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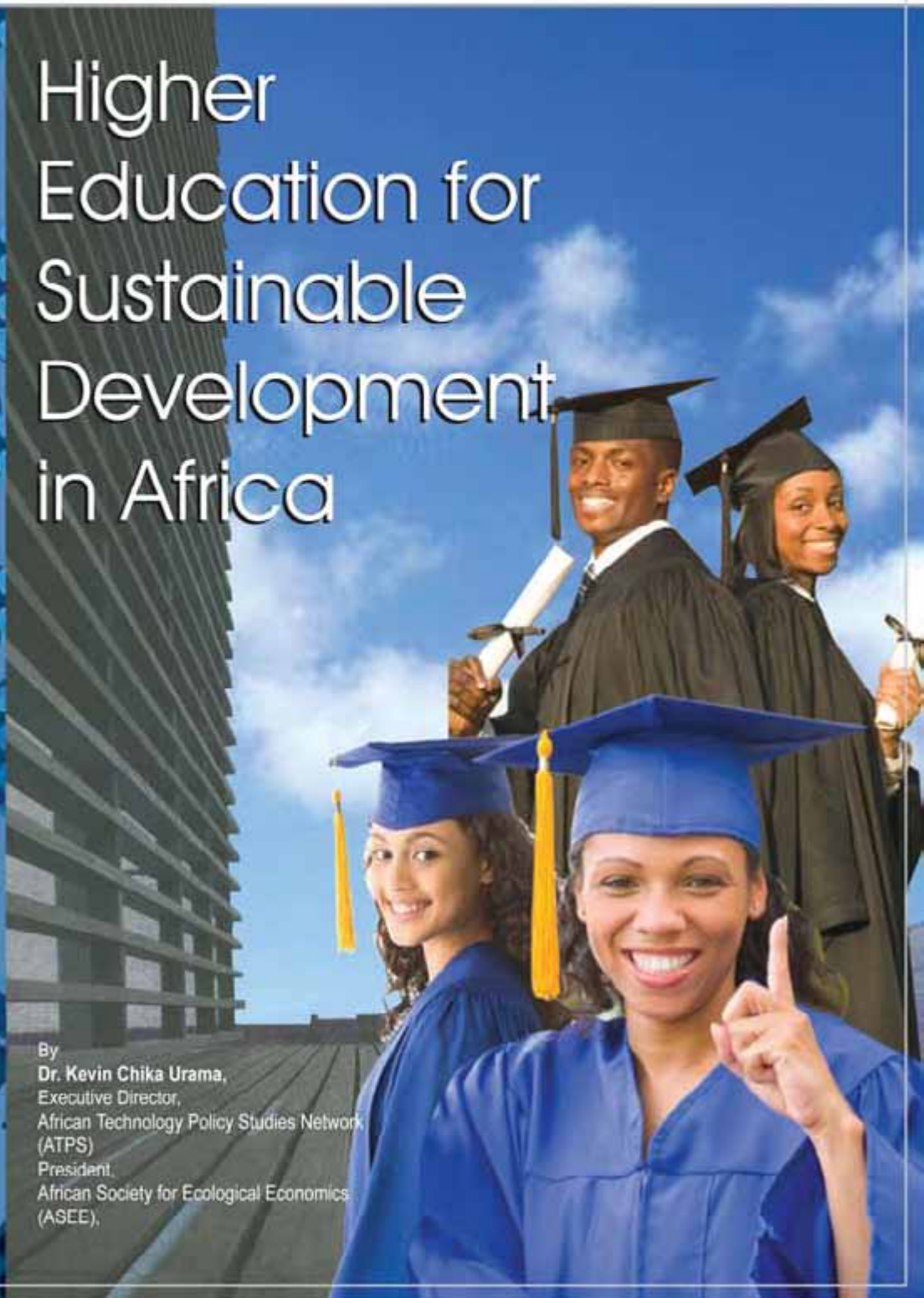
Higher Education for Sustainable Development in Africa



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Higher Education for Sustainable Development in Africa (HESDA)[1]

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Table of Contents

Abstract 4

1. Introduction 5
2. Current Scenarios 9
3. How Can Higher Education for Sustainable Development in Africa be Achieved? 13
4. Conclusions 18

Cited References 19

Abstract

The paper explores the role of higher education in sustainable development in Africa. While there are many definitions of the concept of sustainable development in the literature and many policy documentations have adopted it as the "buzz word" for development planning since the early 1970s, operationalisation of the concept has taken various nuances in different sectors, including higher education. However, whatever nuance it may take, the concept of sustainable development crystallizes in the definition provided by the World Council on Sustainable Development (WCED, 1987): "development is sustainable when it meets the needs of the present without compromising the ability to the future generation to meet their own needs".

The paper argues that higher education can only contribute to sustainable development in Africa if and only if it contributes effectively to meeting the social, economic and biophysical needs of the present and future generations of Africans. Drawing from the concepts of responsible innovation systems as the platform for development and the nexus between the social, biophysical and economic aspects of environmental flows (Urama et al., 2006), it argues that building effective platforms for effective integration and collaboration within and among disciplines, integration and collaboration within and between all actors in national knowledge systems, and building appropriate incentive structures for effective valorization of science are necessary conditions for sustainable development.

Analyses show that current knowledge systems, pedagogies and incentive structures in African Higher education are discipline based and hence precludes trans-discilinarity, systems thinking, and responsible innovation which are necessary conditions for economic progress as well as social and environmental sustainability. It concludes that to make Africa's higher education relevant for social, economic and environmental sustainability, a complete re-engineering (socialization of our knowledge systems) including a re-design of existing curricula, teaching & learning methods, research and development, stakeholder engagement & systems of knowledge sharing, science dissemination and communication, science valorization, incentive structures and reward systems (such research assessment RAE exercises), and staff promotion schemes are urgently required.

[1] *A Keynote paper presented at the 12th General Conference of the Association of African Universities, Abuja, Nigeria, 4th May 2009.*

1. Introduction

Education for Sustainable Development (ESD) is "a dynamic concept that encompasses a new vision of education that seeks to empower people of all ages to assume responsibility for creating and enjoying a sustainable future" (UNESCO, 2005). It aims to integrate the principles, values and practices of sustainable development into all aspects of education and learning (UNESCO, 2005). Higher education for sustainable development in Africa (HESDA) is therefore the mainstreaming of the principles of ESD in higher institutions of learning in Africa. It is expected that adopting HESDA principles will encourage change in behavior and mindsets to create a more sustainable future in terms of environmental integrity, economic viability, and a just society for present and future generations.

It is now widely accepted that knowledge is at the the heart of development and qualified researchers are necessary to produce a broad base of knowledge relevant to the solution of current and future practical problems of development. In fact, many scholars have argued that it is very unlikely that Less Developed Countries (LDC's) will be able to build the research capacity they need simply by adopting the research training schemes developed in the advanced countries and offered by development cooperation agencies. It is therefore apparent that if developing countries hope to prosper and if world leaders expect globalization to foster sustainable development and poverty reduction, building Science, Technology and Innovation (STI) capacities of countries is an absolute necessity. In today's rapidly changing economy, the critical economic development and socio-environmental sustainability question is no longer whether countries should build STI capacity but what type of capacity to build and how to build it, given each country's socio-economic and bio-physical constraints (Urama, 2008). A review of the factors underpinning the success of the developed and emerging economies suggest that supporting policies and institutions, revalorization of traditional and local knowledge, an interdisciplinary, holistic and systems-based approach to knowledge production and sharing, the extent to which requisite national investments in building an indigenous knowledge base to drive the national economy vis a vis the extent to which international developments and events drive the priority given to development and sustainability goals, etc are all critical.

Yet, Africa's education sector still remain weak and attention to mainstreaming sustainable development principles in higher schools of learning remain outside the curriculum development planning and teaching practices. At the global scale, the challenge is deepened by Skeptics who have espoused the idea that: "it is not the job of universities to promote particular political orthodoxy [in the form of Sustainable Development Principle for example]; it is their job to educate students to examine critically, policies, ideas, concepts and systems, then to make up their own minds" (cited in Scott & Gough, 2006). Scott & Gough, (2006) opined

that not only would the development of 'values, skills and knowledge' be inappropriate and contrived for many academic disciplines, but it is arguable that, in purely intellectual terms, the concept of sustainability is still contestable. Similar debates in the literature have led to the sidelining of sustainable development principles in the mainstream higher education curriculum in many continents, especially in Africa, where curriculum have been seldom reviewed in the past decade. As will be shown in the subsequent analyses in this paper, current higher education in Africa therefore do not contribute significantly to any of the triple aspects of sustainable development: economic growth, social equity and environmental sustainability.

1.2 The Science of Sustainable Development and the Sustainability of Higher Education in Africa

To examine the contributions of higher education in Africa, this section of the paper examines the science of sustainable development in the context of the triadic model of sustainability, including the economic, the social and the biophysical/environmental aspects. It examines the current paradigms in higher education in Africa and the implications for economic growth, social equity and maintenance of environmental assets for the current and future generations of Africans.

The concept on sustainable development has been defined in many ways in the literature to the extent that the operationalisation of the concept in development practice now adopts many forms (Urama, 2003). See for example, Pearce et al., (1989), Pezzy, (1992) and Urama, (2003) for a review of the gamut of definitions and implications for development practice. However, the paper adopts the Brundtland Commission's definition that: "development is sustainable when it meets the needs of the present without compromising the ability to the future generation to meet their own needs". (WCED, 1987). Embedded within this definition are the concepts of intra-generational and inter-generational equity, and what is now popularly referred to as the "triadic model" or "three pillars" of sustainable development. In simple terms, sustainable development principles requires that we achieve our needs today without stripping future generations the social, economic and natural assets required for them to achieve their own needs. Operationalisation of the underlying concepts of "intra-generational" and "inter-generational" equity and the triadic model of sustainability therefore leads to fundamental challenges regarding how developed and developing countries ought to implement the sustainability principles in development planning[2] (see Urama, 2003, Chapter 2 for details). To achieve the current needs of the present, African countries need to grow their economies, i.e. increase the productive and consumptive capacities of the population today. This would in turn exert pressures on the biophysical and social environment through resource extraction, waste disposal and resource wars and the potential of depletion of ecosystem services.

While a discourse on sustainable development policy planning is not the subject of this paper, it is pertinent to note here that sustainable development policy is context specific and inextricably linked to the social, economic and biophysical conditions. It is therefore heterogeneous for different countries and continents. For on country, the policy priority may be sustainable production, while for another it may be sustainable consumption. In all cases, growth and consumption practices MUST be decoupled from environmental depletion[3].

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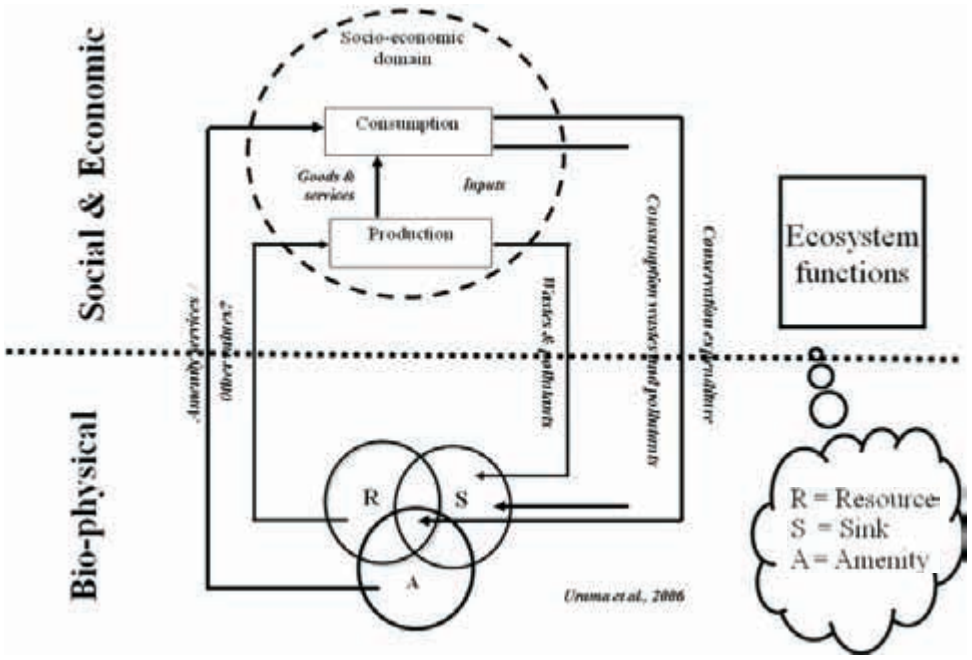
[2] *Inherent in the triadic model of sustainability is the realization of the fact that meeting the social, economic and biophysical needs of the present and future generations are inextricably linked. Preserving forests without meeting the current needs of the global poor is therefore not sustainable development.*

[3] *Details on the different nuances of sustainable development planning will be provided in another paper: "The Politics of Sustainable Development Policy at the Global and Regional Scales", forthcoming.*

1.3 Implications for Higher Education in Africa

The brief discourse on the science and politics of sustainable development show that the concept of sustainability is complex and adaptive, and its operationalisation is context specific and dynamic depending on the prevailing social, economic and biophysical conditions at local, national, regional, continental and global scales. The economies of nations are integral parts of the life support system which we popularly call the "environment", encompassing the social, economic and biophysical life support systems (see Figure 1).

Figure 1: The Nexus between the Social, Economic and Biophysical Environments



This poses significant challenges to the implementation of HESDA in Africa. Some of these challenges are discussed briefly below:

1.3.1 **Complexity & adaptive system:** The environment is "a complex adaptive system": - a dynamic and complex whole, interacting as a structured functional unit. No part of the system can be effectively managed "sustainably" in isolation.

1.3.2 **Collaboration:** We are therefore in a "Space ship earth" where energy, materials and information flow constantly amongst its components. Each actor in the space ship are rational and will necessarily seek their own interests as resources are finite and without boundaries. Knowledge will continue to be generated and shared in the global knowledge economy and these will inform global responses and policies for addressing global sustainable development challenges.

1.3.3 **Dynamic and multiple equilibrium:** Systems are often composed of entities (actors) seeking

(partial) equilibrium but can exhibit **selfish behaviour causing oscillating or exponential behavior in the system.** The science of sustainable development does not therefore respect partial equilibrium", or "certeris paribus" assumptions. Instead, it celebrates "complexity" and feedback loops within the system.

1.3.4 **Externalities:** All actions by each actor in the space ship often have unintended effects (externalities) on other actors, some, with significant implications for global sustainability such as climate change, poverty alleviation, food security, water security, etc[4]. Most significant global sustainability challenges such as climate change are global phenomenon with localized impacts. The externalities of these global sustainability challenges on developing countries are far reaching, especially in Africa. For example, Africa will bear the greatest impacts of climate change while it contributed least to green house gases. If African Scholars do not proactively engage in sustainable development, actions of other global actors will of necessity, have externality effects on African development. This has significant implications for global environmental governance systems and implementation of sustainability principles such as the Polluter Pays Principle (PPP), the Precautionary principle (PP), Payments for Ecosystem Services (PES), Carbon markets, etc.

1.3.5 **Uncertainty & Irreversibility:** Most environmental impacts are low probability high risk events. It is therefore imperative that African scholars should proactively and continually evolve new knowledge to inform Africa's responses to global environmental challenges and polices at all scales.

Based on the brief analyses above, it is evident that the sustainability of African economies is significantly dependent on the extent to which Africa strategically engages in the sustainable development agenda at the global, continental, national and local scales. Africa is a supper power in terms of natural resource endowments but still ranks amongst to poorest continents in the world. Investing in HESDA is therefore a necessary condition for sustainable economic growth, social equity, political stability, biophysical sustainability in Africa, as well as the maintenance of the global natural capital stock. It is therefore not a question of if African should invest in HESDA, but rather how Africa should implement HESDA most cost-effectively.

[4] *Externalities are unintended effects of selfish behaviour of actors in the system*

2. Current Scenarios

To address the question of how to implement HESDA, the paper examines the current scenarios in Africa in comparison with other developed and emerging continents, drawing lessons where appropriate.

A rapid assessment of selected Higher Schools and Universities in Africa show that the current pedagogies and incentive structures in are discipline base, focuses on literacy and publications, organized in faculties with rigid boundaries and hence discourages collaboration, trans-disciplinarity and responsible innovation. The disciplinary domains focus on scientific enquiry and building "academic tribes" rather than collective learning. Single authored publications are often priced more than collaborative publications in the staff promotion exercises and Research Assessment Exercises (RAE). Curriculum has been seldom reviewed in the light of emerging development challenges in many countries. Science is not fully embedded in society and corroboration of theory is often easier to publish in peer reviewed journals than falsification of theory. This is even more debilitating for young researchers as most of the international journals are not accessible. Most of the journals are also hosted in Europe and America and hence are designed to address development agenda of the North, hence scientific enquiries into African development challenges are seldom published. There has been an increase in the emergence of African journals during the past decade, but these are still not very popular as ISI journals attract higher impact factors and hence higher chances of promotions under the current RAE system.

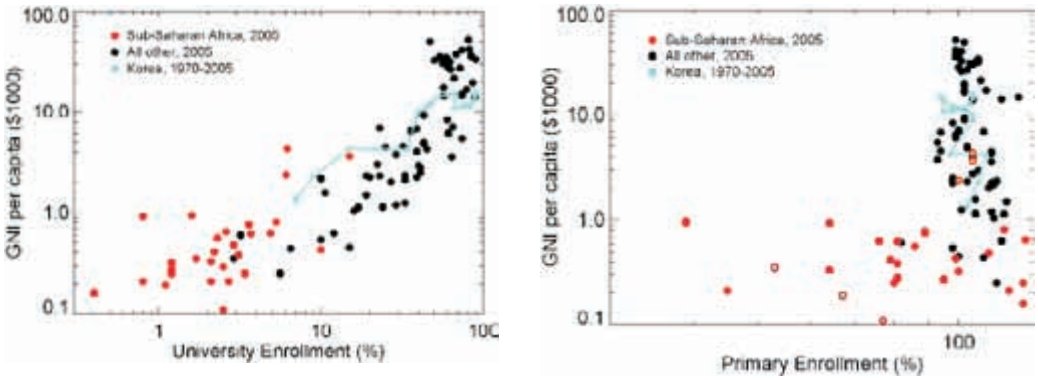
The implications of the above are that contribution of Africa's Higher Education systems to economic growth, social equity and sustenance of Africa's rich natural resources has been dismal. In the following section, the paper illustrates the low impact of current Higher Education paradigms in Africa on the three pillars of sustainable development.

2.1 The Impact of Higher Education on Economic Growth in Africa

Empirical studies find significant correlation between university enrollment rates and growth in national incomes in many countries (Moyer, E.J. 2007). No educational factor correlates as strongly with national incomes as university enrollment rates. Analyses show that attaining full primary education for all which has been the main focus of government policies in many African countries may be a necessary but no sufficient condition for development in most countries globally. For example, Togo and Madagascar have attained over 90% primary school enrollment rates but this has not translated into higher national incomes. The same relationship holds not only between countries but also over time for a single developing country (for details, see Moyer, 2007). On the converse, university enrollment rates in sub-Saharan Africa are among the lowest

in the world, averaging 5%, compared to > 60% elsewhere and up to 72% in the United States of America. The rate of university enrollment also varies within the region with South Africa attaining up to 15%. Overall, the contributions of higher education in Africa to gross national incomes are significantly low[5].

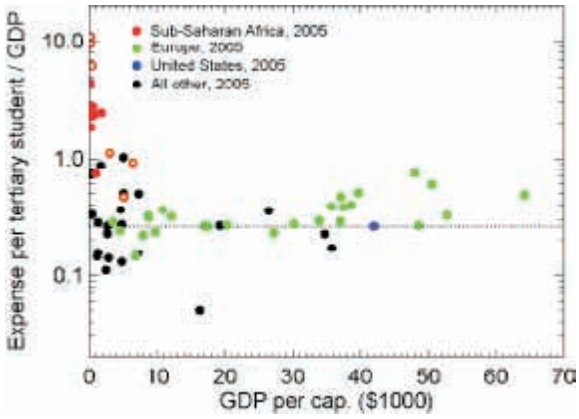
Figure 2: Correlation between Gross National Incomes (GNI) and Enrolment Rates in (a) Universities and (b) Primary Education (Source: Moyer, E.J. (2007).



A more in-depth analyses provided by Moyer et al., (2007) suggest that the relative cost of higher education per student trained as a proportion of Gross National Income (GNI) is higher in Africa than in the developed countries, including the USA and Europe (Figure 2).

This leaves the African Higher Education in significant dilemma. A rapid appraisal of the system shows that African governments are the primary source of funding for higher education in Africa. If higher education does not contribute significantly to national income growth, it is most likely that governments will prioritize other development challenges such as poverty alleviation, climate change adaptation, water insecurity, peace, etc. over continued investments in higher education.

Figure 3: National Government Expenses per Tertiary Student as a Proportion of Gross Domestic Product (Source: Moyer, (2007).



[5]*A more detailed discussion on the importance of higher education for national income growth can be found in Moyer, (1997) and Botman et al.,(2009)*

Yet, providing a reasonable level of higher education will continue to require a minimum threshold of investments in the sector. This would, in turn, limit enrollment rates further as budgetary constraints increase. Inherently, this leads to reduced standards in teaching and learning facilities as University faculties engage in moonlighting activities and staff unions evoke industrial action (strikes) to lobby for increased investment in the sector.

This analysis suggests that it is likely that this could become a vicious cycle unless Higher Education in Africa finds innovative ways of increasing investments, enrollment rates and relevance to the socio-economic and environmental needs of the continent.

2.2. The Impact of Higher Education on Social Sustainability in Africa

The hallmarks of social sustainability are participatory democracy, stakeholder empowerment and social equity. This, in turn requires active engagement of the quadruple helix (the governance sectors, the academia, the private sector and the civil society) in framing and shaping the social, economic and environmental policies of countries.

However, a rapid assessment of the institutional and operational structures of higher education in Africa suggests that most of the governance structures are strictly hierarchical and rigid bureaucracies. Most scholars attribute this to Africa's colonial history. University systems in Africa were designed by the colonial masters to reproduce the characteristics of theirs (mainly British, French & Belgium). Subsequently, there was rapid expansion in Higher Education in the early 1960s, but still within the constrained colonial systems. In the 1970s, the global oil crisis led to reduced funding and Higher Education was viewed as a secondary priority. Since then, Donor funding has remained influential in defining research and teaching programs and university management systems. The socialisation of African science in Africa, i.e. embedding our science in our society therefore took the back seat.

Knowledge and technology transfer mechanisms are still largely based on the linear models of innovation diffusion. Innovation is largely regarded as the product of research within the codified knowledge communities (science disciplines) in which knowledge dissemination is largely an end-of-pipe activity at the end of linear process: information gathering and field observations, data analyses and hypothesis testing, and final dissemination of results. The sector within which most involvement of the stakeholders has been observed is in the agricultural sector. Yet, within the sector, innovation diffusion process is modeled on the assumption that research findings, once packaged by extension staff, are expected to be inherently suited to transfer to the farming community. The initiator of innovation is codified science and increase in scientific inputs into the pipeline will directly increase the number of new innovations and technologies flowing out the downstream end. Little attention is paid to tacit knowledge held by the farming communities and other relevant stakeholders. Traditional farming practices such as multi-cropping and organic farming were described as conservatism until recently when the environmental movement led to the realization that these practices were more sustainable that conventional modern practices (see Urama, 2003; 2005). Years of experience have also shown that "technical changes do not occur in a perfectly linear sequence, but through feedback loops within the system" (OECD, 1997, p. 12).

In addition, the language of science remained the colonial languages, mainly English, French and

Portuguese. This mutually excludes the civil society, the government and the private sector in knowledge generation and knowledge valorization in Africa. Students are often taught about food crops in their locality in Botanical (or Latin) names which make no sense to the student beyond the class rooms. Different discipline evolved its own specialized language "disciplinary jargons" that precludes any form of bilateral or tri-lateral collaboration and interdependencies between university faculties, knowledge networks, the private sector, local communities actors, policy makers, etc. Also, flexibility, creativity and innovation remain seldom rewarded by the research assessment exercises (RAEs) as preference is mainly given to publications in international journals. Science in African Universities has therefore been described as an artifact of Africa's colonial past. Recently, the Chairman of NEPAD Steering Committee urged institutions of higher education in Africa to create "a culture of developing new knowledge and skills for generating solutions to Africa's development challenges" (cited in UNESCO, 2005).

Empirical results of a focus group discussion carried out with stakeholders in Kenya in 2009 as part of a multi-lateral project on socialization of science and technology in developing and emerging countries find that the systems remain largely unchanged. The main constraint to socialization of science in Africa remains the lack of collaboration amongst the quadruple helix. Delegates at the focus group ascribed this lack of collaboration amongst the quadruple helix in Africa to a number of factors, including:

2.2.1 Lack of institutional/policy framework for collaboration,
2.2.2 Low incentives for multi-disciplinarity and trans-disciplinary research,
2.2.3 Donor driven research agenda due to dependency on external donors for STR research funding,
2.2.4 Low investments by national governments to invest in science, technology and innovation programs and scientific equipment,
2.2.5 Perceived superiority of Western Science and Western Scientists,
2.2.6 Perceived and real demand for international experts by Government and Private Sector Actors,
2.2.7 Focus by African Politicians on short-term value addition,
2.2.8 Multiple Ministries and Government Parastatals handling various aspects of the innovation system each with different agenda,
2.2.9 Difficulties of dealing with uncertainty,
2.2.10 Colonial structures and curricula still being maintained in most higher education establishments,
2.2.11 Research Assessment Exercise (RAE) is still based on foreign criteria, e.g. publications in international journals;
2.2.12 Insufficient legal frameworks for Intellectual Property Rights, and other knowledge appropriation strategies, etc,
2.2.13 Low quality of science leading to false or failed predictions and lack of trust in African science by stakeholders, and
2.2.14 Lack of systemic, holistic and interdisciplinary approaches in African science, etc.

The results of the focus group also underscored the fact that current pedagogies and incentive structures in African Universities are discipline based and hence precludes systems thinking, collaboration and responsible innovation which are necessary conditions for economic progress as well as social and environmental sustainability.

3. How Can Higher Education for Sustainable Development in Africa be Achieved?

From the foregoing, it is evident that to achieve higher education for sustainable development in Africa, there is the need for a complete re-engineering of the education system in Africa, staring from the Primary to the Tertiary levels. As aptly noted by (Mamdani, 1996), Education for Sustainable Development (ESD) "does not simply involve an 'adoption' of institutional rhetoric on Sustainable Development, or development of new structures and projects in universities. It requires a deeper engagement with the remaining institutional legacies of colonialism (and neo colonialism) in Africa (Mamdani, 1996). It requires that we think of how we can root African universities in African soil (ibid). This was again emphasized by Moja, (2004): "…there is a need to transform African systems of Higher Education to make sure that Higher Education will contribute to economic development within a globalised economy" (Moja, 2004, p. 22).

This paper makes the same clarion call for the socialization of African Science as the sene qua non for sustainable development and the sustainability of higher education in Africa. This will require a reform of curricula, teaching & learning methods, research and development, stakeholder engagement & systems of knowledge sharing, science dissemination and communication, science valorization, incentive structures and reward systems (such as RAE), and staff promotion schemes to make them relevant to Africa's development agenda. I argue that by socializing African science, i.e. making Africa's Higher Education relevant for social, economic and environmental sustainability, and embedding the science curricular in African's realities, Higher Education in African will contribute more effectively to national income growth, social cohesion and efficient use of Africa's rich natural capital. Collaboration amongst the quadruple helix will also not only generate new innovations for development but will also facilitate the sustainability of higher education in Africa. Private Sector and Public Funding for Higher Education will also increase as a demand led process in exchange for the new relevant technologies and responsible innovations that will be espoused by the collaboration platforms and networks generated.

The paper therefore makes six key recommendations focusing mainly on what the Higher Education sector needs to do, and provision of favourbale policy environments for innovation cultures to flourish:

3.1 **Pedagogical Reforms:** to move from disciplinary science to trans-disciplinary science;

3.2 **Structural Reforms:** to move from current models of science & technology knowledge transfer to providing collaborative platforms for responsible innovation, such as Centers of Excellence, Innovation Incubation Centers, etc;

3.3 **Mindset Reforms:** to move from sector based approaches in teaching and learning (silo thinking) to integrated holistic approaches in knowledge generation and knowledge circulation (systems thinking);

3.4 **Governance Reforms:** to move from knowledge hierarchies to participatory governance and full socialization of scientific and technological research

3.5 **Incentive Structures Reforms:** to move from "publish or perish" to a more inclusive impact based incentives and reward systems including publications, but also societal relevance / local impacts,co-patents and co-publications, private sector citation index, proximity to specialized knowledge centers, relevance to national policy simulations and formulations, etc., and

3.6 **Policy Environment Reform:** to provide favorable policy environments and legislative frameworks to enable cultures of innovation to thrive and flourish at national, regional and global levels.

These recommendations are discussed briefly below:

3.1 Pedagogical Reforms - From Disciplinarily to Trans-Disciplinarily: Trans-disciplinarity is the principle of integrating forms of research comprising a family of methods for relating scientific knowledge and extra-scientific experience and practice in problem-solving. It is a form of joint problem solving among Science, Technology and Society. Unlike disciplinary sciences which examine, at most, one and the same level of reality, and in most cases, concerns fragments of one level of reality; trans-disciplinarily espouses collaboration amongst different knowledge communities and utilizes extra-scientific experiences and tacit knowledge in its approaches. This is also distinct from inter-disciplinarity and multi-disciplinarity. Both multidisciplinarity and inter-disciplinarity approaches overflows disciplinary boundaries while the goal remains limited to the framework of disciplinary research. The core differences between disciplinary science and trans-disciplinary science are shown in Table 1:

Table 1: Differences between Disciplinary and Trans-Disciplinary Approaches

Disciplinary Sciences	Trans-disciplinary Sciences
Simplicity	Complexity
Singularity assumptions	Heterogeneity assumptions
Insulated boundary conditions	Hybrid conditions
Linearity assumptions	Non-linearity assumptions
Unity assumptions and results	Unifying approaches and multiple scenarios
Building consensus in results	Seeking agreement on scenarios
Fragmented models	Coherent models
Universality	Dialogue at multiple scales
Partial equilibrium conditions	Multiple and Dynamic equilibrium conditions

Trans-disciplinarity therefore provides a useful model for addressing current global challenges, including climate change, poverty, and global financial crisis which are mutually exacerbating. There is now growing consensus amongst social and environmental scientists that these complete global challenges can only be effectively addressed through effective partnerships amongst different science disciplines, and amongst the quadruple helix.

3.2 Knowledge Structures Reforms: From Science and Technology Transfer to Responsible Innovation

The Webster's Seventh New Collegiate Dictionary defines technology as (i) applied science, (ii) a technical method of achieving a practical purpose, or (iii) a totality of the means employed to provide objects necessary for human sustenance and comfort.

Banjo, (1988) therefore defines technology as 'the application of knowledge, including the skills necessary to deploy principles, procedures, and processes that can be used to modify, manipulate and otherwise produce changes in the specific features of the physical world to serve human or social purposes" (cited in Urama 2003). In other words, technology can be defined simply as knowledge used to solve problems (Urama, 2003).

On the other hands, the concept of Responsible Innovation pertains to the introduction of new products, processes and services and to organizational and societal renewal, i.e. the valorization (use / application of the results of science and technology for development). Innovation is therefore neither scientific research, nor technology, but rather the application of knowledge in development. The knowledge might be acquired through learning, research or indigenous experiences, but until it is applied in the production of goods or services it cannot be considered an innovation. It is therefore necessary to build national system of innovation as the bedrock for development of nations.

A National System of Innovation (NSI) is a system of interconnected institutions to create, store and transfer the knowledge, skills and artifacts which define new technologies (Metcalfe, 1995). It comprises the national institutions, their incentive structures and their competencies, that determine the rate and direction of technological learning (or the volume and composition of change generating activities in a country (Patel and Pavitt, 1994). It has to be stressed here that NSIs are heterogeneous for different countries. Countries differ in the way in which knowledge flows are structured and in the relative importance of the different types of institutions, actors or linkages for their respective production and consumption systems. Each country must therefore chart its own sustainable development trajectories taking into account the peculiarities of its own NSI.

3.3 Mindset Reforms: From Silo Thinking to Systems Thinking

Systems thinking is the process of estimating or inferring how local policies, actions, or changes influence the state of the neighboring universe. Development challenges are seen as parts of an overall system, rather than reacting to present outcomes or events and potentially contributing to further development of undesired effects or new problems, popularly referred to as externalities. Systems thinking framework is based on the belief that the component parts of a system can best be understood in the context of relationships with each other and with other systems, rather than in isolation. In many ways, systems thinking espouse the principles of collaboration which breeds innovation.

3.4 Governance Reforms: From knowledge hierarchies to participatory governance and Full Socialization of Science & Technology

The whole aspects of scientific practice, scientific mediation, scientific communication, evaluation of science, innovation in science, science governance, gender representation, and scientific cognition are now under serious processes of socialization in the developed countries. The paper therefore recommends that measures should be put in place to ensure that African science is fully embedded in African societies. The socialization process should take into consideration the different knowledge communities (both tacit and codified), amongst science disciplines, faculties and institutions, and amongst all actors in the value chain at national, regional, continental, and global scales. Details on the principles of socialization of science can be found in an ongoing process for the development of a Manifesto for Science and Technology in Africa (see http: //www.ste-dev.eu), for details.

3.5 Incentive Structures Reform: From "Publish or Perish" to a more Inclusive Performance Incentives Systems

This recommendation regards a reform of the Research Assessment Exercises to move away from the current paradigms of "Publish or Perish" to a more Inclusive Performance Incentives to favour problem solving, innovation and socialization of science in Africa. The paper recommends an inclusive weighting system comprising:

3.5.1 Quantity and quality of scientific publications;

3.5.2 Relevance to development policy. This can be measured by:

- 3.5.2.1 Policy impact indicators
- 3.5.2.2 Number of policy briefings produced, and
- 3.5.2.3 Public sector citation index

3.5.3 Number and quality of collaborative activities and innovations generated. This can be measured by:

- 3.5.3.1 Public sector citation index
- 3.5.3.2 Number of joint research activities; joint innovations, etc;
- 3.5.3.3 Co-patents and co-publications
- 3.5.3.4 Private sector citation analysis
- 3.5.3.5 Firm surveys index
- 3.5.3.6 Number of specialized knowledge centers working with the university, etc, and

3.5.4 Societal Relevance. This can be measured by

- 3.5.4.1 Societal panel reports, and
- 3.5.4.2 Stakeholder analyses

While the proposed RAE system may appear arduous, it is expected that once the system is put in place, the added value of using a more inclusive system will override the initial costs of developing the new system. Some countries in the developed world espousing responsible innovation are already using different aspects of the proposed system. For example, the Responsible Innovation (MVI) program of the Netherlands NWO program now requires research projects to be evaluated by a Society Panel as well as a scientific Panel, to ensure both science and social relevance of funded programs. It is now an established empirical fact that research cooperation correlates with improved innovative performance in most sectors (cf: Silicon Valley in California (near Stanford University and the University of California); Biotechnology Clusters in the Boston area (near the Massachusetts Institute of Technology) and Communications Clusters (near Princeton University). The same relationships exist in Germany, Norway, Finland, etc. In fact, the

European Commission now proactively award research grants to encourage trans-disciplinary studies and collaboration amongst the quadruple helix across continents.

Evaluation of cooperative research programs in the EU find that it leads to behavioural additionalities, e.g. increased competencies and skills that lead to innovative capacity, networking capabilities and ability to identify and adapt useful technology. In addition, inter-faculty and student exchanges can address the huge gaps in expertise and inertia for collaboration and innovation in some regions.

3.6 Policy Reforms: - to create enabling policy environments for:

- 3.6.1 Increased enrollment in Universities,
- 3.6.2 Trilateral university-industry-government partnership / collaboration,
- 3.6.3 Bilateral collaboration between university students, faculties and universities
- 3.6.4 Performance based inclusive incentive systems,
- 3.6.5 Long-term investment in trans-disciplinary science and innovation studies,
- 3.6.6 Participatory governance and socialization of S&T in African countries,
- 3.6.7 Change in mindset: to enhance personal commitment of both teacher and learners to addressing Sustainable Development Principle,
- 3.6.8 Pedagogical/Paradigm shift: to mainstream trans-disciplinarity, systems thinking and innovation,
- 3.6.9 Stakeholder engagement in knowledge generation, valorization and RAE,
- 3.6.10 Build effective "contractual" student loan programs,
- 3.6.11 Invest in research infrastructure and existing faculties,
- 3.6.12 Identify and support existing centers of excellence and knowledge networks, and celebrate African Science and Scientists,
- 3.6.13 Invest in entrepreneurship incubation programs and / or small business innovation research grants, and
- 3.6.14 Skills re-orientation and re-tooling - at the disciplinary levels to integrate Sustainable Development concerns.

4. Conclusions

The paper explores the role of higher education for sustainable development in Africa. It explores the emergence of trans-disciplinary sciences, systems thinking, and responsible innovation and their implications for education for sustainable development innovations (ESDI) in Africa. It argues that current pedagogies and incentive structures in African Universities are discipline based and hence precludes systems thinking, collaboration and responsible innovation which are necessary conditions for economic progress as well as social and environmental sustainability.

The paper therefore argues that to make higher education relevant for social, economic and environmental sustainability in Africa, a complete re-engineering (socialization) of our knowledge systems (curriculum design, teaching & learning methods, research and development, stakeholder engagement & systems of knowledge sharing, dissemination, valorization, incentive structures including research assessment exercises (RAEs) and promotion criteria, etc.) are urgently required.

The recommendations hinge around six interrelated aspects of our knowledge systems needing urgent reforms: the current pedagogy, knowledge diffusion structures, mindsets of the actors, institutional governance structures, and policy frameworks.

It advocates for re-design of curricula to mainstream sustainable development principles including trans-disciplinarity, systems thinking and innovation; expansion of RAE systems to include societal relevance, innovation indicators, policy relevance, etc; reform of institutional governance structures and teaching and learning methods to mainstream participatory democracy, stakeholder engagement, participatory learning and full socialization of science in Africa; change in mindsets to move from doing different things to doing things differently, learning to learn rather than teaching codified knowledge as the superstructure for development. At the policy level, it recommends investments in tans-disciplinary entrepreneurship incubation centers and knowledge networks to foster innovation and systems thinking; establishment of student loan programs, etc.

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