is extracted by segmenting the image into regions. Each region is associated with its color, texture, and shape information. The signature has a region-based information along with global color, texture, and shape information to represent the attributes for the entire image. The images will be matched based on color, texture, and shape attributes. The positions of these visual attributes of the image are represented by a location.

The Electromagnetic Spectrum – The color wavelength visible to the human eye ranges from 4000 to 7000 angstroms. This is similar to an electromagnetic radiation with wavelengths between about 380 and 700 nanometers. This radiation is known as light. The visible spectrum and electromagnetic radiation are illustrated below in Figure 3.

Effects of light on pictures - The eye has three classes of color sensitive light receptors called cones, which respond roughly to red, blue and green light (around 650, 530 and 460 nm, respectively). A range of colors can be reproduced by one of two complimentary approaches.
Telediagnosics: An Automatic Biomedical Image Matching and Retrieval in a Multi-distributed Telecommunications Environment in Kenya

Figure 3: The electromagnetic spectrum

Additive and subtractive color. Additive color combines light sources, starting with darkness (black). The additive primary colors are red (R), green (G), and blue (B). Adding R and G light makes yellow (Y). Similarly, G + B = cyan (C) and R + B = magenta (M). Combining all three additive primaries makes white. Subtractive color illuminates objects that contain dyes or pigments that remove portions of the visible spectrum. The objects may either transmit light (transparencies) or reflect light. The subtractive primaries are C, M and Y. Cyan absorbs red; hence C is sometimes called 'minus red' (-R). Similarly, M is -G and Y is -B.

In determining the image similarities, color histogram is one method used. It represents an image by breaking down the various color components of an image and graphs out the occurrences and intensity of each color. Then to compare the two images, one needs only to compare the color histograms of the two images and determine the similarity of the two histograms. Another approach for color comparison is color correlogram (scatter plots) method. This method of comparison does not take into account space information. That is, the space or distance between one color and another color, but solves the issue of integration of spatial information into color histograms.

Texture is another key component of an image. It is the perception of smoothness or coarseness of an object. Similar to the color histogram, many of the current techniques for image texture analysis lack the spatial information allowing one to compare the location of a coarse object within an image and a smooth object. Methodologies such as Gabor filters can be used. Gabor functions when applied to an image, converts image texture components into graphs. Gabor filters allow one to quantify the coarseness or smoothness of an image. The comparison of the images is performed against the mathematical representation of the graphs. This enables content based image retrieval systems to compare the textures of two different images.

Shape features are usually described after the images have already been segmented or broken out. A good shape representation of an image should handle changes in translation, rotation, and or scaling. This is rather difficult to achieve as the images involve numerous geometric shapes that when numerically characterized, will typically lose information.

Weight values can be between 0.0 and 1.0 and during processing, the values are normalized such that they total 1.0. The weight of at least one of the color, texture, or shape attributes

http://uonresearch.org/irs
must be set to greater than zero. Score: The similarity measure for each visual attribute is calculated as the score or distance between the two images with respect to that attribute. The score can range from 0.00 (no difference) to 100.0 (maximum possible difference). Thus, the more similar the two images are with respect to a visual attribute, the smaller the score will be for that attribute.

As an example of how distance is determined, assume that the dots in Figure 4 below represent scores for three images with respect to two visual attributes, such as color and shape, plotted along the x-axis and y-axis of a graph. The application image matching process ensures that image signatures are generated. The score is the relative distance between two images being compared. The score for each attribute is used to determine the degree of similarity when images are compared, with a smaller distance reflecting a closer match.

As an illustration for matching, assume Image 1 is the comparison image, and Image 2 and Image 3 are each being compared with Image 1. With respect to the x-axis and y-axis, the distance between Image 1 and Image 2 is relatively small whereas the distance between Image 1 and Image 3 is much greater. Thus when images are matched, the degree of similarity depends on a weighted sum reflecting the weight and distance of all three of the visual attributes in conjunction with location of the comparison image and the test image.

5.1 METHODOLOGY

The study design involved software modeling and prototyping the biomedical imaging tool using a standard software development life cycle model. The design and integration of interface tools on a multimodal distributed communication architecture as per Figures 5 and 6. The testing and tuning of the tool involved acquiring diagnostic images from reliable sources for research. However, clinical trial and calibration of the tool was out of scope.

The biomedical tool is designed to fit into the overall clinical roadmap for clinical data generation in Figure 7, for natural language processing data enrichment, machine learning data analytics and clinical decision making using electronic medical records (EMR) and electrophysiological (EP). The road map starts and ends with clinical activities.
DISCUSSION

While the evaluation of the digital image compression techniques for optimum transmission and storage was analyzed, the two mostly used image compression algorithms the study came across are lossy and lossless (Table 2). Lossy means that the decompressed image loses some of the information, but the only information that is judged to be insignificant is left. While lossless means they preserve all the original information of the image.

The goal of data compression is to represent the data in a way that reveals some redundancy. We may think of the color of each pixel as represented by a three dimensional vector (R, G, B) consisting of its red, green, and blue components. In a typical image, there is a significant amount of correlation between these components. For this reason, we will use a color space transform to produce a new vector whose components represent luminance, Y, and blue and red chrominance, C_b and C_r.

Digital images such as photographs are generally encoded as rows and columns of pixels (from picture elements). This type of image format is called a raster image. It has been found that, the more the pixels in each row and column, the better the resolution of the image. An image with 24 bits of color information for each pixel will generally look better than an image with only 16 bits of color information for each pixel.

\[
\begin{bmatrix}
Y \\
C_b \\
C_r
\end{bmatrix} =
\begin{bmatrix}
0.29900 & 0.58700 & 0.11400 \\
-0.16874 & -0.33126 & 0.50000 \\
0.50000 & -0.18469 & -0.08131
\end{bmatrix}
\begin{bmatrix}
R \\
G \\
B
\end{bmatrix}
\]

Experimental analysis of similar biomedical image sample data with various image compressions algorithms

A malaria parasite image obtained from center for disease control (CDC) website was compressed into five different image compression algorithms with extension .png, .bmp, .jpg, .tif and .gif. The objective of successful medical imaging technology is the ability to minimize image storage size in order to speed up image data transmission and reduce storage cost.

The experimental procedure for image compression algorithms test was done using this biomedical image tool and the results shows that, out of the five compression methods, all of them gave different computational results as shown in Table 3. It is good to note that .tif and .gif gave different similarity index score (0.012 and 3.26228) of the same image with expected

Figure 6: The multimodal pictorial design architecture of the biomedical tool
similarity index of zero. We can therefore conclude that the image compression algorithm has a direct correlation on storage size and image distortion level.

Table 2: Various Image compression comparison table

<table>
<thead>
<tr>
<th>Format</th>
<th>Extension</th>
<th>C or U</th>
<th>Lossy or Lossless</th>
<th>Geo-aware</th>
<th>Suitable for large image</th>
<th>Proprietary or open</th>
</tr>
</thead>
<tbody>
<tr>
<td>BBB</td>
<td>.bil, .bip, .bsq</td>
<td>U</td>
<td>Lossless</td>
<td>Yes</td>
<td>Yes</td>
<td>Open</td>
</tr>
<tr>
<td>GeoTIFF-raw</td>
<td>.tif</td>
<td>U</td>
<td>Lossless</td>
<td>Yes</td>
<td>Yes</td>
<td>Open</td>
</tr>
<tr>
<td>GeoTIFF-LZW</td>
<td>.tif</td>
<td>C</td>
<td>Lossless</td>
<td>Yes</td>
<td>Yes</td>
<td>Open</td>
</tr>
<tr>
<td>PNG</td>
<td>.png</td>
<td>C</td>
<td>Both</td>
<td>No</td>
<td>No</td>
<td>Open</td>
</tr>
<tr>
<td>GeoTIFF-jpeg</td>
<td>.tif</td>
<td>C</td>
<td>Lossy</td>
<td>Yes</td>
<td>Yes</td>
<td>Open</td>
</tr>
<tr>
<td>jpg</td>
<td>.jpg</td>
<td>C</td>
<td>Lossy</td>
<td>No</td>
<td>No</td>
<td>Open</td>
</tr>
</tbody>
</table>

U-Uncompressed  C-Compressed
Table 3: Image compression comparison score of similarity for image distortion level

<table>
<thead>
<tr>
<th>Specimen Name</th>
<th>Width (pixels)</th>
<th>Height (pixels)</th>
<th>Length (bytes)</th>
<th>Score (k-NN)</th>
<th>File size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compress.png</td>
<td>748</td>
<td>504</td>
<td>436164</td>
<td>0</td>
<td>426Kb</td>
</tr>
<tr>
<td>Compress.bmp</td>
<td>748</td>
<td>504</td>
<td>1131030</td>
<td>0</td>
<td>1105Kb</td>
</tr>
<tr>
<td>Compress.jpg</td>
<td>748</td>
<td>504</td>
<td>26553</td>
<td>0</td>
<td>26Kb</td>
</tr>
<tr>
<td>Compress.tif</td>
<td>748</td>
<td>504</td>
<td>701788</td>
<td>0.012</td>
<td>686Kb</td>
</tr>
<tr>
<td>Compress.gif</td>
<td>748</td>
<td>504</td>
<td>61326</td>
<td>3.26228</td>
<td>60Kb</td>
</tr>
</tbody>
</table>

Figure 8: The diagnostic imaging demand data types considered in the artificial intelligence

Automatic Biomedical Image analysis in a multi-distributed telecommunications environment design and outputs for efficient and effective

While physical examination notes and laboratory results are the main data sources, we point out that with image data with clinical notes contain large portions of unstructured narrative texts that are not directly analyzable. Consequently, any artificial intelligence applications focus on first converting the unstructured text to machine understandable electronic medical record (EMR). Karakülah et al used artificial intelligence technologies to extract phenotypic features from case reports to enhance the diagnosis accuracy of the congenital anomalies.

The diagnostic imaging shows a steady trend in the demand for biomedical image tools and technologies as shown in Figure 8. This study however did not go into the unstructured text feature extraction, but limited itself to similarity computation of biomedical images. There two schools of thought with regards to digital imagery studies. One is the machine learning (ML) techniques that analyses structured data, such as imaging. The second one is natural language processing (NLP) method, which extracts information from unstructured data such as clinical notes or medical journals to supplement and enrich structured medical data.

The application is accessible online once hosted with a user interface and the administrator consoles. After a health worker or user logs in, they will be able to navigate the diseases upload screens for specimen testing per Figures 9 and 10.

Once the upload is done, an SMS report will be delivered only to the registered health worker or user as shown in Figure 11. Figure 12, gives a summary report that can be spooled online from the biomedical tool directly via web page.

http://uonresearch.org/irs
Figure 9: Login Screen

Figure 10: Specimen uploading screen for Malaria specimens

Figure 11: SMS report relayed on registered mobile phone

Figure 12: Web interface report
CONCLUSION AND RECOMMENDATION

The world of telecommunications is becoming globally powerful such that, digital media innovation becomes a factor to poverty alleviation in the developing world. To fight rampant disease outbreaks affordably, early telediagnostics and detection therefore becomes the main objective of this research project. This biomedical imaging solution has the potential to save lives in areas where health experts are limited.

While meeting the objectives above, this study has demonstrated that faster diagnosis of ailments such as malaria, skin diseases, cholera, Tuberculosis, and others is possible. We are able to monitor and trend disease progression in cancer sample specimen. With faster internet access and mobile telephony, we intend to take this study further by integrating it with a portable digital microscopy on a portable mobile application (mobile app) for automatic telediagnostics exploration in mHealth. Further, research into solar energy power for the tool to enhance its mobility, accessibility and availability needs investigations.

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http://uonresearch.org/irs
Blockchain: Building Africa Block by Block

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Abstract
Blockchain is a decentralized, shared ledger of transactions maintained securely over a peer-to-peer network. The records stored are easily verifiable and immutable. Blockchain technology can be used to streamline any data centric system. This paper seeks to explore this emerging technology through a literature review and later propose various applications where the technology can be used – with a keen interest in the African space. With blockchain, innovators across the continent can rewrite the African narrative by creating novel solutions to problems and build a better tomorrow block by block.

Relevance to innovation. With a fresh look on existing challenges, the applications discussed in this paper present new conceptual ideas that innovators and other stakeholders can use to design and/or redesign their solutions. Blockchain technology can be leveraged by anyone since it is open-source and scalable. However, like any other emerging technology, there is a great need to set up policies, frameworks and regulations to ensure it is used ethically and for the greater good of society. Many governments and corporations are already working on such laws and policies and the technology will soon be stable and ready for mass adoption.

Key Words. Blockchain, Innovation in Africa, Smart contracts.

INTRODUCTION
There has been tremendous interest in the transformative power of Blockchain (Shackelford & Myers, 2017). A blockchain is simply a ledger of transactions that is maintained on a peer-to-peer network. This ledger is replicated on all nodes and is secured using cryptographic key hashing. All nodes agree on one sequence of blocks of transactions, usually the longest one, that is accepted as the true order of transactions.

Initial applications of the blockchain were concentrated in the Financial Technology (FinTech) world, with the most notable being the cryptocurrency Bitcoin (Crosby et al, 2015). However, innovators are looking beyond the financial world and are finding ways to use blockchain in solving everyday problems. Africa is ripe with numerous opportunities that can utilize blockchain technology to solve everyday problems. Blockchains are increasingly getting a massive interest from firms which are starting to see them as a potential driver of huge savings in infrastructure and back-office processes by eliminating inefficiencies (Cermeño, 2016; Iansiti & Lakhani, 2017).

There are still a large number of technical challenges prohibiting the wide application of blockchain: scalability (large block size would slow down the propagation speed and lead to blockchain branches), privacy leakage (blockchain cannot guarantee the transactional privacy since the values of all transactions and balances for each public key are publicly visible), and selfish mining (selfish miners keep their mined blocks without broadcasting and the private branch would be revealed to the public only if some requirements are satisfied) (Zheng et al., 2016).
Although blockchain technology is not yet ready for mass adoption, there is no doubt about its transformative power. This paper explores the blockchain technology and proposes potential application areas in Africa where blockchain can be used to streamline processes and service delivery. From quality health to smoother trading, blockchain has the potential to build Africa block by block.

LITERATURE REVIEW

The Blockchain Technology

A blockchain is a decentralized ledger of transactions that relies on a peer-to-peer network to create a trustworthy service for a network of nodes that do not fully trust each other (Cachin & Vukolić, 2017). The transactions recorded in the ledger are grouped together into blocks and are linked to each other using key hashes. The blocks are timestamped and therefore form an ordered chain – the blockchain.

There are four distinctive properties that generally characterize a blockchain: Decentralization, consensus, trust and immutability (Rhian, 2016). Decentralization is important because there is no single point of failure. A distributed system that is Byzantine fault-tolerant is more secure than a centralized system. With decentralization comes the need for consensus. Nodes must agree on one order of transactions. This is done by ensuring each node adopts the longest chain of blocks known to it. But how can nodes trust the longest chain to be the truest sequence of transactions? Measures are put in place to make sure that no one node dominates the network and adds multiple blocks to the chain. With decentralization, consensus and trust in place, immutability becomes very easy to achieve. Once a block is forged onto the chain, it is impossible to alter the transactions in it without creating an alternative chain that is longer. Creating a longer chain would involve creating multiple blocks consecutively which is impossible unless the malicious attacker owns 50% +1 of all nodes and/or computing power on the network (Nakamoto, 2008). In simple terms, malicious nodes are put on a race against trustworthy nodes and unless they control the network, the trustworthy nodes will always create more blocks and have a longer chain that must then be adopted by all nodes on the network.

Consensus Algorithms on the Blockchain

When new transactions are created, they go into a pool of unconfirmed transactions where they await validation before they are added to the blockchain. Nodes on the network then are either chosen randomly or compete to create the next block. There are different schemes used to determine which node gets to add a new block to the chain. The following are the most commonly used schemes:
Proof of Work - In this scheme, nodes on the network compete to solve mathematical puzzles by expending their CPU power (Nakamoto, 2008; Zheng et al., 2016). The winning node verifies transactions, creates a block and appends it to the chain. The difficulty of the puzzle is varied depending on how quickly nodes find solutions to ensure blocks are added to the chain averagely at the same time. One of the most famous blockchains that uses proof-of-work is the bitcoin blockchain. Here, the nodes compete to solve a hashing problem. The nodes scan for a value which when hashed, with say SHA-256, begins with a predetermined number of zeros (Nakamoto, 2008).

With such high demands of computing power, it is impossible to change a block without redoing the proof-of-work. This protects transactions from alterations by malicious nodes as they would have to expend a lot of computing power to redo the proof-of-work. The further back transactions fall in the chain, the more work malicious nodes must do to compute proof-of-work for all other blocks after it to create a longer chain than the truthful nodes securing transactions on the blockchain from alteration. The process of computing proof-of-work to add new blocks to the chain is referred to as mining on the bitcoin blockchain and in return for the CPU power used, miners get awarded bitcoins for each block added onto the chain. This scheme has however been criticized for its high computing power needs which in turn translate to very high energy consumption. It is therefore not sustainable for a fast-growing network of nodes.

Proof-of-Stake - Here, nodes need to prove their stake in the network to win the chance to validate transactions and create a new block (Gupta, 2017). The stake can be quantified in terms of a coin as is in the case of the PeerCoin and the proposed fork on the Ethereum blockchain. Creator of the next block is chosen through a combination of random selection, age and wealth. A combination of these three make it difficult for one node to append more than one block to the chain consecutively as it would be expensive. In this case, malicious nodes are also pitted in a race against truthful nodes and as blocks fall further back in the chain, they become harder to alter. The process of creating new blocks in this case is referred to as forging and may also attract incentives in terms of transaction fees depending on the configuration of the blockchain.

Critics, however, claim that this scheme might not keep away malicious attackers if the only expense is wealth. The attackers might have enough wealth to forge enough blocks to alter transactions. The chances of this can be significantly reduced with the introduction of random selection together with the stake as well as appointing nodes to validate blocks created.

Multi-signature - In this scheme, nodes validate transactions in the unconfirmed pool and cast a vote as to whether a transaction is valid or not. For a transaction to be deemed valid, it must receive a certain threshold of votes from nodes (Gupta, 2017). This implies that a malicious attacker must control nodes equal to the threshold to validate and invalid transaction.

Block-creating nodes - Here, certain nodes on the network are set aside as validating nodes. One node in this set is picked at random and can validate transactions and add them to the chain. The validating nodes are agreed upon by all nodes on the network. This scheme is used more in private blockchains where risk of malicious nodes is considerably lower than in public blockchains.

There are several types of blockchains. These include:

Public blockchains - Also referred to as permissionless blockchains, allow any person to join the network, download the software, run a public node, transact with other nodes and validate transactions on the blockchain (Cachin & Vukolić, 2017). The ledger is also public and anyone can view all confirmed transactions since its genesis.
(b) Federated blockchains - or permissioned blockchains are those that are run by a consortium of companies that determines who joins the network, who can transact as well as the nodes allowed to validate transactions on the blockchain (Cachin & Vukolić, 2017). The ledger of transaction may be available publicly with read-only access. This type of blockchain reduces transaction costs and data redundancies.

(c) Private blockchains - a type of permissioned blockchains that are solely owned by one company or organization for purposes of transacting amongst itself (Cachin & Vukolić, 2017). The company controls who can join, write and validate transactions on the blockchain. Read-only permissions may be granted to the public or according to the company’s discretion and policies. The data on this type of blockchain is open to security breaches as its centralized nature makes it an easy target for attackers.

**Smart Contracts**

Smart contracts may just be the most transformative addition to the blockchain technology (Iansiti & Lakhani, 2017). A smart contract is a self-executing and/or self-enforcing piece of code that represents a protocol that governs how a negotiation or performance of a transaction should be carried out and is stored on the blockchain (Gupta, 2017). The contract can be designed using If This Then That (IFTTT) rules to represent the logic surrounding a transaction. Smart contracts can be used to completely automate transactions in various industries such as travel insurance. The contract can be written and stored while it awaits certain conditions to be passed before it autonomously executes itself (Iansiti & Lakhani, 2017).

Smart contracts facilitate credible transactions that are trackable and irreversible without third parties. Advantages of smart contracts over conventional counterparts include reducing settlement time, minimizing risks, increasing transparency and reducing costs by removing third parties completely. Though a lot of discussion and policy-making is in progress to regulate this technology to encompass issues of law that affect it, smart contracts will without a doubt change how parties transact with each other over networks.
Issues Arising

The blockchain technology is still far from being ready for mass adoption, due to technological, operational, business and regulatory frameworks (Cermeno, 2016). As an emerging technology that is still in the exploratory phase, designers and developers have yet to fully grasp its capabilities and shortcoming to build stable and practical applications. Bitcoin, the most popular blockchain application, is riddled with a lot of controversy (Hurlburt, 2016). From fluctuating market value to being used in black market sales and fraud, bitcoin exposes issues that may affect future blockchain applications.

These issues have caused governments and other regulatory bodies to start finding ways to regulate activities carried out on blockchains. This may take a while since technology, by definition, is not object of regulation, but rather the different uses of the technology (Cermeno, 2016). This implies that until the uses of the blockchain technology are explored, it will be impossible to fully regulate and govern its use.

BLOCKCHAIN-POTENTIAL APPLICATIONS FOR AFRICA

Sustainable transformative applications are still a long way off but it makes sense to evaluate their possibilities now and invest in developing technology that can enable their fruition (Iansiti & Lakhani, 2017). The blockchain technology is prime to help create a true sharing economy (Rhian, 2017a). It enables users to transact over a network without the need for trust. This cuts off intermediaries and lowers the overall transaction costs. It also reduces the time taken to settle transactions from days to minutes. Blockchain applications such as Arcade City1 and Winding Tree2 are already disrupting the markets once dominated by their traditional counterparts Uber3 and AirBnB4 respectively. Any industry that relies on trust, consensus and immutability is ripe for disruption as more stakeholders continue to embrace blockchain applications (Rhian, 2016).

The African space presents many opportunities to streamline systems, innovate novel solutions to existing problems and improve service delivery and accountability. Below are some blockchain applications for various sectors in Africa.

Health

Blockchain can improve collaboration and data-handling in hospitals. Patient records can be kept on a permissioned/federated blockchain and shared with other hospitals. Read access can be restricted to only those medical practitioners who need to view the records. These records can be anything from bio-data to insurance details to diagnosis and prescriptions. Once a patient comes to a medical facility, the facility would only need to get the patients identification (probably a public key as is used currently) and all relevant information about the patient’s medical history will be readily available for the doctors and nurses to make informed speedy decisions. This can greatly reduce the time taken to attend to a new patient due to paperwork and bureaucracies.

There is also no limit to the functionality that can be appended to such a blockchain. Smart contracts can be used between the medical facilities and insurance companies to immediately settle medical bills. Patients can also willingly volunteer their medical information to get better insurance premiums from insurance companies. Doctors can append significant medical findings on the blockchain to be used by other doctors in other hospitals. The data on the blockchain can also be used for research purposes and data analytics as it is anonymous/pseudonymous.

Education

Blockchain can improve data openness and sharing in the education sector. Every student can be issued with a key and all their academic records stored on the blockchain. As students move from
one school to another, there will be no need for paper based transcripts or certificates to prove one’s academic history. These records can also be revealed to employers by generating a digital certificate that can be used in place of the education section of a cv. Schools can also append co-curriculum and extra curriculum achievements to the blockchain. Security features that come with the blockchain technology would come in handy in curbing fraudsters and be instrumental in identity management. The blockchain can also be permissioned or private to avoid just any person reading or appending to the chain.

Trade

There is a lot of ongoing discussions about creating a Pan-African currency. A cryptocurrency backed by governments would go a long way in easing trading activities in the continent. Just like any other coin, any person can run a node and transact with other nodes. Any nodes can also validate transactions and append blocks to the chain after being selected by any scheme such as proof-of-work, proof-of-stake, proof-of-burn etc. Having a common currency for trade on the continent would streamline inefficiencies brought about by banks, exchange rates between different currencies and fluctuation of these exchange rates. It would also cut down the time taken to settle transactions and in turn significantly boost trade amongst member states. A lot of regulations and policies would however have to be put in place to curb fraud and any other illegal trading activities that may come up due to the anonymity/pseudonymity of users. The currency may also need to be backed by real world valuable assets such as minerals to cushion it from experiencing volatile value.

Digital marketing

Digital marketing is the use of digital platforms such as mobile phones and the internet to advertise goods and services to users. Social media influencing is a type of digital marketing that has gained a lot of popularity over the past couple of years. This is where users with a big following on social media platforms are paid to influence buying patterns or attitudes of their followers towards a certain brand. The industry can benefit from blockchain to automate certain aspects of this process. Smart contracts can be used to access the level of influence each user has on each platform. This can then be used to compute a rate of payment for every post or discussion started by the user and even measure the reach of the post. After all this is done, payments can then be disbursed to the influencer according to the terms agreed upon with the brand.

The data on the blockchain can be used by brands to better assess various influencers during the selection period. Influencers can also use the statistics to build their portfolios and present them to brands. Any person can join the network and become an influencer regardless of how small their following is. Sometimes, brands might even choose more people with smaller followings as opposed to one person with a bigger following if the calculated impact per post for the former exceeds the latter. There also may be a need to create an incentive system to encourage users to stay on the network and validate transactions.

Agriculture

A combination of IoT and blockchain can be used to store useful information such as daily weather conditions, soil moisture and pH, nutrient composition, soil type as well as crops grown in various regions. This data can be sent directly by sensors which will acts as nodes on the networks. The data collected will over time be very instrumental in analyzing what crops do well in what regions and during what seasons. Governments can easily identify areas with arable land that can be cultivated, even under irrigation, to increase food production. It would also make it very easy to
experiment with new varieties of crops and keep track of yields. Strategic crop cultivation can quickly increase food production in Africa and gradually eradicate famine in the continent.

Blockchain can be used to create a peer-to-peer marketplace where farmers can directly sell their produce to willing and ready consumers. By cutting out intermediaries, the farmers will maximize on their profits and the buyers will get produce at reasonably cheaper prices. Farmers can also sell their grains to the government for mass storage to improve food security in countries. Land owners too can lease their unused land to willing farmers or the government. This will increase the acreage of land under cultivation and simultaneously improve the lives of farmers economically.

**Transport**

A tokenized transport system can streamline the transport industry. Governments can incentivize vehicle owners to transmit traffic data using location and speed sensors to a blockchain. This data can be analyzed using deep learning algorithms to efficiently control traffic at traffic light junctions without the need to invest in sensors or cameras or human labour at these junctions. In very busy cities, commuters can be incentivized to use public transport such as trains and buses to reasonably reduce traffic. Urban transport planning committees can also use data on the blockchain to properly allocate city-owned shuttles and trains to routes depending on demand by commuters. An efficient public transport system will reduce the number of people who will opt to drive themselves and this will in turn reduce traffic in major cities.

A blockchain application can also be used in the goods and courier delivery industry. Sellers and drivers/riders can quickly transact with each other without the need for courier companies. Drivers and riders can work for multiple clients without being tied down to one company. Any person with an item that needs to be delivered will just need to hail a driver or rider on the platform, select the delivery location and enter into a smart contract with the driver or rider. The contract will ensure the goods reach their destination before payments are disbursed to the drivers and riders. Clients can also publicly rate the riders and drivers to further cultivate a culture of trust. This will provide a more efficient and quicker transit of goods and in turn lower transit costs.

**Government Services**

Governments keep track of a lot of records. From citizens’ bio data to birth, marriage and death registrations to police records, a lot of data replication and redundancy is experience as various government bodies use separate databases. Moving to a blockchain based decentralized database can remove these inefficiencies and significantly reduce the time taken to process user requests for certain services. These government bodies can join a federated blockchain and populate all necessary data that will be shared. Every police station, for instance, should be able to append new offenders and their details to the blockchain.

Similarly, transport authorities should be able to quickly append details of new drivers issued with licenses and those with traffic offences. A user would no longer have to spend hours lining up to apply for an identification card or wait for weeks on end to receive a police clearance certificate. All a user would have to do is raise a request online, say for a police clearance certificate, and wait for the relevant body to do a quick scan of data on the blockchain and return the certificate. The changeover from the current systems to such a system would however take a while considering the amount of data that would have to be converted as well as formulating policies on data privacy. However, once a blockchain system is operational, record keeping and identity management will become more efficient and service delivery will be significantly improved.
Crowdfunding and Investments

Initial Coin Offerings (ICOs) have revolutionized the crowdfunding and investment space. Basically, a startup creates a coin or token embedded on a public blockchain, such as the Ethereum blockchain, and makes it available for sale to the public. During the sale, investors who believe in the business idea and future of the startup exchange fiat currencies or popular cryptocurrencies such as bitcoin and Ethereum for the company’s coins. The coin or token can be used by the startup to represent a right of ownership or royalties to the project and can even be used to represent shares of the company. The coin can also be used solely as a currency which investors can use to obtain a product or service in the future.

Like any other investment, the value of the coin can appreciate or depreciate with time depending on whether the business is successful or not. The startup scene in Africa is ripe with innovation but struggling with funding. ICOs can be used to present these great innovations to the world and attract the needed capital from investors across the globe without the need to meet and physically pitch ideas.

Environmental Conservation

Coupled with the tokenized transport system suggested above, commuters can be encouraged to be environmentally conscious with their choices of commute. Persons who opt to cycle instead of drive can be given free parking or free tokens that they can redeem to pay for regular parking or bus fare in their next commute. Car owners who opt to buy electric or hybrid cars with lower carbon emissions can be incentivized with lower taxes at the port. These small steps can help create a people that are more intentional with their decisions especially when they involve the environment.

Manufacturing companies can also be required to populate their carbon emissions and means used to handle their waste on a public blockchain. This information can then be validated by environmental bodies and be made available to the public. Periodical reports can be produced showing the companies doing their best to conserve the environment. Such information will then influence buying habits of the consumers once they are aware just how much a company has regard or disregard for the environment. This influence on buying habits will force manufacturing industries to continually put effort in cutting down pollution and create a culture of environmental conservation.

Procurement and Supply Chain

The procurement process and supply chain is a complex system that generally involves a lot of industry players and paperwork. This can slow down the process of product development and delivery. A blockchain based supply chain system can significantly smoothen this process. Documents such as quotations, tenders, invoices and receipts can be generated and stored permanently on the blockchain for book-keeping. Payments and delivery of goods can be automated using smart contracts that can also be stored on the blockchain. A product’s history can be documented right from the procurement of raw materials down to the stocking of the product at a retail store. This can make it easier for companies to pinpoint steps in the supply chain that need improvement to achieve cost effectiveness.

In case a poor-quality product is spotted, the company can trace its history and find out what went wrong and correct it. Auditing of financial records of such a company will also be easier as relevant documents such as tenders and receipts are stored permanently on the blockchain and cannot be altered by any party. This will improve the overall Quality of Service of goods and services that flow through the supply chain pipeline.
CONCLUSION

The blockchain technology will disrupt many industries as it presents more secure and efficient ways to share, transact, audit and lower overall costs of doing business. It may take years to transform these businesses, but the journey begins now (Iansiti & Lakhani, 2017). The technology goes beyond cryptocurrencies and can be implemented for any application that can benefit from or relies on decentralization, consensus, trust and immutability. This paper seeks to explore the blockchain technology and present possible applications of the technology in various sectors of the economy in the African space.

Though the list is not exhaustive, the adoption of this technology may take a while as companies and governments are still trying to fully understand it and create necessary laws, legislations and policies to govern its use. As the technology matures however, risks associated with it will be lowered significantly and the adoption rate will increase. Indeed, the blockchain technology has the capacity to completely revolutionize the world and how we do business. Blockchain can build Africa, block by block.

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Innovations for a Better Tomorrow:
Human-Wildlife Interface in Kenya

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Abstract

Since the days of human civilization on earth, man has always cohabited with wildlife. However with the growth of both human and animal population, limited land and water resources and climate change related challenges, human-wildlife conflicts have escalated. This research will discuss the new solutions towards mitigating human-wildlife conflicts at interface spaces in Kenya, analyse the present compensation schemes, and especially their shortcomings regarding transparency and effectiveness and suggestions of incorporating private sector insurance firms, enhanced adoption of modern technology including geographical position and wildlife tagging.

Relevance to innovation. This approach is exploratory as it would be the first time Kenya and the innovative product would bring on board many stakeholders while at the same time enhance socio-economic benefits including jobs and retain sustainable wildlife numbers. The research uses both quantitative and qualitative methodology and innovative tools to model ecosystem utilisation and human activities along the interface. This innovation will solve human-wildlife conflicts in the Laikipia County, Kenya, cause communities to be tolerant to the wildlife and may be replicated in wildlife management.

Key Words. Communities, compensation, ecosystems utilisation, insurance of human activities, human-wildlife conflicts

INTRODUCTION

Kenya’s National Parks, National Reserves and Conservancies, about 58 of them, have been casualties and witnesses to human-wildlife conflict (HWC), a phenomenon sometimes referred to Human Wildlife Interface (HWI). Whatever it is known by, it represents a conflictual situation to which an immediate solution is of great interest locally, nationally and globally because the biodiversity resources is dwindling (Fjeldsa and Burgess, 2008; Global Biodiversity Forum (GBF), 2004) and may even become extinct. Conflict defines a condition in which opinions, values and views are considered but remains contradictory or incompatible (McNamara, 2007). In this regard, the needs and behavior of the wildlife impact negatively on the socio-economic goals of humans or vice versa (International Union of Conservation of Nature [IUCN], 2003). This research innovation is grounded on the fact that HWC is a human conflict in wildlife areas because humans are able to make choices regarding whatever they may want to do and where to do it. The painful fact relating to destruction, loss of life or property and interference with rights of individuals or groups are attributable directly or indirectly to wild animals in areas considered to
be interfaces or areas adjacent to wildlife sanctuaries, determined by humans and choreographed in time by climate and spaces. This research innovation shall examine human conflict in and adjacent to wildlife areas in time, seasons and spaces.

Cases of HWC are on the rise in terms of frequency and magnitude of loss; and these cases have been witnessed both inside and outside protected areas and conservancies. Although protected areas and conservancies are managed through legal or policy framework (GoK, 2013), a timely global solution is needed to curb extinction of wildlife through technologically proven in-situ conservation and widening space for diversification of the economy in the face of rapid and volatile socio-economic changes and growing ethnic and clan conflicts. Past models of diversification include Community Based Natural Resources Management (CBNRM) (Berkes, 2004) programmes adopted in the early 1990s, establishment of conservancies, designation of wildlife corridors through the establishment of community or group ranches and improved wildlife management. In spite of these efforts, significant increase of incidences of human-wildlife conflict result from, partly increase in human population, that tends to lead to land fragmentation, competition for pasture and water; infrastructural development; climate change, poverty and weak law enforcement on poaching amongst many others (Scholte, 2011; Maisels, et. al., 2013; Ogutu et. al., 2016). The Wildlife Management and Conservation Act (2013) is very specific on the issue of compensation for every life lost, crop damages, snake bites and any injuries caused by wildlife (GoK, 2013) and a total of KSh 4.83 billion was spent to compensate victims of human-wildlife conflict between 2013 and April 2016 by KWS (Mutai, 2016). KWS approaches, methods and effectiveness of dealing with compensation to the local people not transparent and tedious.

**PROBLEM STATEMENT**

Wildlife plays a major role in Kenya’s economy. It is a major tourist attraction, accounting for over 12% of the Gross Domestic Product (GDP) and provides more than 300,000 jobs. Wildlife numbers has increased in spite of the dominance of pastoralism in Laikipia County. However frequent droughts and political and negative ethnicity (Mwamidi et. al., 2012; Mathenge and Chepkwony, 2016) have increased the number of HWC to escalate throughout the county. Bordering the Aberdares Mountains to the west and Mount Kenya to the south-east, Laikipia County has the third largest area under conservation of mammals. HWC especially by elephants, hyenas and baboons (herbivores) and lions and leopards as carnivores is on the rise. The wildlife damages include killing of livestock, infrastructural damage, human casualties and crop damage (Hemson et. al., 2009; Frank, 2011; Hazzah et. al., 2014). Over the years the numbers of conflicts have increased and so have compensation costs majorly because there is no efficient, timely and verifiable reporting mechanism. The innovation research proposes tools that will increase efficient and effective monitoring of conflict areas, seasonal utilisation of the ecosystem and timely and verifiable rates of compensation.

The HWC may be escalated by changing lifestyles and production systems of the local population in Laikipia County (Blair and Meredith, 2017). The area population of Kikuyus, Pokot and Samburu have different production systems, land use preferences, cultural practices including cattle raids, legacies of colonial history and power relations as documented in the grey literature showing claims and counter claims between the local leaders and civil society organizations. Reports by Kenya Wildlife Service (KWS) on HWC demonstrate unharmonious relations with the local population. Presently there is no singular and agreed modality of reporting, verification of facts and arbitration mechanism to resolve the conflict amongst stakeholders in spite compensation issues being spelt out in law (GoK, 2013). The innovation research will investigate, document and locate the possible ways not only to track wildlife movements but also to identify human activities close to the park boundaries that are vulnerable to wildlife damage.

The human interface between reporting, compensation determination and payment involves
many intermediaries (County Wildlife Conservation and Compensation Committee) thus opening the process to abuse and corruption. The innovative research will identify mechanisms for identification of individuals, transmission of compensation payments and connecting stakeholders to an insurance firms. Baseline information on the number of people living in a boma (home), the number of livestock and land in terms of hectares and the approximate value of crops grown in their land area will be taken into account. The risk factor for insurance premium will depend on distance away from the protected area (conservancy), KWS response in the previous incidence and wildlife tracking systems. Furthermore KWS having the knowledge of the entire ecosystem will be able to determine the location of wildlife at that specific time of the season thus pre-empt clashes between people, livestock and wildlife.

Examining the past land use change, climate change scenarios, growth of population, the human-wildlife tension in Laikipia will escalate and therefore begs the following questions:

(a) What are the land use, population and wildlife population scenarios in Laikipia County?
(b) To what extent is the HWC threatening biodiversity conservation in Laikipia?
(c) Has the government addressed the HWC issue by efficient and accurate reporting of wildlife problems?
(d) Can compensation issues be addressed through alternative dispute resolution methods such as engaging the insurance companies, community compensation methods, etc?
(e) To what extent can wildlife tracking systems and ecosystem or conservation area management plans assist in detecting areas of conflicts?
(f) What alternative methods should be used to reduce or end the human-wildlife conflicts in Laikipia?
(g) Can these methods be replicated in other conservation areas in Kenya?

COMPENSATION RESULTING FROM WILDLIFE DAMAGE

Based on global, national and local best practices, compensation for wildlife damage has proved to have mixed results (De Klem, 1996; Mishra et. al., 2003) and is still debatable due to it being inefficient, expensive and in many cases full of corrupt practices (Bauer et. al., 2017). Compensation schemes include various funding sources from governments, enhanced donor funds, community, private or combinations of the above examples. The schemes target farmers whose crops or livestock are damaged or killed by wildlife. Europe has had compensation schemes and many of these schemes are government funded. In Europe examples of well managed and existing compensation schemes are found in Germany, Finland, Belgium, Sweden, Spain, France and Italy. The common predator species covered under these schemes are for birds of prey, wolves and bears. Their main source of funding is the national or regional government and in some countries like Germany and Belgium the hunting tenants are also included (Morrison et. al., 2009). On the other hand, government funded schemes are few in the developing countries and most of them have been unsuccessful (Morrison et. al., 2009). However there are few which have started under the initiatives of Non Governmental Organizations (NGOs), private sector and community initiatives.

In developing countries especially those in the tropics, wildlife is actually a boon if well preserved as it is amongst the main boosters of foreign exchange. For example in Kenya tourism is the second largest earner after agriculture and the backbone of the economy in Botswana and Namibia. With the help of the NGOs and private sector, the countries are continuously trying to bring in new compensation mechanisms so as to conserve wildlife, sustain livelihoods and make communities live in tolerance and harmony with the wildlife. For example in Turkmenistan, the World Wildlife Fund (WWF) and local ranchers have been providing compensation by replacing stock from a group stock to ranchers who lose livestock to Central Asian Leopards. Under this scheme in case of any loss, the ranchers are compensated through the Kara Kala Ranchers Society.
The rancher is compensated only if the rancher took managerial care of livestock including setting up of a good boma (Lukarevsky, 2003).

In Africa, Namibia’s example is very convincing though on a small scale and involving only conservancies. An insurance scheme has been initiated by an NGO called the Integrated Rural Development and Natural Conservation (IRDNC) and it works very closely with the Namibian Government. The aim of this scheme is to increase tolerance by communities on wildlife; increase education amongst farmers on stock and crop management; improve management strategies to mitigate problems and promote equitable distribution of benefits from wildlife income. Under this scheme staff are trained and tracking wildlife is done through the efficient monitoring systems of commonly so-called problematic species which are elephants, crocodiles, hippopotamus, buffalos and rhinos. It compensates livestock raiding, crop destruction, human injuries and deaths. The scheme has a Memorandum of Understanding (MoU) between the communities, conservancies, NGO and the Ministry of Wildlife and Tourism as the Government stakeholder. However reporting of any incidence must be done within three days, community rangers will immediately check on the report and visit the affected area and do a report. The affected member fills a form and attaches documentation which is then sent for verification to the traditional committee and conservancy committee where the form is reviewed by the NGO and Government and finally the compensation is paid. Each farmer on joining the scheme is supposed to declare his crop wealth in terms of crop acreage and livestock. However with seasonal changes, his declaration also changes for records and incase of any conflict. Furthermore, the payment is also determined on whether the farmer took precautions including not planting/grazing within wildlife corridors, protected areas or wildlife limits of conservancies; livestock not out at night; type of boma and fencing amongst other measures (Namibia’s Communal Conservancies Tourism Sector (NACSO), 2013; Bowen-Jones, 2012).

In Kenya KWS is the lead body which is in-charge of all the wildlife within and outside the protected areas (Shah, 2016). According to the Wildlife Management and Conservation Act (GoK, 2013), KWS is mandated to pay compensation on any wildlife issues. The Predator Compensation Fund (PCF) which started in 2003 in the Mbirikani Group and Ogulului Group Ranches around the Amboseli Tsavo ecosystem is an example. The scheme is run under the Maasailand Preservation Trust and their aim is to protect the endangered lions, hyenas, leopards, cheetahs and wild dogs; reduce conflict and retaliation with tolerance and cohabitation and bring in benefits of living with wildlife (Maclennan et. al., 2009). Accompanying the compensation scheme, the pastoralists are trained on how to protect livestock through predator proof bomas, not to venture in wildlife zones, alerted on wildlife movements regularly, provided with conservation and ecotourism education as well as benefit sharing through ecotourism. Overall the PCF has been a success except conflict reports increase during droughts (Bauer et. al., 2017) to which the present innovation is meant to tackle.

**METHODOLOGY**

The basis of this innovation is to develop a tool or combination of tools that will assist tracking of wildlife, put corrective measures before damage and or afford insurance firms a mechanism of computing damage insurance according to agreed premiums in Kenya. The specific goals of the innovative research are to:

(a) Determine the seasonal status of the ecosystem,
(b) Determine habitat utilization,
(c) Assess wildlife population demographics, and
(d) Provide data for decision making for wildlife - human damage in Kenya

WWF-Kenya in collaboration with KWS has been able to use technology for tracking wildlife such as rhinos for some time. Equipments and instruments to be used will include Telemetry
equipment, Global Positioning System (GPS)/Global System for Mobile Communications (GSM), Radio Tag-14 (or its equivalent), traditional animal tracking technology, and Thermal Imager Cameras.

Data collection tools will include Key Informer interviews, questionnaires, focus group discussions, video clips, photographs and will complement data from other sources.

The ecosystem will be defined by the conservancy or collaborating conservancies in Laikipia County. The ecosystem consists of vegetation, water resources, and animals identified as of interest. The first method will involve direct observation. The target animals will be lions, leopards, elephants buffaloes, rhino and wild dogs. The status of the ecosystem will be monitored using Remote Sensing. Environmental parameters such as the seasonal weather (rainfall, temperature, humidity, etc) stations will be sited within the ecosystem. The weather will provide research data to be used in calibrating the remote sensed data thus depicting seasonality. GPS will be used to locate specific features or landmarks to assist in positioning the movement of the wildlife.

The herbivores will be dependent on vegetation cover and water sources while the carnivores will be directly dependent on distribution and density of the animals (prey). Maps showing goals (a), (b), and (c) will be developed to organize spatial data. From these data ecological indicators that are able to depict wildlife movement will be presented. Away from the conservancies, satellite images of land use and human activities adjacent to the conservancies will be analyzed to assist insurance firms in making financial decisions.

Remotely sensed data will be analyzed to make it available in a form suitable for use by the insurance firms for decision making. Global Information Systems (GPS) and statistical and spatial tools will be used to organize data. Based on the land use-climate change scenarios, seasonal and long-term ecosystem management plans, a computer model will be built to effectively track wildlife types that cause damage and a damage reporting mechanism, and a compensation scheme. The model will be tracked by the KWS, Laikipia Wildlife Forum (LWF) and selected not-for-profit organizations in the area. The insurance companies will be involved in providing risk insurance to communities who will be affected by HWC to eliminate delay, build trust and develop a positive attitude towards wildlife conservation in the county. Complete with monitoring indices, the model will offer the best solution for resolving HWC. Not the level of damage will be reduced but reporting to KWS, LWF, insurance companies and the conservancies for compensation purposes will be transparent and cost effective by eliminating on the spot checks by conservation rangers. The contribution of this innovative research to resolve human-wildlife conflict is one of the greatest scientific infrastructures in resolving human-wildlife issues.

**CONCLUSION**

The innovation will highlight the land use, population and wildlife population in Laikipia County in conservancies and adjacent areas near the parks, conservancies, amongst many. It will also lead to the examination of wildlife compensation laws, rules and guidelines and identification of wildlife tracking systems, status of ecosystem and conservation area management plans and sustainable methods of reducing human-wildlife conflicts. The research will finally lead to a solution in terms of developing an economic model for protected areas and lead to the development of an App to solve and compensate human-wildlife issues in a sustainable manner.

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Product-Service Systems Design for E-Waste Management: A Case Study of Waste Electrical and Electronic Equipment Centre in Nairobi County

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Abstract

This paper develops a product service system for e-waste management in Nairobi County. Due to improper management system for e-waste and policies, informal recycling procedures are used which poses unpleasant health and environmental effects. Evaluation and establishment of efficient integrated e-waste management system was critical. From the case study, there were existing gaps in collection, transportation, financing, producer responsibility, consumer awareness, stakeholder collaboration and in lack of e-waste flow monitoring policies. The System developed advocates for a shift from provision of products to provision of systems of products and services collectively with stakeholders’ collaboration towards for efficient e-waste management.

Relevance to innovation. This paper presents an innovation of an e-waste management system, which is based on the product, services approach. The system encourages transition from selling electronics (which gives room to -pay as you throw- method, leading to informal e-waste management) to dematerialization which involves selling services rendered by electronics to satisfy consumer demands. Using this system, no e-waste is handled by consumers after the end of life of electronics therefore a reduced amount of the e-waste landing on landfills. The designer’s role consisted of putting together customer’s, provider’s and policy makers into the design of the Product-Service Systems.

Key Words. Electrical and electronics equipments, end of Life, E-waste, product-service systems, system design.

INTRODUCTION

Globally, among all other streams of waste, e-waste has surfaced to be one of the hastily growing streams. The production of large quantities of e-waste has resulted due to the increased consumption of electronic products. This is an outcome of technological product obsolescence because of the global rapid economic development. Arguably, e-waste poses one of the greatest environmental challenges regionally as it is estimated that 3000 tons of e-waste from electronic devices are generated yearly in Kenya. This is directly linked to increased importation of sub-standard or poor quality equipment in the country despite deployment of the Basel and Bamako conventions that controls the trans-boundary movement of harmful wastes. Due to improper management system for e-waste, informal recycling procedures are still been used such as dumping
and open air burning regardless of the fact that Nairobi undertakes formal e-waste recycling practices. This possesses unpleasant effects on the people’s health especially those living near these disposal areas not forgetting the environment. Due to these potential hazards, evaluation and establishment of efficient integrated e-waste management system was critical. Unfortunately, in Kenya, there is inefficient management system to address how to collect, transport, treat, safely dispose and monitor of electronics waste flows (Waema & Muriuki, 2008). Furthermore, due to unproductive waste management system, stakeholders do not take up their responsibilities in regard to e-waste disposal. This study endeavored to develop a product service system for e-waste management in Nairobi County.

The objectives of this study were:

(a) To determine the influence of existing systems of e-waste management on management of electronic waste in Nairobi county.

(b) To identify the sustainability priorities for the current e-waste management system in Nairobi County.

(c) To develop a service oriented system for e-waste management in Nairobi County.

According to ABED,(2006) in regard to customers preferences, e-waste Product-Service System signifies a transformed system enticing purchasing services and system solutions rather than purchasing products, which is likely to reduce the consumer needs and wants ecological impacts. These systems imply a top level of accountability for producer and service providers. Product-Service Systems may at times involve transfers of owner’s property rights for both consumers and producers. The principal objective of Product-Service Systems is to lessen ecological impacts posed by means of using electronic items. These systems also allow the achievement of sustainability by providing a variety of social and economical benefits for business propositions (Sousa & Miguel, 2015). According to Adrodegari et al. (2015), Product-Service System can be defined into five configurations categories: ownership and service oriented as shown in Figure 1.

In ownership-oriented type of Product-Service System, services act as add-on to the products, which are the major source sales returns. One can sell the services without a contract or agreement or they may use an approach of maintenance contracts. In service-oriented types of Product-Service System, the main source of returns is the services that are firmly connected to the product to be used, and a customer is not given the chance to own a product. The various manufacturers and distributors are able to provide product-service systems for electronics, which promote selling of use of electronics rather than selling the electronics themselves for consumer ownership. It is no longer the ‘product’ that is the result, but rather the solutions. This context requires designing products that meet engineering requirements while simultaneously providing greater value for the customers, considering the new ownership structure of a Product-Service System. Hence, developing a Product-Service System is not merely a matter of choosing the best technical
solution but is rather about finding the best combination of products and services to maximize stakeholders’ and customers’ value.

Switzerland is majorly known as the pioneer country to design and implement a product–oriented e-waste management scheme that is formal and well-organized entailing collection to disposal of e-waste materials (Wath et al., 2010). The Swiss system works under a recycling fee that based on products. To ensure that there is enough funds for running the system, an Advance Recycling Fee is gathered from all buyers as they purchase fresh electronics. This fee funds operations of the whole system, as the manufacturers incur the full implementation responsibility and operating e-waste from all brands in the Waste Electrical and Electronic Equipment Centre field (Widmer et al. 2005). In addition, the fee equals to the differences between entire system cost and sum of e-waste value recovered. In this system operation, there is no consumer responsibility, hence a reduced amount of waste that ends up in the landfills as shown in Figure 2.

METHODS

A case study based approach was adopted for this research whereby the researcher collected data at Waste Electrical and Electronic Equipment Centre which is located in Mihango, Embakasi, off the Eastern By-pass in Nairobi, Kenya. This center mainly recycles e-waste together with offering collection of e-waste services, dismantling and processing services that are automated in Nairobi and other numerous key Kenyan cities. Waste Electrical and Electronic Equipment Centre mainly gets e-waste from the public, private sector, and domestic sector using collection campaigns.

This study relied on mixed method design for data collection and for comprehensive data analysis. Strategy of enquiry was convergent parallel mixed methods where both qualitative and quantitative data were merged by the researcher so that the research problem is provided in a comprehensive analysis (Creswell, 2014). Quantitative data was obtained from numeric description from opinions, attitudes and trends of the key informants such as private consumers, Hewlett Packard and Waste Electrical And Electronic Equipment Centre on the use of a product-service system for e-waste management through structured questionnaires and interviews. Further, qualitative data was obtained from the case study in which the researcher developed an in-depth
analysis of a case using in-depth unstructured interviews, observation and desktop study to provide comprehensive information. According to Waema & Muriuki (2008), the e-waste ‘universe’ in Kenya consists of stakeholders such as distributors, assemblers, retailers, consumers, refurbishes, recyclers and final waste disposers to policy-makers. Thus, the target population of this study was Waste Electrical and Electronic Equipment Centre (encompasses recyclers, refurbishers), Hewlett Packard a cooperate consumer and private consumers that bring their e-waste to Waste Electrical and Electronic Equipment Centre.

Purposive sampling was utilized to select key informants that included the managerial, recycling department, refurbishing and education department at Waste Electrical and Electronic Equipment Centre and Hewlett Packard who are crucial in explaining the e-waste phenomenon in Nairobi County. Simple random sampling was used to select respondents from private and corporate consumers who frequently deliver e-waste at Waste Electrical and Electronic Equipment Centre. For the convenience of data analysis and discussion the sample size for the study consisted of four respondents from the organizations’ departments and one producer. From the organizations database, there were 30 frequent private and corporate consumers. Only 10 consumers were randomly selected hence, the total number of respondents was 15. Both qualitative and quantitative approaches were used for data collection. The instruments for data collection were first pre-tested (piloting) and readjusted to ensure accurate capturing of the required data.

Mainly, the study was qualitative involving utilizing interviews with the use of a set of confidential unstructured interview schedules for the key informants. This allowed much greater freedom to seek clarification, in case of need, allowed development of supplementary questions or omission of certain questions that might have been tackled or solved from the subject’s reaction. The researcher conducted site visits at Waste Electrical and Electronic Equipment Centre, and Hewlett Packard distributors and carried out face-to-face interviews so as to better understand the existing situations together with assessing the quality of the work done as well as the processes used. All responses were written down for later analysis. Observation was done to inform or show type of e-waste delivered in Waste Electrical and Electronic Equipment Centre and how it was handled. As one of the core data collection methods, the study used observation to directly seek and obtain information from the subjects in the case study without necessarily seeking their responses. To collect and keep records of the observed data, the study used digital cameras to gather and store observed data for later examination. The secondary data was obtained from the previous documented information about National Environment Management Authority and Waste Electrical and Electronic Equipment Centre in Kenya to get more information on how they handle their e-waste management in Nairobi County.

Data Analysis and Management

Quantitative Method - Data collected was analyzed using descriptive statistics whereby all numerical information gathered in the field was analyzed using rankings, percentages, and frequencies. Data results were presented in tables and figures for interpretation.

Qualitative Method - All data collected using qualitative methods such as key informant interviews and questionnaires in this study was sorted and arranged into themes and descriptions which was represented in a qualitative narrative to convey the findings of the analysis. An interpretation of the data was done which aided in designing the product service system for e-waste management.

RESULTS

The interviews from case study departments and producer were answered together with those of the two corporate consumers collaborating with the case study. Out of the projected private
consumers 75% answered questionnaires. All informants agreed to having at least some end of life electronics in their houses whereby 20% claimed that they kept them as souvenirs, 60% did not know where to take it and 20% for future use. Respondents who would rent electronics but on condition that data protection was provided as it is cheaper to source were 60%. On the question about disposal, 80% of the informants agreed to have discarded their e-waste at one point through the pay as you throw mechanism to the solid waste collectors. All informants thought it would be important for National Environment Management Authority to ensure that e-waste is managed in the appropriate manner in the country.

From the case study which is NEMA licensed, one respondent pointed out that the organization gets e-waste such as medical equipments, household equipment and office equipments from several private and cooperate consumers at a fee. Unfortunately, it was reported that the capacity of the organization to deal with e-waste was 350 tons per year but only about, 200-250 tones are received annually. It was also reported that a number of consumers did not understand why they have to pay to have their e-waste recycled. Some public organizations and institutions do not to pay this fee according to the responses given. On the question on the type the e-waste processes the company undertakes a respondent reported the they dismantle, separate, shred, refurbish and export harmful materials for further recycling for ecological preservation. In the process raw materials, such as plastics and metals are recovered and sold to small companies for making items such as recycled plastic posts. In social sustainability questions, it was responded that the company train their workers for a period of one year, which gives the workers skills therefore improving their lives. From the refurbishing sector, the organization also donates electronics after data wiping and maintains electronics at a fee.

On a question about the key obstacles facing appropriate e-waste collection it was reported by one respondent that currently there is no legal framework in Kenya for e-waste management and also that the 2006 Act e-waste is not categorized alone but under hazardous waste. In addition, it was mentioned that there has been a proposed draft e-waste bill 2013 pending in parliament. It was also reported that management of e-waste was expensive therefore; no other formal companies have ventured into it. Besides these, many people lack awareness on e-waste management. Lastly, most of the original electronics and electrical equipment manufacturers were said to be irresponsible for their end of life products despite the existence of the extended producer responsibility. The respondent recommended that the government should enforce the producer responsibility for appropriate e-waste management. From the response therefore it is noted that a system or framework and policy should be developed to aid in managing e-waste. Additionally the pending e-waste bill should be passed into a law so that manufacturers can take responsibility of their e-waste seriously. Creating awareness to consumers about e-waste management is also seen also a major input in managing e-waste in the country. The distributor respondent reported that they had little quantities of e-waste collected from consumers since most consumers believe that they should be paid for bringing back their end of life products. On the question of whether they would rent products to consumers the respondents thought it would be a good idea as the demand would go high due to the low prices. The only concern was that some consumers might not bring back product after getting the services.

Desktop data on NEMA, which is a governmental representative whose main objective entails ensuring universal conformity and implementation of environment policies as well as making standards and laws to prosecute offenders who violate the prescribed provisions, showed that they proposed a 2013 Bill. In this bill, it is proposed that producers intending to bring in new or second-hand electrical and electronic equipment into Kenya will be required to apply for registration from the authority. In addition, every producer will only obtain an annual compliance certificate upon declaring the previous year’s weight of electrical and electronic equipment introduced in the market by product type and production of a valid contractual agreement with a licensed treatment facility. Lastly, every producer shall ensure that e-waste returned under individual take-back schemes, is not disposed of at municipal disposal site/facility. Recyclers will be required to ensure...
that e-waste is dismantled in a safe manner for the environment by establishing infrastructure
that allows recycling that is environmentally friendly and technologies that are sound (NEMA,
2013). The bill also outlines that, refurbishers shall ensure that the resultant e-waste is transferred
to a collection centre or to licensed recyclers and that very person involved in the repair or
refurbishment of electrical and electronic equipment shall ensure that the e-waste is recycled in a
facility licensed by the Authority (NEMA, 2013).

DISCUSSION

Methodological Concerns in Designing Product-service Systems

From the data collected from the case study and stakeholders, we propose a product -service
system design as the best method to help solve the e-waste management challenge in the country.
This system is based on a shift from selling electronics to provision of a unit of satisfaction to
consumers, stakeholder collaboration, and access to services rather than ownership of electronics
as shown in the figure 3. The Product-Service System design for e-waste management was based
on the following approaches-: Stakeholder configuration approach, which mainly is based on the
interaction of stakeholders in the system, satisfaction approach which is related to satisfying
consumer demands in relation to products and services. Lastly, the sustainability approach which
relates to economical, social and economical beneficial solutions.

Interaction of Stakeholders in the System

An field exploratory study by Schluep et al. (2008) indicated that the waste e-waste re-processing
systems are typically based on existing collaborative network amongst the manufactures, traders,
recyclers and consumers. Each key player in the scheme is tasked to provide value addition,
job creation at every point of processing chain in which in turn is also the cascade of activities
involved in the reuse, recycling and disposal of e-waste. Using the SDO Toolkit shown Figure 4,
a concept-profiling map involving di

From Figure 4, consumers are to rent large electronics from producers and pay for them for
the use. The consumers are required to return the electronics to the manufacturers or distributors
after use. For the existing electronics and small equipments the consumer will purchase them
from consumers but with an additional advance recycling fee.

After the end of life of these products, the consumer will be required to take them freely
to the manufacturers take back collection points similarly to the Switzerland e-waste collection
system that mainly relies on extended producer responsibility. This fee will be used to finance
the whole e-waste management process, which includes, collection, transport of e-waste, recycling
and training. The informal sector participants can get employment from the different take back
collection centres. The manufacturers and distributors will be responsible for taking this e-waste
to recycling and refurbishing centres at a fee. Raw materials recovered from the system will be
sold other to make new products.
Satisfaction and Sustainable Approaches for Product-Service System for e-Waste Management

In this system manufacturers will offer large electronics to consumers on rental terms rather than selling them. This lessens the initial purchase fees, which was originally too high, therefore electronics can be accessed more easily by all consumers through selling the "unit of satisfaction" rather than the electronic. Simultaneously, it is anticipated that advertising the new services or adopting alternative products and substitute systems of product-service utilization can assist in new job creation. Additionally, employment opportunities may be created through labour-services such as information services on design, collection systems, take back systems, repair, refurbishment and disassembly offer support training and, process of installation repair, maintenance together with treatment of their End-of-life components. (Elia & Gnoni, 2015). On the other hand, consumers gain from a product-service system by obtaining a greater variety of options of electronics in the market; various payment schemes; repair services and the vision of diverse systems of electronic utilization which are suitable to them on basis of possession responsibilities. In that consumers are free from the responsibility of an electronic; this is absolutely under the ownership of the producer in its whole life span.

Through Product-Service System, buyers can learn more on ecological properties of electronics as well as how they can contribute to reduce the environmental effects arising from electronic consumption. Product-Service System ‘s have the potential to reduce the sum of products by the introduction of substitutes of product use such as pooling, sharing or leasing to end-users, without affecting the product design. To compliment this offer, the manufacturers will be responsible for maintenance, repairing, upgrading their electronic components and the treatment of their end-of-life components thus reducing the unexpected small costs incurred by consumers. Through Product-Service System, manufacturers will become more accountable for their product and services lest material cycles are closed (Adrodegari et al., 2015). Manufactures are encouraged to retract their commodities, improve, renovate and put them for use. Eventually, less e-waste ends up in incineration or open landfills.

Product-Service System approach will transform the current economic pricing systems as cost of production will become smaller in reference to cost incurred while making a product accessible to the end-user. This implies that the end-user do not pay for the product rather for the service offered which in turn can perceived as technical improvement of dematerialization (Corvellec & Stal, 2017).

In the end, the development of an appropriate Product-Service System with a well-organized take back scheme for the small and already existing e-waste with consumers will possibly entice
end-user to return their End-of-Life electronics as shown in Figure 5. Second it will ensure that electronics at disposal stage have a worth market value. In the third state of a cost-effective Product-Service System is to adopt a substitute scenario of product application to generate extra profit. For instance, the legislation can require that a producer of an electronic to take care of their electronics after they are sold out. Under such scenario, the maintenance of the product accrues an extra cost. In case the manufacturer, rather than selling the electronic, decides to offer its utility, it typically becomes a profit maker and an incentive to minimize the utilization of the electronic that is favorable for the consumer as well (Sousa & Miguel, 2015).

The Product-Service System to be in Figure 5 also recommends the use-oriented services approach, which may include Product leasing whereby the ownership of the product does not change. The ownership rights are reserved for the producer, who often takes the responsible of maintaining, repairing and controlling the product. The end-user pays value charges mainly for product utilization and normally has limitless access to the leased product (Tukker, 2004). In addition Product renting can also be utilized whereby the producers generally owns the product and is also accountable for maintenance, repair and control of the product. The end-users are charged for making use of the item, however, the end-user has limited access to the product implying that different end-users can utilize the same product at other times (Tukker, 2004). Lastly, product pooling which is much similar to product renting, although it encompasses synchronized utilization of the product (Tukker, 2004).

In the system, the government can execute institutional frameworks and policies which can be put in place to deal with the management of e-waste challenge in the county. Therefore the product service system has been developed from the findings of the study and mainly relies on collaborative and consultative process with all e-waste stakeholders.
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Development and Release of New Stress Tolerant Canning Beans for Smallholder Farmers in Eastern Africa

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Abstract

Productivity of canning beans in eastern Africa has declined drastically in the last four decades due to susceptibility to drought, diseases and lack of new high yielding varieties with grain quality characteristics required by the processing industry. The objective of this study was to develop new bean lines with desired canning and agronomic qualities acceptable to the consumers, industry, farmers and seed producers. A genetically diverse nursery of 445 lines was evaluated for drought tolerance, grain yield, disease resistance, canning quality and sensory attributes. Results showed significant differences (P<0.05) in drought tolerance, yield potential, resistance to disease, canning quality and a 35% reduction in cooking time among the lines leading to the release of four new varieties superior to the industry standard check variety. Drought stress reduced grain yield by 18 to 31% among test lines. Several new lines out-yielded local and international drought checks by as much as 100% in drought stressed conditions.

Relevance to innovation. These new varieties have the potential of increasing productivity, incomes of smallholder farmers, and ensure regular supply and diverse value added products for the processing industry and the consuming public.

Key Words. Dry bean, canning quality, drought tolerance, disease resistance

INTRODUCTION

Canning bean is one of the most important commercial grain types grown in eastern Africa. Smallholder farmers in East and Central Africa predominantly grow small white bean (also known as white pea or navy bean) for export and local canning industries. They are grown on an estimated 310,000 ha per year and account for 9.6% of total bean production in Africa (Wortmann et al., 1998). They are particularly important in Ethiopia and Sudan. Canning beans are of moderate importance in Kenya, Uganda, Tanzania and DR Congo. They are in high demand for the canning industries of Kenya, South Africa and Zimbabwe and in urban areas where they are popular because of their taste, short cooking time and low levels of flatulence. Major constraints
Development and Release of New Stress Tolerant Canning Beans for Smallholder Farmers in Eastern Africa

to improved productivity include susceptibility to rust, common bacterial blight, angular leaf spot, anthracnose, drought, low soil phosphorus, low soil nitrogen and attack by bruchids during storage (Kimani et al., 2008).

The processing industry is severely constrained by erratic and inadequate supply of canning beans, poor grain quality, poor linkage with farmers, reliance on one disease susceptible variety (Mexican 142), and lack of an organized system of providing certified seed of canning beans to smallholder farmers. Yield of Mexican 142 varies between 220 to 670 kg ha⁻¹ in farmers' fields, depending on disease incidence and severity, drought, cropping system and soil fertility. With good husbandry, yields can be higher. Mexican 142, was first released in Tanzania in early 1950s as one of the few varieties that met stringent canning criteria and agronomic traits (Leakey, 1970; Macartney, 1966). However, it is very susceptible to rust and anthracnose, common bacterial blight and other diseases. It has type III (semi-climbing) growth habit. Farmers prefer type I (bush upright) growth habit because of ease of harvesting and threshing. In Kenya, farmers and seed companies stopped producing Mexican 142 more than 15 years ago because it became uneconomic to grow due to its low productivity and susceptibility to diseases and drought. As result, local processing companies have relied on poor quality imported grain for processing.

Although navy bean has been the main type of canned bean in eastern Africa (Jaetzold, 2006; Macartney, 1966), other market classes including the large seeded red mottled, red kidney, small reds, sugars and pinto are now being canned to meet diverse consumer preferences (Kimani et al., 2005). However, little has been done to develop improved bean varieties of diverse market classes suitable for canning industry in eastern Africa. This was partly due to lack of facilities to assess canning quality of breeding lines during variety development process. Before the initiation of the current project in 2011, breeders had to send their bean samples to South Africa or Italy to determine their canning quality.

The objective of this project was to develop new drought tolerant and disease resistant bean varieties of diverse market classes to meet the existing and emerging needs of farmers, processing industry and consumers.

MATERIALS AND METHODS

Plant Materials

The study materials were 445 bean lines. These lines were selections from a larger nursery of more than 1400 entries which were previously field tested for drought tolerance under severe early season, mid season, intermittent and terminal drought stress in 2007, 2008 and 2009 at Kabete and Thika. Of the 445 lines, 73 were red mottled, 57 red kidney, 48 speckled sugars, 44 pintos, carioca and purples, 144 navy, 42 small reds, and 57 were of mixed colours. The red mottled, red kidneys and speckled sugars are large seeded, and represented the Andean gene pool. The other four market classes are medium or small seeded and represented the Mesoamerican gene pool of Phaseolus vulgaris L.

Experimental Sites

Field experiments were conducted at Kabete Field Station of the University of Nairobi, the Kenya Agricultural Research Organization (KALRO) Horticultural Research Institute (NHRI) experiment stations at Thika and Tigoni, and in a farmer’s field in Bahati, Nakuru County. Kabete Field Station is located on latitude 1°15′ S and longitude 36°41′ E at an altitude of 1,820 meters above sea level. It falls under agro-ecological zone UM3 (Upper midland). The area has a bimodal rainfall pattern with peaks in April and November (Jaetzold, 2006). It receives an average annual rainfall of 980 mm which is received during long rains (March to May) and short rains (October to December) seasons every year. The site has a mean minimum temperature
of 13.7°C, and maximum mean of 24.3°C. The soils are Nitosols, characterized as very deep, well-drained, dark reddish, deep friable clay type resistant to erosion (Jaetzold, 2006).

Thika trial site was located in co-ordinates 00° 59’ South and 37° 04’ East at an elevation of 1,548 m above sea level in agro-ecological zone UM3 (Upper Midland). It experiences bimodal pattern of rainfall with an annual mean of 1000 mm. Long rains occur between March and May, while short rains occur between October and December. Mean monthly rainfall is 142 mm during the long rain season, and 116 mm during the short rain season. The mean annual maximum and minimum temperatures are 25.1 and 13.7°C, respectively.

Tigoni trial site falls under the lower highland (LH) agro-ecological zone (Jaetzold, 2006). It is located on altitude of 2,131 meters above sea level, and latitude of 1°15’ S and longitude 36° 46’ E. The average annual rainfall is 1,400 mm annually. The soil type is humic Nitosol. These soils are well drained, extremely deep, dusky red to dark reddish brown, friable clay, with an acid humic topsoil.

The trial site in Nakuru was in a farmer’s field in Kabatini area of Bahati Division, Nakuru North District. The field was located on latitude of 0° 12’ S and longitude of 36° 10’ with altitude of 2070 masl. The average annual rainfall is about 1,000-1,200 mm in two seasons. The mean annual maximum and minimum temperatures are 22.6°C and 9.1°C, respectively (Jaetzold, 2006). Soils are vitric Andosols. They are well drained, moderately deep to deep, brown to dark brown, very loam to sandy clay loam.

**Line Testing**

The 445 advanced bean lines were evaluated under drought stressed conditions at Kabete Field Station during the long rain season of 2011. More than 150 drought tolerant lines of diverse grain types and representing the two bean gene pools were selected. Local commercial varieties for seven market classes were included as checks. The 150 advanced bean lines were further evaluated for drought tolerance under moisture stressed and no-stress conditions in preliminary yield trials (PYT) at Kabete and Thika during the 2011 short rain season. Seventy lines were selected and further tested in intermediate yield trials (IYT) at the two locations during the 2012 long rain season, and in advanced yield trials (AYT) at four sites (Kabete, Thika, Nakuru and Tigoni) during the 2012 short rain season. Twelve lines from five market classes (red mottled, red kidney, speckled sugar, navy and small red) were submitted for validation in national performance trials (NPT) and for distinctiveness, uniformity and stability (DUS) in February 2013.

**Field Trial Management**

Drought tolerance of the 150 lines was validated in preliminary yield trials (PYT) during the 2011 short rain season at Kabete Field Station and at Thika. The trials were laid out in a randomized complete block design with three replicates. Plots had 3 to 4 rows of 5m. Spacing was 10 cm within rows and 50 cm between rows. Drought treatments were imposed at flowering. Non-stress plots received three supplemental irrigations for 3 h each using sprinklers. Stressed plots did not receive any supplemental irrigation. Reaction of the selected lines to infection by diseases was subsequently evaluated in intermediate yield trials (IYT) at Kabete and Thika during the 2012 long rain season. Conditions for disease development at Kabete Field Station during the 2012 long rain season were very favourable. Disease pressure was very high.

The high disease severity helped to distinguish between resistant and susceptible lines. Seventy lines combining drought tolerance, resistance to diseases and agronomic potential were selected. To further expose the lines to a broader range of growing conditions and pathogens, and validate their agronomic potential, the selected lines were evaluated in multi-location advanced yield trials (AYT) across major bean growing agro-ecological zones at four sites (Kabete, Meru, Tigoni and Nakuru). These trials also were designed to increase seed for subsequent canning evaluations.
Participatory Variety Selection

To obtain the farmer preferences and identify their selection criteria, the 150 promising lines were evaluated in on-farm participatory trials under stress and non-stress conditions at Mwea during the 2011 short rain season, and at Kabete during the 2012 long rain season (Alufa et al, 2012; Kabutbei et al., 2012).

Cooking Time and Water Uptake

Cooking time of beans soaked in tap water for 16 h, was determined using a Mattson cooker, following procedures described by Warsame (2014). Water absorption was determined by soaking duplicate bean samples with fresh weight of 10.00 ± 0.01 g in 100 ml tap water at ambient conditions for up to 16 h. The soaked beans were blotted with a paper towels and cotton cloth to remove excess water, weighed and placed back into the soaking water. Samples were weighted at intervals of 3, 6, 9, 12, and 16 hours. Water absorption rate at anytime was expressed as a percentage of weight increase of the initial weight.

Evaluation for Canning Quality

Basing on agronomic potential, resistance to drought and diseases and farmers criteria, 70 lines were selected for laboratory canning tests at the Pilot Food Processing plant, Dept of Food Science, Nutrition and Technology, University of Nairobi. Evaluation for canning quality (and agronomic evaluation) was conducted in partnership with two bean processing firms in Kenya (Warsame and Kimani, 2014). Twelve lines that met laboratory processing criteria were subjected to industrial canning tests and also submitted for national performance trials conducted by Kenya Plant Health Inspectorate (KEPHIS) in 2013.

All data were subjected to analysis of variance using GenStat software (v.13, VSN, UK, 2010) with locations, treatments and genotypes as fixed factors and the measurements as random variables. Fisher’s Least Significant Difference (LSD) was used for mean separation.

RESULTS AND DISCUSSION

Agronomic Traits

Analysis of variance showed that there were significant differences (P<0.05) in grain yield and reaction to diseases, among the 12 lines submitted for national performance trials (Table 1). Average grain yield across six test environments varied from 2277 kg ha-1 for KCB 13-08, to 3071 kg ha-1 for KCB13-11 indicating inherent yield differences among the market classes. Grain yield under stress was positively associated with pod partitioning index (r=0.89***) , pod harvest index (r=0.40**), and stem biomass reduction (r=0.32**). Among the red mottled market class, the two new lines had a yield advantage of 5.8 to 14.6%. In addition, the two lines were resistant to root rots and anthracnose, to which GLP 2 the check variety was susceptible. The new red mottled lines also had higher levels of resistance to angular leaf spot and common bacterial blight compared than GLP 2.

In the red kidney market class, the two new lines (KCB 13-03 and KCB13-04) had a yield advantage of 26.8 to 34.3% compared with the check variety, Canadian Wonder (GLP 24). They were also resistant to root rots to which the check variety is susceptible (Table 1). The new red kidney lines were also more resistant to angular leaf spot, anthracnose and common bacterial blight than the check variety.

The new speckled sugar candidate lines had yield advantage of 56.3 to 67.8% compared with check variety, Miezi Mbili. The new lines also were resistant to root rots, angular leaf spot,
Table 1. Grain yield, reaction to diseases, cooking time and water uptake of the new candidate canning bean varieties developed at the University of Nairobi, 2013.

<table>
<thead>
<tr>
<th>Candidate Variety</th>
<th>Market Class</th>
<th>Mean Yield (kg ha⁻¹)</th>
<th>Disease Reaction Root rot</th>
<th>ALS</th>
<th>CBB</th>
<th>Anthracnose</th>
<th>Cooking Time (min)</th>
<th>Water Uptake (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>KCB13-01</td>
<td>Red mottled</td>
<td>2336</td>
<td>2</td>
<td>3</td>
<td>2</td>
<td>3</td>
<td>46.3</td>
<td>104.0</td>
</tr>
<tr>
<td>KCB13-02</td>
<td>Red mottled</td>
<td>2529</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>5</td>
<td>42.8</td>
<td>115.5</td>
</tr>
<tr>
<td>KCB13-03</td>
<td>Red kidney</td>
<td>2617</td>
<td>3</td>
<td>3</td>
<td>2</td>
<td>5</td>
<td>31.3</td>
<td>101.1</td>
</tr>
<tr>
<td>KCB13-04</td>
<td>Red kidney</td>
<td>2771</td>
<td>2</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td>41.6</td>
<td>115.3</td>
</tr>
<tr>
<td>KCB13-05</td>
<td>Speckled sugar</td>
<td>2732</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>36.1</td>
<td>128.8</td>
</tr>
<tr>
<td>KCB13-06</td>
<td>Speckled sugar</td>
<td>2934</td>
<td>2</td>
<td>3</td>
<td>2</td>
<td>3</td>
<td>30.1</td>
<td>101.8</td>
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<td>KCB13-07</td>
<td>Small red</td>
<td>2398</td>
<td>3</td>
<td>3</td>
<td>2</td>
<td>3</td>
<td>40.8</td>
<td>105.5</td>
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<tr>
<td>KCB13-08</td>
<td>Small red</td>
<td>2278</td>
<td>2</td>
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<td>KCB13-09</td>
<td>Navy</td>
<td>2663</td>
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<td>3</td>
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<td>34.6</td>
<td>99.2</td>
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<td>Navy</td>
<td>2752</td>
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<td>2</td>
<td>41.3</td>
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<td>Navy</td>
<td>2902</td>
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<td>39.2</td>
<td>102.4</td>
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</table>

**Checks**

<table>
<thead>
<tr>
<th>Market Class</th>
<th>Mean Yield (kg ha⁻¹)</th>
<th>Disease Reaction Root rot</th>
<th>ALS</th>
<th>CBB</th>
<th>Anthracnose</th>
<th>Cooking Time (min)</th>
<th>Water Uptake (%)</th>
</tr>
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<tbody>
<tr>
<td>Mex 142</td>
<td>2472</td>
<td>7</td>
<td>3</td>
<td>4</td>
<td>2</td>
<td>47.3</td>
<td>89.7</td>
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<td>GLP 24</td>
<td>2063</td>
<td>7</td>
<td>5</td>
<td>4</td>
<td>4</td>
<td>70.9</td>
<td>92.8</td>
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<tr>
<td>Miezi Mbili</td>
<td>1748</td>
<td>6</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td>67.1</td>
<td>97.3</td>
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<td>GLP 585</td>
<td>1879</td>
<td>8</td>
<td>5</td>
<td>5</td>
<td>7</td>
<td>81.3</td>
<td>75.9</td>
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<tr>
<td>GLP 2</td>
<td>2207</td>
<td>7</td>
<td>4</td>
<td>4</td>
<td>7</td>
<td>67.1</td>
<td>97.3</td>
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<tr>
<td>Trial mean</td>
<td>1106</td>
<td>4</td>
<td>2</td>
<td>4</td>
<td>3</td>
<td>45.5</td>
<td>85.6</td>
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</table>

LSD 0.05 = 296.8, CV(%) = 27.5

Mexican 142 used as the check. It had a cooking time of 41.6 minutes, and water uptake of 89.7% after 16 hours. ALS= angular leaf spot, CBB= common bacterial blight. Disease score based on CIAT (1987)/international scale, where 1-3 =resistant, 4-6=intersmediate and 7-9=susceptible.

Among the navy commercial grain type, the four candidate lines showed a yield advantage of 7.7 to 24.2% compared with industry check variety, Mex 142 (Table 1). In addition, the new lines showed combined resistance to root rot, angular leaf spot, common bacterial blight and anthracnose. In contrast, the check variety showed high susceptibility to root rots, and tolerance to common bacterial blight.

### Canning Quality

Results showed that there were significant differences in cooking time, water uptake, hydration coefficient, washed drained weight, percent washed drained weight, grain size, uniformity, splits.
Development and Release of New Stress Tolerant Canning Beans for Smallholder Farmers in Eastern Africa

Table 2. Canning characteristics of the new drought tolerant and disease resistant candidate bean varieties developed at the University of Nairobi.

<table>
<thead>
<tr>
<th>Line</th>
<th>Market Class</th>
<th>HC (%)</th>
<th>WDWT</th>
<th>PWDWT (%)</th>
<th>Size</th>
<th>Shape</th>
<th>Uniformity</th>
<th>Splits</th>
<th>Clump -ing</th>
<th>Brine Clarity</th>
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<tbody>
<tr>
<td>KCB13-09</td>
<td>Navy</td>
<td>1.92</td>
<td>272.4</td>
<td>66.0</td>
<td>2.33</td>
<td>4.7</td>
<td>6.3</td>
<td>5.7</td>
<td>6.3</td>
<td>7.0</td>
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<td>KCB13-10</td>
<td>Navy</td>
<td>1.70</td>
<td>294.4</td>
<td>71.1</td>
<td>2.67</td>
<td>2.7</td>
<td>4.7</td>
<td>2.3</td>
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<td>6.0</td>
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<tr>
<td>KCB11-11</td>
<td>Navy</td>
<td>1.64</td>
<td>267.1</td>
<td>64.8</td>
<td>2.67</td>
<td>5.0</td>
<td>4.7</td>
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<td>6.0</td>
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<tr>
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<td>Navy</td>
<td>1.78</td>
<td>273.6</td>
<td>67.8</td>
<td>3.67</td>
<td>5.3</td>
<td>5.0</td>
<td>3.3</td>
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<td>KCB13-08</td>
<td>Small red</td>
<td>1.59</td>
<td>276.6</td>
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<tr>
<td>KCB13-07</td>
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<td>1.58</td>
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<td>5.3</td>
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<tr>
<td>KCB13-01</td>
<td>Red mottled</td>
<td>1.55</td>
<td>284.0</td>
<td>69.0</td>
<td>5.3</td>
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<td>6.0</td>
<td>5.7</td>
<td>5.7</td>
<td>3.0</td>
</tr>
<tr>
<td>KCB13-02</td>
<td>Red mottled</td>
<td>1.49</td>
<td>284.3</td>
<td>69.4</td>
<td>4.7</td>
<td>5.3</td>
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<td>6.0</td>
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<tr>
<td>KCB13-03</td>
<td>Red kidney</td>
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<tr>
<td>KCB13-05</td>
<td>Sugar</td>
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<td>KCB13-06</td>
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<td>Mex142</td>
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<td>Trial mean</td>
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<td>274.2</td>
<td>65.7</td>
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<td>CV (%)</td>
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<td>11.9</td>
<td>13.8</td>
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</table>

HC= Hydration coefficient; WDWT = washed drained weight; PWDWT = per cent washed drained weight. Note: Market classes; navy, small red are small/medium seeded; red mottled, red kidney and sugar are large seeded clumping and brine clarity of the canned products (Tables 1 and 2). Cooking time of the new lines varied from 31.3 to 46.3 minutes. The results showed that all the 12 candidate varieties cooked in shorter period compared with Mex 142, which cooked in 47.2 minutes. All other check varieties showed long cooking time which varied from 67 to 81 minutes, implying that they are not suitable for canning. Water uptake of the new lines varied from 98.7 to 140.6%. In contrast, Mex 142 had a lower water uptake (89.7%) (Table1). Among the commercial varieties, GLP 585 had the lowest water uptake (75.9%). This implies that the new lines exceeded the optimum 80% water uptake required for canning beans (Sastry et al., 1985). Hydration coefficient varied from 1.43 to 1.92. Two navy lines (KCB 13-09 and KCB 13-12) had better hydration coefficient compared to Mex 142. Two red mottled (KCB 13-01 and KCB 13-02) and one navy line (KCB 13-10) had higher washed drained weight compared with Mex 142. All 12 lines had higher percent washed drained weight than the recommended 60% for dry bean destined for the canning industry (Balasubramanian et al., 2000). The size, uniformity, shape, splits, clumping and brine clarity were comparable and often better than the industry reference variety, Mex 142 (Table 2), and meet a broad range of consumer preferences. For example, some consumers may have a preference for small seeded types, while others may prefer large seeded types.

Results presented in this study mark a major milestone in the breeding of improved canning beans for the processing industry since the first variety Mexican 142 was introduced in Kenya more than 60 years ago. During this period, development of new canning bean varieties received little attention. Research effort concentrated on dry bean types for general household consumption. As
result, no new varieties were released since the 1950s. Three of the candidate varieties (KCB13-09, KCB 13-02 and KCB 13-11) were released after validation by the regulatory authority (KEPHIS) in February 2015.

CONCLUSIONS

Three new canning bean varieties, Kenya Mamboleo (KCB 13-02), Kenya Salama (KCB13-09) and KenStar (KCB13-11) have several agronomic and canning advantages compared with the industry reference variety, Mex 142, which was introduced in Kenya from Tanzania more than 60 years ago. The new varieties have yield advantage of up to 24% compared with Mex 142. They also have combined resistance to root rots, angular leaf spot, angular leaf spot and common bacterial blight. They cook faster by more than 12 minutes and have better water uptake, hydration and meet all important canning criteria set by canning industry. However, utilization of the new varieties requires development of an integrated system for the production of certified seed and quality grain, creating awareness and building critical skills of all actors in the canning bean value chain.

Acknowledgements

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REFERENCES


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