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**Promoting critical knowledge, skills and qualifications for
sustainable development in Africa: How to design and
implement an effective response
through education and training systems**

Sub-theme 3

**Lifelong acquisition of scientific and technological
knowledge and skills for Africa's sustainable
development in a globalized world**

Synthesis Paper- Sub-Theme 3

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Working Document

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Acronyms and abbreviations

AAS	African Academy of Sciences
AAU	Association of African Universities
ACTS	African Centre for Technology Studies
ADEA	Association for the Development of Education in Africa
AfDB	African Development Bank
AIMS	Africa Institute of Mathematical Science
ALC	African Laser Centre
ANSTI	African Network of Scientific and Technological Institutions
APHRC	Africa Population and Health Research Centre
ATPS	African Technology Policy Studies Network
ASSAF	Academy of Science of South Africa
ASTII	African Science, Technology and Innovation Indicators Initiative
ASTIPI	African Science, Technology and Innovation Policy Initiative
AU	African Union
AUCC	Association of Universities and Colleges of Canada
AUST	African University of Science and Technology
CARTA	Consortium for Advanced Research Training in Africa
CGIAR	Consultative Group of International Agricultural Research
COEs	Centres of Excellence
COMESA	Common Market for Eastern and Southern African States
CPA	Consolidated Science and Technology Plan of Action
DAAD	German Academic Exchange Service
DFID	Department for International Development
EAC	East African Community
ECOWAS	Economic Community of West African States
EFA	Education for All
EMIS	Education Management Information Systems
GDP	Gross Domestic Product
HEI	Higher Education Institutions
ICEGB	International Centre of Genetic Engineering and Biotechnology
ICIPE	International Centre for Insect Physiology and Ecology
ICT	Information and Communication Technologies
ICRAF	International Centre for Agro forestry

IDRC	International Development Research Centre
IK	Indigenous Knowledge
ILO	International Labour Organization
ILRI	International Livestock Research Institute
ITU	International Telecommunication Union
IUCEA	International University Council for East Africa
MDGs	Millennium Development Goals
LPA	Lagos Plan of Action
NEPAD	New Partnership for Africa's Development
OAU	Organization of African Union
PPPs	Public-Private Partnerships
PUIB	Public University Inspection Board
QA	Quality Assurance
R&D	Research and Development
RECs	Regional Economic Communities
SADC	Southern African Development Community
SIDA	Swedish International Cooperation Development Agency
SMEs	Small Medium Enterprises
STI	Science, Technology and Innovation
TVET	Technical, Vocational, Education and Training
USAID	United States Agency for International Development
USHEPiA	University, Science, Humanities and Engineering Partnership in Africa
UIS	UNESCO Institute of Statistics
UNECA	United Nations Economic Commission for Africa
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNFPA	United Nations Population Fund
WB	World Bank
WIPO	World Intellectual Property Organization

1. EXECUTIVE SUMMARY

Introduction

1. Sub-Theme3 synthesis paper brings out salient points that need attention of policymakers, educators, scientists, economic actors, development partners and civil society to build and intensify utilization of scientific and technological capacities for sustainable socio-economic development in Africa.

2. The paper is informed by a number of contributions from country teams, development agencies and private sector, the Association for Development of Education in Africa (ADEA) Working Group on Higher Education, regional organizations and individual consultants. The contributions were supplemented by a literature review of reports by the African Union (AU)/New Partnership for Africa's Development (NEPAD), the World Bank, United Nations Educational, Scientific and Cultural Organization (UNESCO), United Nations Economic Commission for Africa (UNECA) and the African Development Bank (AfDB). Studies by regional research networks and researchers were also utilized.

3. Africa is richly endowed with abundant natural resources, diversity of cultures and indigenous knowledge, and a population which is predominantly youthful. Nevertheless, it faces the challenges of poverty, food security, health and climate change. This synthesis discusses how Africa can utilize its natural and human resources to fundamentally transform socio-economic status of its people. The envisaged transformation would be anchored on acquisition and utilization of scientific and technological knowledge and skills to add-value to natural resources, and tap the energy and talents of the people, especially the youth. This would facilitate the continent to be competitive and secure its rightful share of the global market and opportunities.

4. The synthesis paper has identified eight key issues critical to the process of acquisition and utilization of scientific and technological capacity for innovation and sustainable development in Africa for discussion at the 2012 Triennale.

Articulation of Science and Technology Policies and Programmes in Africa

5. The analysis starts with issues of articulation of policies and programmes pertaining to the development of scientific and technological capacity and institutions in Africa. The paper has analyzed how policies and programmes are articulated at continental, regional, national and institutional levels. The analysis has focused closely at the AU/NEPAD policy document entitled *AU/NEPAD, Africa's Science and Technology Consolidated Plan of Action (CPA) (November 2005)*. In addition to the policies and programmes articulated at the continental level, the paper has shown how these have been cascaded by Regional Economic Communities (ECOWAS, EAC, COMESA and SADC) and at national and institutional levels.

6. A major issue identified as a constraint to the realization of science and technology in Africa is lack of effective mechanisms for implementation, monitoring and evaluation. The CPA has also initiated an ASTII process for this purpose.

7. The analysis has concluded by identifying action points to strengthen implementation of the agreed agenda in science and technology. Building national capacities in African countries was identified as a critical need for implementation of the agreed commitments at various levels.

Foundations of Lifelong Learning of Science and Technology

8. The ability to continue to learn as the world changes, knowledge increases and technologies become more sophisticated is very critical for survival and sustainable development. The analysis has identified three critical areas to lifelong learning namely: i) appreciation and incorporation of indigenous knowledge in the learning process; ii) quality teaching and learning of science and technology in schools; and iii) investing in quality teacher education especially in science and mathematics. The paper argues that integrating indigenous knowledge within the education system coupled with quality teaching and learning of science and technology in the early stages of basic education is crucial to success in acquisition, adoption of scientific and technological knowledge at other levels of education and training, and in the society.

9. Tertiary education bears the major responsibility for pre-service training of teachers for basic and technical education. While recruitment into teacher education and formation of teachers is major constraint in provision of quality education at all levels, research to guide policy and interventions is lacking. Hence increased attention to research on status of science education at all levels: content, pedagogy and practice is required.

10. Quality of science education in Africa will ultimately depend on the quality of those recruited for teacher education, quality of in-service training and professional development provided especially for mathematics and science teachers, and in sufficient numbers to meet current and future demand for the rapidly changing enrollments at all levels of the education system. The paper has argued that the strategies proposed are critical to establishing a firm foundation for lifelong learning of mathematics and sciences among African learners.

Preparing African Youth for Science and Technology Endeavors

11. By any definition, youth constitute a large proportion of the population of Sub-Saharan Africa. In 2010 the total Africa population was estimated at 867 million and youth age 0-14 constituted 43.2 per cent, while those aged 15-34 were 34.9 per cent. Those above 35 were 22 per cent. However according to the United Nations Population Fund 2011 report, Africa population surpassed a billion people in 2009 and is projected to increase to two billion in the next 35 years (2044). This population will however remain relatively young, as fertility in most African countries is unlikely to change dramatically in the next three decades. According to Michelle Gavin, 2007 “Africa is currently in the midst of what demographers call “a youth bulge,” indicating a significant increase of young people in the structure of the population. The impact of this youthful population on the current and future developments in Africa is worthy a close analysis.

12. Investing in “youth bulge” to acquire scientific and technological knowledge and skills through quality education at all levels, provision of healthcare and democratic space through visionary leadership, offers a great opportunity for Africa to turn its rich natural resources into a firm foundation for economic growth, entrepreneurship, employment creation, competitiveness and sustainable development.

13. The national governments should establish mechanisms and institutions for promoting innovations among youth. Articulation and implementation of comprehensive and inclusive policies and mechanisms to build scientific, technological and entrepreneurial capacities of youth for socio-economic transformation of Africa societies should be policy imperative. National governments and other stakeholders should also widen opportunities for young scientists to access research funds and fellowships for further studies to improve their capacities for research and innovation.

14. Ignoring the youth potential is to deny Africa its most precious resource for sustainable development.

Tertiary Institutions: Research, Innovations and Linkages

15. Tertiary education is highly valued in Africa. The proportion of household income and national budgets allocated to tertiary is indicative of the high demand and value placed on access to tertiary education. The almost insatiable demand for tertiary education is fueled by the increasing number of secondary school graduates and adults interested in improving their qualifications and skills. However, despite the rapid expansion of tertiary education institutions in the last two decades and increased resources, Africa remains the only region in the world with the lowest proportion of higher education cohort accessing tertiary education. In 2011, only 6 percent of appropriate age cohort was able to access higher education. Tertiary institutions are critical to socio-economic development in Africa as they represent a concentration of resources and talents (staff and students). In many African countries they are an integral part of the national research and innovation system.

16. The synthesis paper has discussed at the length the role of tertiary education in transmission of scientific and technological knowledge, research and innovations. A number of issues have been explored under this rubric: i) the nature and implications of the expansion of tertiary education; ii) the quality of education provided thereof and strengthening of QA especially in scientific and technological education; iii) the role of centers of excellence in building the necessary capacity for teaching and undertaking relevant research and iv) university- industry linkages.

17. The growth of tertiary institutions in the last two decades has been remarkable. While private universities continue to increase at a higher rate than the public ones, student enrolments in private institutions remain low. Hence public universities remain dominant in terms of diversity of academic programmes, public funding, research infrastructure and overall quality of staff and student body.

18. Given the limited resources allocate to higher education and R&D, issues of transparency, efficiency, accountability, and effectiveness in utilization of the available funds in expansion of tertiary institutions and in the improvement of research and innovation processes should be given more attention than hitherto.

19. On the whole the expansion higher education particularly in sub-Saharan Africa has not given appropriate weight to science, technology, research and innovation. Consequently there is an urgent need to reorient African universities and other tertiary institutions towards science and technology to bring out the much needed balance between social sciences and science-based courses and professions.

20. There is no question that Africa needs differentiated universities, training colleges, research institutes, polytechnics and other tertiary institutions to meet its scientific and technological advancement and other developmental needs. A balanced development of tertiary education to meet diversity of needs of national economies is therefore necessary. A policy rethink on the current approaches to increasing places in higher education is urgently needed.

21. A continuing challenge is not only to improve overall quality of education and professional training in African universities but also to create Centers of Excellence in post-graduate training, post-doctoral exposure and research and development. Efforts geared towards this are notable at national, regional and international levels. The establishment of African Institute of Science and Technology and the proposed Pan-African University are initiatives intended to harness Africa's talent in a collaborative manner by utilizing limited resources effectively through concentrated endeavor in critical and strategic fields of development.

22. Under university –industrial linkages, two papers were prepared focusing on this critical concern in development discourses. Both have given examples of university and productive sectors linkages, and analyzed various dimensions of the emerging relationships. A number of action points have been identified. University –industry linkages need to be re-defined to bring it closer to the African socio-economic reality, especially the fast growing small and medium enterprises in the informal sector. Universities need also to articulate policies and rules to guide and govern the

relationships between them and the productive sectors. The relevance, focus and quality of research and innovation capacity need to be strengthened to meet the expectations of the productive sectors.

Exclusion and Inequalities in Access to Science and Technology

23. The equalities in access to education and subsequently to science and technology related fields tend fall into three broad categories: gender, regional and socio-economic status. Two contributions by FAWE entitled, *Strengthening Gender Research to Improve Girls and Women's Education in Africa* and *FAWE Gender in Higher Education Research Synthesis for ADEA Triennale* have been analyzed to highlight gender inequalities in access to scientific and technological knowledge and skills, under-representation and under- utilization in science and technology in the Africa society.

24. Consequently, women remain an underutilized resource in science, technology and innovation, robbing Africa the potential and talent of women. To improve access and conditions of women in higher education it is important to increase resources for gender mainstreaming and implementation of national policies and international commitments (EFA) and MDGs). The gender inequalities observed in tertiary education and R&D can be traced to the quality science education learning in primary and secondary schools.

25. While gender inequality in access to higher education is a subject to many studies, and policy debates, it should nevertheless be recognized that other forms of inequalities do exist. The most obvious is the increasing marginalization of students from poor households accessing tertiary education. In the first instance, children coming from conditions of poverty, at the initial stages have problems of accessing basic and secondary education, continuing to the other levels, and performing well to be considered for the very competitive access to tertiary education. However access to science related courses and professions is the most constrained. Discourses on social class and marginalized communities access to scientific and technological fields is limited by lack of systematic and reliable data, an issue that researchers and policymakers need to address.

ICT for Scientific and Technological Capabilities and Innovations

26. The rapid growth of ICT in Africa has created enormous opportunities and innovations that have accelerated political and socio-economic development. There is still a major digital divide between Africa and the rest of the world that could continue to widen if Africa does not address the persisting challenges, namely: (i) articulation of ICT policies and strategies (ii) development of ICT infrastructure; and (iii) capacity building.

27. Having quality capacity as well as quantity particularly on ICT is critical to building a creative and innovative knowledge society for sustainable socio-economic development in Africa. Building a scientific capacity requires not only adequate funding and infrastructure but also effective linkages where information and experiences are shared and learned. Governments that have embraced ICT in their economic development plans and vision documents need ICT professionals to oversee implementation of agreed policies and plans. The shortage of professionals is real, and those in place overworked and underpaid.

28. Hence African countries should go beyond articulating policies and investing in ICT infrastructure, to build and strengthen critical mass of professionals to spearhead changes required to realize MDGs, national visions and sustainable development.

Galvanizing Public Support for Scientific and Technological Development

29. Mobilizing public support for scientific and technological development in Africa is an important input in the process of implementation of commitments for Science, Technology and Innovation. Three elements are highlighted here: i) strengthening political will and building ownership of the

science and technology agenda and strategies for monitoring and evaluation of implementation; ii) cultivating scientific and technological literacy among politicians and decision makers; and ii) building creative partnership with media to communicate messages that underpin the contribution of science and technology to sustainable socio-economic development in each country.

Strengthening Regional Cooperation and International Engagements

30. Development of quality institutions for development of science, technology and innovation requires enormous resources (financial, infrastructural and human capital) which can be brought together through regional initiatives. The Lagos Plan of Action, 1980 and AU/NEPAD CPA, 2005, are some of the policy documents that recognize cooperation and collaboration in science and technology as a necessity for Africa's sustainable development and self-reliance. It is also noteworthy that countries which have articulated their national strategies for scientific and technological development have also indicated possible areas for regional cooperation.

31. Tapping the trained and qualified human resources base in Diaspora to support the development of science and technology in Africa is an unexplored opportunity and a challenge that need to be dealt with.

32. The synthesis paper has reaffirmed the value of regional and international cooperation in science and technology to bring out optimal benefits of collective actions to tackle common problems, and to tap the limited financial and human resources for this purpose.

Conclusion

33. In conclusion, the paper emphasized a number of areas where changes are required. These include: teaching and learning of mathematics and sciences at all levels of the education system, building scientific and technological capacity of the youth, revitalizing research and innovative capacities of the universities and linking them to productive sectors of the economy, ensuring inclusion of girls and women and marginalized groups in the development of scientific and technological capacity, building ICT infrastructure and capacity as a platform for change and innovation and strengthening the burgeoning regional cooperation. The paper calls for urgency in implementing science and technology agenda and visions for Africa to realize full benefits of its natural resources and youthful population in economic growth, industrialization, global competitiveness and sustainable development.

2. INTRODUCTION

2.1. Thrust of Sub-Theme 3

34. Sub-Theme 3 attempts to identify ways and means of building and strengthening Africa's capacity to acquire, generate, adopt and utilize scientific and technological knowledge and skills to confront the myriad and diverse challenges of sustainable development in the context of rapid globalization. The underlying assumption of the Sub-Theme is that development in Africa has to be fully anchored in acquisition and utilization of high level knowledge and skills by, and for its people to effectively exploit its rich natural resources to achieve sustainable socio-economic development. This has to be realized in the context of democratic transformation and gainful engagement at the global level.

35. To realize the above, Africa needs take a number of well calculated measures and strategies. These includes: articulation of a vision of scientific and technological development; investing in lifelong quality learning of mathematics and science in the education system that incorporates indigenous knowledge and skills; investing in scientific and technological capacity of all its youth; revitalizing higher education and linking with industry and productive sectors; work towards inclusion of women and marginalized groups in science and technology (S&T); building a strong capacity and infrastructure for knowledge creation and innovation through Information and Communication Technologies (ICTs); and strengthening international and regional cooperation and collaboration in research and development and innovation.

36. The synthesis brings out salient points that need attention of policymakers, educators, scientists, economic actors, development partners and civil society to build and intensify utilization of scientific and technological capacities for sustainable socio-economic development.

2.2. Guiding Concepts

37. This synthesis paper is guided by three interrelated concepts. First, lifelong learning that entails continuous acquisition of scientific and technological knowledge and skills from childhood to adulthood, throughout the education process, working and life situations. It underscores and recognizes obsolescence of knowledge and skills and the need to retool and acquire new knowledge and know-how. Thus learning to learn, openness to new ideas and ways of doing things and ingenuity are critical attributes. Secondly, sustainable development implies careful utilization of current resources to meet present needs while being stewards for the future generations. Thirdly global integration and competitiveness implies Africa taking up its rightful place in the world not only as a producer of raw materials and consumer of imported products, but as a critical player that adds value to its natural resources and creates goods and services that compete in the knowledge economy.

2.3. Methodology

38. The synthesis is informed a number of contributions from country teams, development agencies and private sector, the Association for Development of Education in Africa (ADEA) Working Group on Higher Education, regional organizations and individual consultants. The contributions were supplemented by a literature review of reports by the African Union (AU)/New Partnership for Africa's Development (NEPAD), the World Bank, United Nations Educational, Scientific and Cultural Organization (UNESCO), United Nations Economic Commission for Africa (UNECA) and the African Development Bank (AfDB). Studies by regional research networks and researchers were also utilized.

39. The synthesis incorporates lessons and experiences from all African regions.

2.4. Scientific and Technological Development: Global and African Contexts

40. The last three decades the world witnessed unprecedented development of scientific and technological knowledge. Generation of new knowledge has in turn led to creation new technologies, processes and products into the global market. Innovation is the hallmark of this epoch. The economies of developed countries have been fundamentally transformed and shifted to what has been termed as knowledge societies. The development of ICT has been decisive in this regard.

41. Developed countries and emerging economies in Asia and Latin America embrace the ongoing global transformation and are investing enormous resources to strengthen their research capacity, institutions and programmes not only to spur socio-economic development but also to be competitiveness and expand their share of global market. Universities and research institutions are therefore not only in the forefront of increasing human capacities for their expanding economies, but also undertaking cutting-edge research. Emerging economies in particular have accelerated their investments in R&D as shown by the proportions of GDPs being devoted to generation of new knowledge and innovations (South Korea - 3.5%; Singapore - 2.6%; China - 1.5%; Brazil -1.0; Malaysia - 0.8 and India - 0.6 (UIS.2009). Consequently the economies of these countries have become highly competitive in development of scientific and technological research and innovation. Their readiness to bring new products into the market has generated fierce global competition as evident recently between Apple and Samsung corporations. The globe has therefore become a marketplace for ideas, creativity and innovation.

42. While Africa is richly endowed with natural resources it is nevertheless economically marginalized in the global knowledge economy given its low scientific and technological capacity. Africa's share of global trade is also marginal, being about 3 percent (AfDB, 2009). The continent has 15 per cent of the global population, but its scientific and technological publications compares poorly with other regions being less than 2.0 per cent (Pouris and Pouris, 2009; ATPS, 2010 and Hassan, 2009).The leading countries in this respect are however, South Africa, Egypt, Morocco, Nigeria, and Tunisia. On average African countries allocate an average of 0.3 percent of their GDP to R&D.

43. Thus most African countries continue to be predominantly producers of raw materials: oil, agricultural and mineral commodities. Since independence no significant movement towards value-addition to primary products, a persistent challenge to the continent's scientific and technological capability. Scientific and technological advancement is also caught up in the midst of challenges of building and entrenching democratic institutions and practices, bringing civil conflicts and wars to an end, realizing the MDGs, ensuring sustainable and effective management of natural resources in the context of climate change, and turning the relatively youthful population into a demographic dividend. Regional integration is also a challenge needing attention in terms of increasing inter-Africa trade, building infrastructure and effective utilization of the available resources and expertise.

44. All these challenges points towards the necessity of building credible African scientific and technological capacity and capability geared towards utilizing the enormous natural resources and population to create opportunities and wealth for the present and future generations. In this context, Africa needs to identify critical drivers in transformation of the current situation to the envisaged rapid and sustainable socio-economic growth (AU/NEPAD, 2007).

45. Below, the synthesis paper has identified key drivers and actions to be taken by various stakeholders to enable Africa not only to run, but to do so faster than other regions in order to catch-up and win the global marathon for sustainable development.

3. ARTICULATION OF SCIENCE AND TECHNOLOGY POLICIES AND PROGRAMMES IN AFRICA.

3.1. Background and Continental Initiatives

46. Since the 70s African countries have articulated policies and programmes geared towards harnessing science and technology for development and in particular in the agricultural sector. However, two major continent wide policy documents stand out in their articulation of African vision for socio- economic development, through adoption and utilization of science and technology for sustainable development. These are the Lagos Plan Action for Economic Development of Africa 1980-2000 (April 1980) and the AU/NEPAD, Africa's Science and Technology Consolidated Plan of Action (CPA) (November 2005). The two documents have articulated African aspirations for acquiring, building and strengthening capacity for utilization of scientific and technological knowledge and competences for sustainable development (Adedeji, 1985; Miho, 2011).

47. Building on past African experiences and ideas, the AU-NEPAD's Consolidated Science and Technology Plan of Action thrust is to articulate Africa's broad vision and 'objectives and commitment to collective actions to develop and use science and technology for the socio-economic transformation of the continent and its integration into the world economy.' This thrust is anchored on three pillars: capacity building, knowledge production and technological innovation. Hence the CPA is a rallying call for Africa to utilize scientific and technological knowledge and skills to release the full potential of its people and endowment of abundant natural resources. In this way, the continent can liberate its people from the scourges of poverty, implement the Millennium Development Goals (MDGs) and realize its cultural renaissance, while integrating into the global knowledge economy.

48. The CPA has identified a number programmes for research focus among them being biotechnology, biodiversity and indigenous knowledge, water, energy, ICTs, use of laser technologies, mathematical and material sciences.

49. The document has articulated in a summary form the collective desires and aspirations of the African people as discerned in the last three decades in various fora: head of government's summits, policy workshops, scholarly discourses and research documents. These have included the views of political leaders, policy makers, development partners, private sector players, civil society actors, scholars and researchers. In essence the role of science and technology in socio-economic development of Africa is fully accepted, and no longer a matter of debates or pious declarations, but the concern is how to harness the power inherent thereof (AU/NEPAD, 2007; ATPS, 2010; Hassan, 2009 and Kamoun, 2011).

50. A broad consensus has thus been reached that concerted implementation of the articulated policies and programmes to acquire adopt and utilize of scientific and technological knowledge and skills is critical to the realization of the continental and national commitments that African governments have made. Such commitments relate to implementation of EFA, realization of the MDGs and sustainable development. All these require building and marshalling scientific and technological capacity for their realization.

51. AU since its formation has built political consensus needed to give priority and increased attention to the development of science and technology for socio-economic development. These efforts have been accompanied by solid support by the UN agencies such as the UNESCO and UNECA.

52. UNESCO in particular has taken leadership through the UN Science and Technology Cluster to support of AU-NEPAD initiatives. For instance, it has launching the African Science, Technology

and Innovation Policy Initiative (ASTIPI) to assess the status of Science and Technology policy formulation in Africa, provide technical advice and support for national STI policy reviews, develop common African STI indicators, and create of an African STI observatory.

53. The articulation of African policies and programmes and initiatives on STI undertaken at continental level while a culmination of past regional and national efforts, it has gone a long way to galvanize, and reinforce policies and actions being made at regional, national and institutional levels. These are reviewed briefly below.

3.2. Regional Economic Communities

54. Regional Economic Communities (RECs) have also indicated strong commitment to promotion of S&T for socio- economic development in Africa. The continental vision on S&T finds echoes in RECs namely: the Common Market for Eastern and Southern African States (COMESA), Economic Community of West African States (ECOWAS), East African Community (EAC) and Southern African Development Community (SADC). These regional entities have not only strong mandates in this field, but have also gone ahead to articulate and formulate regional policies and collaborative programmes to realize ST&I in their respective regions (Mugabe, 2009; Mihyo, 2011).

55. International and regional institutions such as the World Bank, UNESCO, and AfDB have also indicated support to these efforts. In 2008 the AfDB came up with its *Higher Education, Science and Technology Policy* to guide engagement and funding of projects in this field.

56. A number of international and regional research institutions are hosted in a number of African countries, but with regional mandates. These have become centers of excellence in their respective fields of research and development (Mugabe, 2009). Kenya is a host to a number of such important international institutions whose mandates are regional and international. These are: the International Centre for Agro forestry (ICRAF), the International Livestock Research Institute (ILRI) and the International Centre for Insect Physiology and Ecology (ICIPE). A number of research institutes, networks and such as the Africa Population and Health Research Centre (APHRC), African Centre for Technology Studies (ACTS), African Technology Policy Studies (ATPS), the African Academy of Sciences (AAS) are located in Kenya.

57. South Africa is also a host to the International Centre of Genetic Engineering and Biotechnology (ICEGB), the African Institute of Mathematics and Science (AIMS) and the Southern African Biosciences Hub, among others.

58. Some of the networks and institutions work under the auspices of AU and NEPAD, some these being, the African Bioscience Initiative, AIMS, African Laser Centre (ALC) and the African Science, Technology and Innovation Indicators Initiative (ASTII) (AU/NEPAD, 2007 and UNESCO, 2005).

59. These initiatives are intended to serve African countries and do receive support not only from African governments hosting them but also international development agencies. In many respects they complement and supplement efforts of national research systems and centers of excellence that are being built through collaborative programmes within and outside higher education institution throughout Africa (Mihyo, 2011).

3.3. Establishing National Priorities and Initiatives

60. While AU and NEPAD tend to articulate continental objectives and regional economic communities have taken initiatives to the regional levels, the articulation of national priorities and strategies remain the prerogative of national governments, ministries and institutions responsible for S&T. While the ongoing African- wide initiatives or those of RECs are appreciated, they cannot replace national processes and plans.

61. At national level we would like to observe that each country tend follow its path in articulating scientific and technological priorities and strategies. In the past each national council for science and technology had the mandate to articulate Science and Technology strategies, programmes, institutions and innovation processes. Morocco had a proactive innovation policy. The country has extensively reformed its universities and research system since 1997. Measures to promote technology transfer, technology networks, ambitious thematic networks (quality, biotechnology, marine research, high-energy physics, space technology) have been introduced. But more recently this task has been taken up by the Ministries responsible for science and technology. In some countries, however this is done through political statements, national vision documents and strategic documents (UNESCO, 2010a; Mugabe, 2009). The vision documents of Ghana, Kenya, Nigeria, Rwanda and Uganda, for instance, incorporate S&T strategies (Ghana Vision 2020, Kenya Vision 2030, Nigeria Vision 20: 2020, Rwanda Vision 2020 and Uganda Vision 2020).

62. A few countries have indicated their priority in a number of documents such the development plans, white papers and other strategic documents on science, technology and innovation. Mozambique and South Africa have tended to follow this path. In some countries, research priorities in science and technology have tended to be defined from a sectoral perspective, for instance in agriculture biotechnology and energy as priority areas for concentration (Mugabe, 2009). Burkina Faso, Senegal and Uganda fall into this category. The resurgence of mineral trade has led to increased interest in pursuing scientific research and technologies related to development of mining. This interest is observable in Botswana, Liberia, Sierra Leone, Zambia, and Zimbabwe where mining and minerals are dominant economic activities.

63. In setting their priorities, some countries have adopted a process that brings together stakeholders to articulate collective national vision and priorities of their countries. This commendable as to where this has happened, the process has tended to mobilize support, create a sense ownership and build public awareness of the value of pursuing policies oriented towards acquisition and utilization science and technology for development.

64. Countries with the most successful innovation record are those that have been able to ensure consistency between their policies and actions. They are also often those that have managed to ensure continuity in the long run. The examples of Korea, Finland and Japan are striking in this respect: in these three countries, technological progress was a national imperative for half a century; innovation policy was a fixed strand of government action. National experts have insisted that this continuity was guaranteed when there were changes in governments, which did not question these aspects of policy.

3.4. Emerging Issues and Expected Action Points

65. While most African countries recognize usefulness of articulating policy, creating requisite institutions, building capacities and promoting regional cooperation there is need for increased and consistent investment in science, technology and innovation. However, these investments must demonstrate concrete and widespread benefits to the people whose concerns for food security, health, water, energy and livelihoods are priority. This can be done through coherent implementation of national policies, programmes, creation of relevant institutions and building requisite capacities. In this way national agendas can be realized while fulfilling the agreed upon continental, regional and international commitments. Hence national ownership of policies and implementation strategies is critical to success (ATPS, 2010).

66. Despite good intentions, unfortunately Africa is not adequately prepared to exploit the potential of ST&I in development its rich resources and the relatively youthful population. This lack of preparedness will be discussed in other sections of this synthesis paper (ATPS, 2010).

- Make STI key to national vision. Hence the need to build capacities of policy makers to make good policies, follow them through and recognize good practices from elsewhere. Also there is

need to build awareness among national leaders, policy makers and other stakeholders on significance of science and technology for present and future development,

- Create in each country a national observatory on ST&I,
- Identify clusters of excellence – as emphasised in the AfDB strategy — in order to permit effective cooperation between institutions and countries.
- Build capacity for regularly updating scientific data to inform policymaking. Each national government to establish a science depository centre for keeping scientific and technological research data for assessing current situation and for future reference.
- Increased national coordination and funding for Research and Development (R&D) as per continental and regional commitments of 1 per cent of the GDP. The
- Establish monitoring and evaluation systems as well as follow-up on agreed implementation processes.

3.5. The Way Forward

67. The articulation and promotion of policies, programs, institutions and capacity building related to the development science, technology and innovation, have been identified and analyzed at four levels: at the continental level (AU/ NEPAD, UNESCO and UECA); regional economic entities (COMESA, EAC, ECOWAS, SADC and regional research institutions); national bodies (national science and technology councils, Ministries, etc) and institutions (universities, research institutions and networks). In the process of formulating its policies and strategies, Africa has benefitted a great deal from international expertise and funding. These efforts are at different stages in various countries.

68. There is an urgent need to institute mechanisms for monitoring and evaluation of the progress to be achieved in the process of implementation of the agreed policies, strategies and set targets. An assessment of the effectiveness and output of African institutions, scientists and other professionals in science, technology and innovation need to be measured at country and regional levels; and international comparisons made. The CPA made a welcome recommendation where it advocated the establishment of African Science, Technology and Innovation Indicators Initiative (ASTII) for this purpose. This initiative under the auspices of NEPAD produced the *African Innovative Outlook 2010*, which covered 19 countries in all regions of the continent. This is a positive step in the direction of creating systematic indicators for measuring effectiveness of African efforts in turning policies and programmes into tangible results (Kamoun, 2011). Previous efforts have been made to evaluate the output of Africa scientific and technological communities and overall impact to the society, but they have been found wanting (UNESCO, 2010a and Pouris and Pouris, 2009). However the work of ASTII will initiate useful debates and eventually appropriate indicators to fill this important need will emerge.

4. FOUNDATIONS OF LIFELONG LEARNING OF SCIENCE AND TECHNOLOGY

69. In a world where scientific knowledge and technologies are changing rapidly and dramatically impacting socio-economic development, it is imperative that individuals not only acquire skills and knowledge for the present, but are empowered to continue learning and revitalizing their capacities to cope with the rapid changes. Such competencies and resilience is often referred to as lifelong education (World Bank, 2003). It embraces all aspects of human development from childhood, through adolescence to adulthood; entailing learning at household level, among peers, at school and at workplace. Such an education is gained through a process of interaction and encounter with other peoples and physical environment. The ability to continue to learn as the world changes, knowledge increases and technologies become more sophisticated is very critical to survival and sustainable development.

70. Therefore, the purpose of the Triennale is “to promote the critical knowledge, skills and critical that can help meet the challenge of sustainable development of Africa.” The three sub-themes focus on the central role of higher education in the development of STI in Africa and posit that “the development of Africa must be based on the use of knowledge and high-level skills so that its people can manage effectively, the daily challenges of development and global economic competition.” The main idea of this Sub-theme is based on what has become almost self-evident in studies related to sustainable development, namely, that the strengthening of scientific and technological development is the key to development. To explore the most important means by which Africa can develop an STI system means exploring the different roles to be played by the multiple actors involved in this work. This is a complex process which can be found at the center of higher education, involving actors as diverse as governments, universities, private sector, NGOs, the informal sector, the international community and local and regional communities. This is indeed an approach that lies at the heart of what constitutes sustainable development, namely, development that is no longer focused on increasing economic competitiveness, but mainly on economic development based on an ethical vision of the different dimensions of development and their implications for the development of the individual and society and to safeguard the environment. Promoting STI for economic development in the context of globalization thus entails an approach that requires critical concepts without which we cannot address the issue.

71. Below we identify and discuss two critical foundations for lifelong process for acquisition, adoption and utilization of scientific and technological knowledge and skills in Africa to improve livelihoods in a sustainable manner. These are: indigenous knowledge (IK) systems and the schooling system.

4.1. Indigenous Knowledge

72. As Nicolas Gorjestani (2000) argued, “indigenous knowledge (IK) is used at the local level by communities as the basis for decisions pertaining to food security, human and animal health, education, natural resources management, and other vital activities.” It therefore entails knowledge, practices and skills embedded in local beliefs, customs, cultural and spiritual values of communities that guide decisions and actions related to livelihoods; interaction, utilization and safeguarding the environment. It also entails the process and methodologies of acquisition and transmission of IK on a continuous basis, as well as creative adoption and utilization in the changing circumstances of the communities.

73. In the last two decades indigenous knowledge has been recognized as a potent resource for tackling issues related to sustainable development, improvement welfare of individuals and

communities, empowering people and an essential foundation for building firm ownership of development processes (World Bank, 2004; ATPS, 2010; AU/NEPAD, 2007).

74. The turn round in the way development actors or practitioners view the indigenous knowledge as an integral part of sustainable development has been remarkable, and in turn has boosted research interests in this field. This rekindled interest in indigenous knowledge came after many decades of neglect, reviling and marginalization. Development experts and scientists often ignored or reviled indigenous knowledge as a mechanism of knowing, understanding and solving community problems. It is this turn around which has brought a flurry of IK activities by international institutions, local civil societies and communities. As former Tanzanian President Benjamin Mkapa acknowledged, in affirming support of IK, “local solutions were even discriminated against as hindering progress, outdated, “old wives tales” or simply just unfashionable. As we “modernized” our societies, a “degree” in traditional indigenous knowledge was not planned for. Hence, we overlooked its potential as a resource and even further neglected the knowledge that women and men, families and communities had developed themselves for centuries” (Benjamin Mkapa, 2004).

75. The assault on indigenous knowledge was carried through various channels such as religion, education system, foreign languages and other forms of domination. It is upon this backdrop that the current revival of indigenous knowledge needs to be seen.

76. The acquisition and transformation of this knowledge and related skills are embedded in the life of the communities as means of livelihoods and sustainable development. It is living and vibrant. Thus its continuity in the midst of the onslaught of ‘modernizing’ forces attests to its resilience. It is essentially lifelong and adaptive to the changing circumstances (World Bank, 2011a). The fact that it continues to survive parallel to modernization tendencies of colonialism and westernization is an indication of its strength, flexibility and relevance.

77. However, the ongoing revival and interest in indigenous knowledge need be incorporated into the learning and teaching methodologies, processes and practice of science in schools. In this way becoming an essential pillar for learning of scientific and technological knowledge and skills throughout the schooling system. This would breakdown the current duality between local community knowledge (environment where students are brought up), and what is taught in the classrooms. This is a challenge and an opportunity for integration and harmonious development of the two approaches to acquisition of scientific and technological knowledge relevant to sustainable development Africa.

78. Where the language of instruction is the language of the community, this integration can be relatively smooth and duality minimized. The use of mother tongue as the initial language of instruction would go along to facilitate the integration of indigenous knowledge and school learning.

4.2. Teaching and Learning of Science and Technology in Schools

79. The second foundation of lifelong learning and renewal of scientific and technological knowledge and skills is what is learnt through the formal schooling system. The critical element here is the teaching and learning of sciences. Teaching an appreciation of scientific methodologies and principles is perhaps better inculcated in the early stages of basic education (Juma et.al, 2005), if not done at household level.

80. In this context the role of the teacher is fundamental to cultivating an appreciation and mastery of the subjects, and especially mathematics and science. Hence the quality of teaching is very important for attainment of the requisite knowledge, competences and behavior needed by students for success in further training and higher education.

81. The environment created for pupils to learn mathematics and science is also very important. It starts with acknowledgement and appreciation of learning gained by learners in their families, among peers and the communities where they live. The challenge to school management and teachers is to recognize the knowledge and skills that pupils bring along with them, and build on them by providing quality learning environment in the schools. Where teaching and learning in schools recognize the knowledge in the community, then school does not alienate students in the process of schooling. This is the integration which we have argued above is needed throughout the schooling process.

82. For pupils to succeed in acquisition of scientific and technological knowledge and skills necessary in the society, learners need to interact with parents, communities, teachers and school environment. A rich school environment provides and appreciates the totality of the environment of the learner, the community and the school. This is intended to incorporate the concept of “education through science’ where the learner’s environment is the laboratory (Holbrook, 2009).

83. Unfortunately in Africa the teaching and learning environment that pupils encounter in schools is not often the best in terms of competence and qualification of teachers, availability of textbooks, classroom space and laboratories. In addition, the dominant teaching methodologies are often not learner centered, least interactive and rely on rote learning. The teaching and learning is oriented towards passing examinations. Parents, teachers and students are fixated on doing well in examinations rather than learning.

84. At the basic level students are confronted with poor quality teachers and learning environment. In this way, learning is hampered and requisite knowledge and competences are not achieved.

85. In this situation the starting point is to recognize that the pupils come from their environment with the knowledge and skills available in the communities. This could be skills of language, numeracy, inquiry and observation and overall knowledge of the environment in which they live. The school environment through teachers and the management can enhance the knowledge and skills that pupils bring from home to school and build on them. In many instances school ignore this and proceed to inculcate new knowledge, behavior and skills.

86. Hence the training, attitudes and behavior of teachers in relation to IK, is critical to integration of home and school knowledge. Their creativity and innovation in this context are crucial to providing quality and relevant education and especially learning of mathematics and science.

87. However the challenge remains that of bringing together what is learnt at home and school, integrating it into school learning and continuing education.

4.3. Teacher Education

88. Quality of teaching and learning of science and technology hinges on the quality of teachers available at all levels. This is usually varied. In some schools, qualified teachers dominate while in others poorly trained and unqualified teachers are common. Yet the foundation of advanced training in scientific and technological knowledge and skills is built at these early stages where teachers are engaged with the pupils in classrooms on daily basis. This remains a major challenge to education systems in Africa.

89. The in-service training for basic education teachers is undertaken at two levels: the non- degree colleges, and the degree granting colleges and universities. The quality and effectiveness of these programmes are in many cases constrained by the caliber of students’ recruited, pedagogical exposure and subject content provided while undergoing teacher education (World Bank, 2007; Kerre 2000). Overall the students recruited are academically weak and especially in mathematics and science. Again while in training they are not given adequate exposure to subject content to prepare them for teaching of science (World Bank, 2007). Often they get pedagogical training with minimal in-depth knowledge of the subjects they are expected to teach. One would expect these initial weaknesses to be

rectified through subsequent professional development of teachers. However these programmes tend to be poorly funded and planned to make a real dent in improving the quality of teaching and learning in schools and especially in subjects such as language, mathematics and science.

90. Hence we need for policies and effective quality assurance mechanisms that integrates the process of recruitment, training, professional development, motivation and rewards system and status of science and technology teachers (World Bank, 2007; UNESCO, 2007a).

91. Tertiary education bears the major responsibility for pre-service training of teachers for basic and technical education. However the recruitment into these institutions is not often for students who have performed well in mathematics and sciences, but more often those who cannot make it elsewhere.

92. While recruitment into teacher education and formation of teachers is major constraint in provision of quality education at all levels, research to guide policy and interventions is lacking. This is an area which needs research to unravel the quality of teacher education provided in the institutions which are mandated to do so. This is especially for mathematics and science teachers.

93. For Africa to realize its vision of a science and technology driven society, it has to break the vicious circle of recruiting poor students for teacher education, giving them half- baked teacher education and then sending them out to prepare the future generations of scientists, technologists and innovators. It is imperative that this vicious cycle is broken for Africa to build a firm foundation for scientific and technologic advancement. Multi-prolonged policies and strategies for this should be articulated starting with initial training coupled with professional development of those teachers who are motivated and are interested in improving their knowledge and skills.

94. Coupled with the above, teaching profession in Africa is characterized by low status, poor remuneration and lowly motivated personnel. Yet these persons are the ones given the responsibility of nurturing the future generations of scientists and technologists. These professionals are often on looking out for what they consider better opportunities elsewhere. This leads to hemorrhage of the teaching profession. The students and especially the girls who survive this battering process must indeed be intelligent, committed and determined to overcome and succeed.

4.4. Expected Action Points

- Articulation of policies and strategies for capacity building of science and mathematics teachers: pre-service in-service and continuous profession development focusing on subject content (incorporation of IK), pedagogy and practice.
- Increased attention to research on status of science education at all levels: content, pedagogy and practice
- Quality of science education in Africa will ultimately depend on the quality of those recruited for teacher education, quality of in-service training and professional development provided especially for mathematics and science teachers, and in numbers to meet current and future demand for the rapidly changing enrollments.
- Use of ICT and internet in teaching and learning: distance education targeting teachers and students: ICT enhance access to and dissemination of information as well reduce time and cost
- Quality assurance mechanism: to validate and certify skills and knowledge acquired, accrediting institutions and making information available .

5. PREPARING AFRICAN YOUTH FOR SCIENCE AND TECHNOLOGY ENDEAVORS.

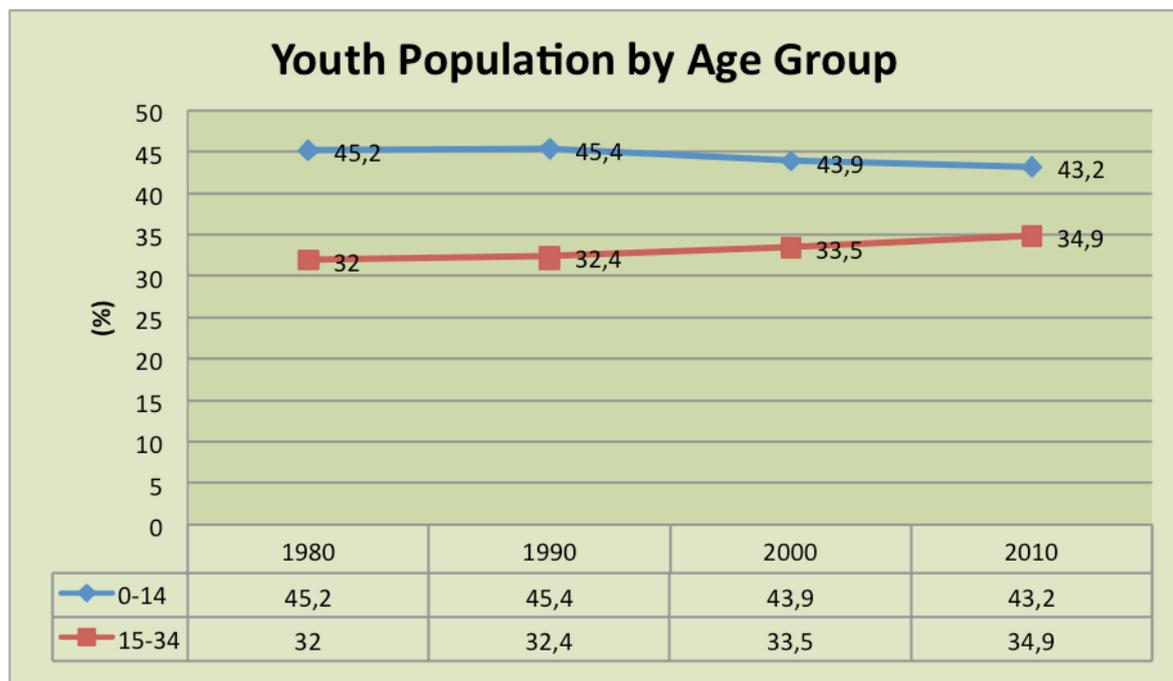
95. The term “youth” is complex; assuming multiple meanings in different organizational and cultural contexts. In some situations youth refers to a population category delineated by years, while in other situations, youth is considered as a “problematic” stage in human growth and development (Sommers, 2001). In most African societies, the youth are “commonly perceived in the process of becoming rather than being” (Diouf, 2003 and Boeck & Honwana, 2005), perhaps because they are perceived as “young” and not fully grown up adults.

96. In practice and depending intended purpose(s), regional and international organizations define the term by specifying varying age categories of youth. The United Nations (UN) agencies like International Labour Organization (ILO) define youth “as those aged 15-24 years”. We find the definition too restrictive in Africa as it excludes a critical mass of young people at different stages of development in and out of education and training institutions, and going through various transitions. Some are transiting from childhood to adults, from basic of education and training to higher education, and from school to the labour market in search of jobs (Youth Consultation, 2011). Hence in this context we have adopted a definition of youth that is favoured by AU and more embracing to include all those below 34 years of age.

97. By any definition, youth constitute a large proportion of the population of Sub-Saharan Africa. In 2010 the total Africa population was estimated at 867 million and then youth age 0-14 constituted 43.2 per cent while those aged 15-34 were 34.9 per cent. Those above 35 were 22 per cent (see Table 1 below). However according to the United Nations Population Fund (UNFPA) 2011 report, Africa population surpassed a billion people in 2009 and is projected to increase by two billion in the next 35 years (2044). This population will however remain relatively young, as fertility in most African countries is unlikely to change dramatically in the next three decades.

98. According to Gavin (2007), “Africa is currently in the midst of what demographers call “a youth bulge,” indicating a significant increase of young people in the structure of population. The impact of this youthful population on the current and future developments in Africa is worthy a close analysis. Unless meaningful national policies and measures are put in place to guide and utilize the potential they represent, the projected growth will exacerbate youth unemployment and levels of poverty levels in the region, leading to entrenchment of hopelessness and instability. This situation could explode into violent struggles as the youth challenge the existing institutional, economic and political arrangements. The rumblings of discontent are already being felt in some African countries.

Table 1: The Growth of Youth Population in Sub-Sahara Africa, 1980-2010.



Sources: United Nations, *World Population Prospects cited in World Youth Report (2007)*; Population Reference Bureau, 2010; Trading Economics.com

5.1. Preparing for Youth Bulge Dividend

99. Youth in Africa are generally marginalized and allocated limited space and resources (Chinguta, 2002; Deborah, 2004; Boeck & Honwana, 2005; and Comaroff & Comaroff, 2005). This youth is characterized by high rate dependency requiring high investments in education, health care and jobs. With 60% of the total unemployed, the youth make up the bulk of the unemployed or underemployed in Africa. The share of unemployed youth among the total unemployed can be as high as 83% in Uganda, 68% in Zimbabwe, and 56% in Burkina. Recent estimates of the AfDB based on household surveys for selected countries in Sub-Saharan Africa and data from ILO reveal that youth unemployment, including those who have stopped actively searching for employment is around 34% (Figure 2). Youth unemployment in Tunisia was estimated at 14.2% in 2010, and is even more pronounced among young graduates with masters’ degrees in law, economics and management, estimated at 47 percent in 2007 for individuals between 23-29 years old (Stampini & Verdier-Chouchane, 2011).

100. They are well informed of the technological advances being realized globally, but often lack appropriate knowledge, skills for formal employment or entrepreneurship. Hence access and utilization of the available technologies for productive activities in their environment is limited. On the whole the young people are looking for better education, training, skills and opportunities to be productively engaged (UNECA, 2011; UN, 2010).

101. The “youth bulge” in Africa if well taken care of in terms of investing in acquisition of scientific and technological knowledge and skills through quality education at all levels, healthcare and democratic and visionary leadership, offers a great opportunity for Africa to turn its rich natural resources into the basis for economic growth, employment creation, and sustainable development (Gidoomal, 2011; ATPS, 2010). The challenge of the “youth bulge” is to see how the young people can become a force for transformation of the current situation to a future where their energies are utilized to unlock the wealth that is theirs in their countries. However when denied these opportunities,

they became a potent force of frustrated and angry missile for violence, crime and unruly behavior. Recent experiences in Liberia, Sierra Leone, Cote d'Ivoire, Guinea, DRC, and Somalia, and indeed in North African are a pointer to the urgency of proactive policies and initiatives targeting the youth.

102. Hence African countries need to see how the AU/NEPAD CPA could become a platform for African countries to articulate pro-youth policies, programmes, institutions and capacity building to target a wide spectrum of youth, in addition to those enrolled in the education system, technical and vocational institutions. This would go a long way to respond to the needs of out-of-school youth, those leaving school early and graduates unable to find jobs.

103. Until recently, African youth were largely excluded from key decision making structures and processes (Comaroff and Comaroff, 2005) Also due to their state of joblessness, African youth face challenges in accessing basic essential services, positions of leadership and decision-making in the economy, education and training, science and technology, healthcare, politics and community.

104. An assessment of youth programmes that have been initiated in a number of African countries to respond to youth unemployment, underemployment and lack of scientific technological skills, for instance, Kenya, Tunisia and Sierra Leone often do not give adequate attention to the diversity of youth needs.

105. A typical policy response has been to raise educational levels and increase enrollments in higher education programs. This has however not always yielded the expected results in North Africa. In 2007, youth unemployment in Tunisia was 20% among those without diploma, 30% with secondary diploma and close to 50% among those with advanced degrees in economics, management and law (Stampini & Verdier-Chouchane, 2011). This policy may even have heightened social tensions, as graduates expectations of high returns on their education were not met.

106. We would like to argue that a comprehensive youth policy taking into consideration the heterogeneity and diversity of youth needs should be articulated in each country. Since three quarters of the population in each country is youth, national policies including scientific and technological ones should be geared towards this group. This youth will eventually become an African middle class in few years time and drive political, economic, scientific and technological agenda (McKinesy, 2010; AfDB, 2011).

107. The Table 1 below attempts to show differentiation among youth, and the need for differentiated and specific responses to the needs each category in its social milieu. Comprehensive and differentiated responses should take into consideration all youth irrespective of whether they are in school, training, formal or informal employment or not engaged at all. Countries and other stakeholders targeting youth in differentiate manner can expect to benefit from youth bulge dividend as they are entrenched in the development processes.

Table 2: Differentiated Youth, Diversity of Responses:

Location of youth in socio-economic development	Existing responses	Interventions to strengthen Scientific and Technological capacity
In school youth: pre-school, primary, secondary and tertiary	EFA, MDG goals , free primary education	improve teacher's education in sciences; develop relevant and quality curriculum and integrate indigenous knowledge; improve performance at all levels; Increase enrollments in science-based

		courses in tertiary education; strengthen post graduate training programmes; increase funding for research and development; enhance mechanisms for assessments and quality assurance; strengthen university – industrial linkages
Youth out of formal education into skills Training	Revitalization of differentiated national Technical and vocational training system,	Improve infrastructure, curriculum reforms for TVET, strengthen public-private partnership for skills development, apprenticeships, internships and attachments
Youth in employment: formal and informal	Increased economic growth resulting from macro-economic reforms, pro-business policies, investments and development of the informal economy	Retooling; improve ICT infrastructure; leadership and governance training; integration of S&T in youth policies and programmes ;enhance public-private partnerships; improve access to capital
Youth Not engaged	Public works programmes (Kazi Kwa Vijana), Job placement programmes (Ministry of Labour in partnership with Ministry of Youth and Sports) Youth policies-creation of Ministries of Youth. Allocation of Fund for Youth enterprises	Non-formal education geared to scientific and technological literacy; demobilization from conflict situations through technical skills formation; and continuing learning (lifelong learning) Microfinance programmes

Source: Author, 2011

5.2. Creating an Enabling Environment: Policies, Institutions and Private Sector

108. National governments should increase resources and intensify efforts to support young innovators and entrepreneurs irrespective of their educational backgrounds. As indicated earlier youth in the informal sectors should be availed funds and training opportunities to renew their capacities and engagement in projects and activities that require scientific and technological skills and competences.

109. The national governments should establish mechanisms and institutions for promoting innovations among youth. This would motivate young people to engage or be engaged at different levels of research and development and processes of innovation. Such mechanisms and institutions would become essential platforms for young innovators and entrepreneurs to learn, share, interact and inform policy makers on policy directions for innovations geared towards creation of youth employment and wealth within ambit of sustainable development.

110. In regard to young people emerging from conflict situations, national governments should redefine the second-chance programs to include acquisition of scientific and technological skills and knowledge as core elements in their integration in their communities and reconstruction of the society.

Conflicts and wars in some parts of Africa destroyed not only the economy but also rendered young population unskilled, idle and poor. Majority youth missed schooling opportunities for prime years hereby becoming unskilled, unproductive and unemployable. Re-defining second- chance programs for youth at risk of violence and those emerging from conflict situations, offers great opportunities to prepare them for lifelong acquisition of relevant skills and competences necessary for gainful engagement or employment.

111. The role of private sector in stimulating economic growth is well recognized in Africa, despite the fact that it is still underdeveloped in many countries. Private sector promotion strategies are not necessarily geared to employ highly skilled labor (partly because of technological constraints). Off-shoring and outsourcing strategies implemented in North African countries as well as in some SSA countries (Senegal, Kenya, Ghana and South Africa) which provided job opportunities for unskilled and middle-skilled workers can be considered as a good illustration. Few countries have implemented a global strategy to enable employment for university graduates. Morocco and South Africa have taken some actions in this regard and more university graduates could enter this segment of the labor market. The partnership with the public sector can become a creative channel for acquisition of skills and learning needed for employment in the first instance, and entrepreneurship among young graduates.

112. Although this is a challenge, it is also a marked opportunity for developing something new from scratch. In practice, however, such cooperation is not developing on equal terms as companies involved generally view their counterparts as clients. As such, partners are not true partners: education authorities seeking learning reforms are simply differently labeled customers for companies looking for promising markets. This doesn't mean that there cannot be a mutual benefit but it is important that all partners are aware of not just their common interests but also their different agendas. This partnership could also help promote university-industry alliances for employment creation.

113. In Morocco, the private sector plays a growing role in higher education. While there has been a law to supervise private higher education since 2000, about ten decrees to regulate the sector, encouraging finance and taxation are still awaiting promulgation.

114. Country authorities must look into their own specific needs, either through self-developed monitoring mechanisms or with external support, before they enter into advanced negotiations with private sector partners. They must insist on tailor-made learning programs and training but make sure that these follow internationally accepted standards.

5.3. Emerging Issues and Action Points

- Articulation and implementation of comprehensive and inclusive policies and mechanisms to build scientific, technological and entrepreneurial capacities of youth for socio-economic transformation of Africa societies.
- National governments to expand opportunities for scientific and technological exchanges especially among graduate students and young scientists, regionally and through south- south linkages.
- Widen opportunities for young scientists to access to research funds and fellowships for further studies and improve their capacities for research and innovation
- Improve ICT infrastructure at all levels to facilitate access to knowledge acquisition, creativity, and innovation among youth.
- More impact evaluations of programs seeking to integrate youth in the labor market are needed.

- Create partnership for science and technology in involving national governments, regional economic communities, private sector, international agencies, civil society institutions and grassroots communities.

5.4. The Way Forward

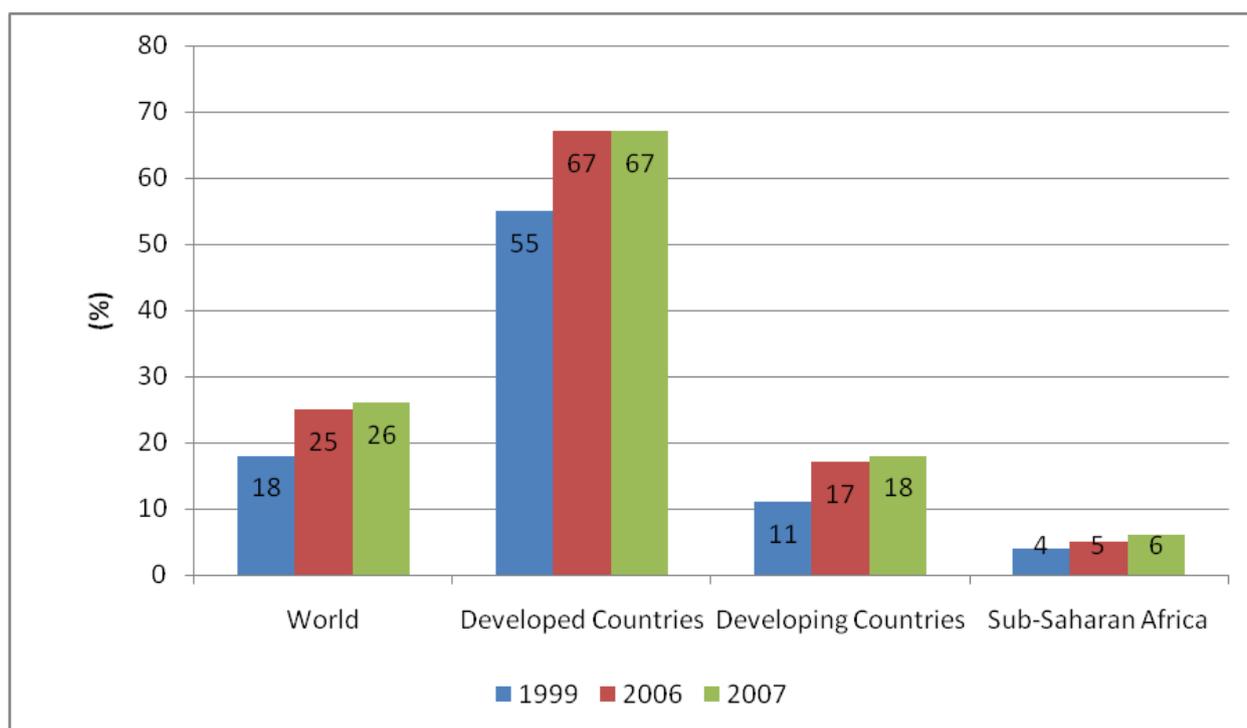
115. Since young people constitute more than two-third of the population in Africa (about 78 percent in 2010), it is imperative that their energy, creativity and innovativeness are harnessed for sustainable cultural, socio-economic and political development in Africa. Africa needs to go beyond provision of formal education and training opportunities to young people to critically reflect what happen to them after school. And not just to think only of those who are privileged to be in the formal education system, but also embrace the out-of-school youth.

116. The challenge is to take a holistic and lifelong approach to societal acquisition, adoption of scientific and technological knowledge and skills for innovation focusing on creation of jobs, value-addition to natural resources and overall wealth creation for the majority of the population. The achievement of MDGs is central to this approach. Hence investments in all aspects of the youth development should be central to any country's vision and strategy. This should be the core of any strategy and programmes geared towards advancement scientific and technologic al capacity of young people and society. In this way Africa would benefit from the demographic bulge which was observed earlier in this synthesis paper. The report of the ADEA Youth Consultation has a pointed of actions that could be taken to bring youth into the center of development. Ignoring the youth potential is to deny Africa its most precious resource for sustainable development.

6. TERTIARY INSTITUTIONS: RESEARCH, INNOVATIONS AND LINKAGES.

117. Tertiary education is highly valued in Africa. Competition for the available places is very intense. The proportion of household income and national budgets allocated to tertiary is indicative of the high demand and value placed on access to tertiary education. However, despite the rapid expansion of tertiary education institutions in the last two decades and increased resources allocated, Africa remains the only region in the world with the lowest proportion of higher education cohort accessing tertiary education. In 2011, only 6 percent of appropriately age cohort was able to access higher education (Table 3). This was a slightly increase from 5 percent in 2005 (UNESCO, 2011 EFA GMR; World Bank, 2009 b). This is well below other regions where the appropriate age groups accessing higher education are over 60 per cent (UNESCO, 2011 EFA GMR). Africa is far from providing adequate opportunities to those who need tertiary education. The intense competition for the available places has led increasing number of students to seek educational opportunities in North America, Europe, Asia and Australia (Varghese, 2008). Within Africa this phenomenon is also common, with countries like Uganda, Ghana and South Africa being preferred destinations.

Table 3: Gross Enrollment Ratio (GER) in Tertiary Education in 1999, 2006 and 2007



Source: UNESCO EFA Global Monitoring Report, 2009 and 2010b

118. Nevertheless it should be recognized that a few countries on the continent (South Africa, Tunisia, and Mauritius) are able to provide an increasing proportion of their eligible students with higher education. In discussing equitable access we need therefore to recognize that only a small proportion of African youth aged about 18 to 24 are accessing higher education (World Bank 2009b). This is despite an annual expansion of 8.7per cent in enrolments compared to 5.1 percent for the world

in the last two decades. Enrollments at tertiary level in SSA almost doubled since 1999 from 2,136,000 to 4,140,000 in 2007 (Altbach & Salmi, 2011 and UNESCO EFA Global Monitoring Reports, 2009 and 2010b). This figure now estimated at about 6.5 million. The bulk of the students are enrolled in social sciences and humanities.

119. Tertiary institutions are critical to socio- economic development in Africa as they represent concentration of resources and talent (staff and students). Each country in Africa has invested in a number of public universities as a matter of national pride, need to train high level personnel and for research. Universities and other tertiary institutions therefore not only centers for training of high level human resources, but also critical players in research and development enterprise in their countries. They host important laboratories and centers of innovation. In many countries they are integral part of national research and innovation system. In light of this, the quality of education provided and research undertaken thereof is critical to the realization of national, regional and continental S&T objectives (Kamoun, 2011 and Diarra, 2011).

120. The synthesis highlights a few aspects of tertiary education that are critical to the development and application of scientific and technological knowledge and capacities to research and innovation in Africa. These are: impact of the expansion of tertiary education; the quality of education provided and especially scientific and technological education; concept of centers of excellence and the university-industry linkages.

6.1. Expansion of Tertiary Education

121. The growth of tertiary institutions in the last two decades has been remarkable. The number institutions is currently over 650 (200 public and 468 private) and increasing. The private sector providers have established themselves as important players in provision of learning opportunities at the tertiary level, accounting for about 18 percent of the total enrollments in the Africa (World Bank 2009b). For instance, in the last eight years the expansion of private universities in the three East African countries has been remarkable. In 2003 there were 15 public universities compared to 40 private universities, while in 2011 the numbers had risen to 21 and 76 respectively. However these data do not include constituency colleges and institutes which eventually will become fully-pledged universities.

122. While private universities in the three countries continue to increase at a higher rate than the public ones, student enrolments in private institutions remain low. Public universities remain dominant in terms of diversity of their academic programmes, public funding, research infrastructure and overall quality of staff and student body.

123. The existing expansion of tertiary education is fuelled by an almost insatiable demand for tertiary education by the increasing number of secondary school graduates and adults interested in improving their qualifications, The rising qualifications for jobs is necessitates acquisition of higher qualifications to compete for the limited opportunities in the labour market. Although the expansion of tertiary education has hardly met the existing social demand, it has nevertheless strained resources, infrastructure and staff in both private and public universities.

124. Higher education institutions have therefore resorted to income generation through commercialization and “vocalization” of university programmes. Higher education institutions have resorted to entrepreneurial activities in response to reduced government support for the sub-sector (Bok, 2003 and Mamdani, 2007). Establishment of parallel programmes for students who missed access to public HEIs during merit selection, are willing to pay to be provided with opportunities they missed in the initial selection. This trend tends to compromise the quality of student intake and subsequently learning and teaching (PUIB, 2006).

125. Intense competition for the limited quality staff, has often led to recruitment of academic staff without requisite qualifications such as PhDs. A straddling phenomenon has therefore emerged whereby staff employed in public universities constantly travel from their primary employer to teach in private universities to supplement their incomes. Private universities in turn recruit of part-time staff to meet staff deficit and minimize personnel costs. Staff development and post-graduate training in many HE institutions is received minimal attention, and almost grinding to a halt (Kinyanjui, 2010).

126. The expansion has also led to a situation of overcrowding in lecture rooms, libraries limited access to ICT and for students taking science minimal exposure and access to laboratories for practical lessons. The situation of African universities has been analyzed extensively by individual researchers, donor agencies, regional organizations and networks (AAU, AfDB, UNESCO, etc) and African governments (Diarra, 2011). The outcomes of these studies need not to be repeated in this synthesis.

127. The changing higher education landscape in Africa is attributed, to a large extent, to the emerging realization of the benefits that can accrue to the continent through enhanced global competitiveness and participation in the knowledge economy. At national level the change is driven by demand for improved qualifications by individuals to compete for promotion and the limited jobs in the labor market. In addition, there is a felt need to redirect education and training of youth and adults towards acquiring scientific and technological knowledge and skills necessary for unlocking Africa's economic potential and reap benefits of integration into the global economy (World Bank, 2003 and 2009b; PHEA, 2008).

6.2. Strengthening Capacity for Science and Technology in Tertiary Institutions

128. On the whole the expansion of HE has not given appropriate weight to science, technology, research and innovation. Social sciences and humanities continue to receive the biggest slice of the budget. A balance is required if Africa is to achieve global competitiveness and value-addition to its commodities (Kamoun, 2011).

129. As already observed most of the enrollments in African universities and in particular private universities are in the social sciences and humanities. Hence there are limited investments in science-based and technology programmes and courses (Juma et.al, 2005; PUIB, 2006; World Bank 2009b). Consequently there is an urgent need to reorient African universities and other tertiary institutions towards science and technology to bring out the much needed balance between social sciences and humanities offerings, and science and science-based courses and professions. The required balance cannot be achieved without reforms in secondary education to improve the quality of education and in particular performance in mathematics and science. The change is expected to be gradual, but remedial programmes are required in the meantime.

130. Scientific and technological capacities which are needed at this juncture to unlock the potential of African natural resources cannot be realized without radical restructuring and re-orientation of the universities to focus on increased numbers and output of scientists, engineers and technologists. Increased research output and innovations is imperative. This remains a critical challenge for the continent as evaluation of African outputs in terms of publications, journals, patents, innovations and other indices remain a minuscule compared with other regions of the world (Kamoun, 2011).

131. Issues that need urgent attention are: increased national funding of research; reducing heavy teaching load on quality researchers; minimizing donor dependency; management of consultancy and individualization of research enterprise; installation of up to date equipment, facilities and research laboratories; increased resource allocated to graduate education to replace graying intellectuals while building academic communities through peer mentoring and review. Access to ICT and journals are also critical to uplifting research standards in African universities and institutes.

6.3. Towards a Differentiated Tertiary Education

132. The ongoing expansions at tertiary level need however to be differentiated to provide diversity of knowledge, competences and skills requirements in growing economies, and to cater for different student abilities and needs. Institutional specialization and concentration is required.

133. These kinds of differentiation could cater for excellence in research and development and benefit from concentrated pool of talents. Given the limited resources available to higher education, differentiation is necessary for effective and accountable utilization of the available resources for R&D, modernization of infrastructure, graduate formation and capacity building of talented scientists and researchers (Hörig, 2011; Kuria et.al, 2011; World Bank,2009b).

134. The nature of expansion of tertiary institutions in many African countries has tended to emasculate development of middle level institutions that produce sub-professional and skilled labour to meet the needs of the industry, and to complement the highly skilled graduates, scientists and engineers. A balanced development of tertiary education to meet the needs of the economy is therefore necessary. A policy rethink on the current approaches to increasing places in higher education is urgent.

135. There is no question that Africa needs differentiated universities, training colleges, research institutes, polytechnics and other tertiary institutions to meet its scientific and technological advancement and other developmental needs. The tendency of institutions to be everything for everybody does not augur well for quality outputs, specialization and innovation. The case studies undertaken under auspices of study on the *Role of Tertiary Education Institutions in the Development of Technical and Technological Capabilities for Employment Creation* has demonstrated the value of institutional differentiation in Ghana and Namibia.

6.4. The Challenge of Quality and Quality Assurance (QA)

136. The quality of the rapidly expanding tertiary education in Africa has been the subject of research studies and many comments (AU, 2007; World Bank, 2009b and 2000; Sabaya, 2004). There is almost near agreement that accreditation processes are weak leading to introduction of courses in fields such as Engineering, Medicine and Law that do not meet required standards and approval of professional bodies. Such courses tend attract fee- paying students interested in entering high status professions.

137. Needless to say not all universities are providing poor quality courses and programmes. Across Africa there are universities doing excellent teaching, research and community service, although in global rankings they do not necessarily reach the top of the ladder.

138. The study by the German Academic Exchange program (DAAD) and the Inter-University Council of East Africa (IUCEA) entitled "*Regional Cooperation for Quality Assurance: The IUCEA/DAAD East African Quality Assurance Initiative*" is a collaborative initiative of German institutions, ICUEA, and commissions for higher education in Kenya, Tanzania and Uganda. The research and training provided underscored the need for universities and tertiary institutions as a whole to internalize QA mechanisms focusing on students, courses given, teaching and learning process and expected results. The study also emphasized the need to strengthening national regulatory bodies as well as regional cooperation and collaboration in QA.

139. The value of this kind of regional cooperation cannot be underestimated, as well as the need for informed leadership, legal and financial support at regional level for sustainability of these kinds of interventions beyond donor funding.

140. Comprehensive, independent and effective QA in both public and private universities, the study has underlined, is essential to acquisition of high quality of scientific and technological knowledge and skills. Investing in internal and external mechanism for QA is therefore vital for Africa, if production quality research and innovations needed for socio-economic development are to be guaranteed (AU, 2007; Sabaya, 2004). Other regions can build on the lessons and experiences gained in East Africa.

141. It has been observed that poor quality of teacher education at tertiary level tend to be manifested in poor teaching and learning of mathematics and sciences at lower levels of education. There is need to improve the quality of in-service training of teachers in all tertiary institutions. Effective QA mechanisms can help in improving the quality of teacher education.

142. The ADEA Youth Consultation (2011) emphasized this concern by indicating the need to uplift the overall quality of education provided at lower levels of the education system in Africa. In this way the cycle of poor students being recruited into teacher education institutions and then coming back poorly equipped into the teaching profession can be broken. Quality assurance should be extended to profession development of science and technical teachers as a priority.

6.5. The Relevance and Efficiency

143. The increase in the number of higher education graduates has often been at the expense of quality. Within 10 years (1999 to 2009), the number of higher education graduates in low-income SSA countries has almost tripled (from 1.6 to 4.9 million). It is anticipated that this figure will reach 9.6 million in 2020. Only 5% of relevant age group are enrolled in universities in Africa vs. a world average of 25% (World Bank, 2011). Incomplete and low quality education hinder the fair and inclusive participation of African youths in the labor markets causing them to be more likely stuck in low paying, low productivity jobs.

144. More investment in education is not always the answer and may only be a delaying strategy. Recent events in Egypt, Tunisia and Libya have showed that despite the government's heavy investments and the country's rapid expansion of primary, secondary and tertiary education, schools and universities are producing graduates lacking the skills they need to succeed in employment markets.

145. In Sub-Saharan Africa, large amounts of funding have been dedicated to infrastructure inputs for schooling (e.g., school buildings) and much less to quality inputs (e.g., teacher training) and more cost-efficient models of schooling such as e-learning and twinning. This has left the continent with a largely unfunded traditional schooling model and poor education policies producing large cohorts of graduating students and few skilled youth that can cater to the needs of Africa's 21st century labor market.

146. The reinforcement of scientific skills in higher education sector must be focused on relevance. In the past, the relevance of an educational system was equated with quality, and quality was in turn judged according to theoretical principles. Today, the conception of quality has changed; it's the mastery of specific skills that match the ambitions of the country or the region where the university is located. According to the World Bank document on higher education in Africa "it is advisable for higher education institutions to incorporate the essential skills necessary for the understanding of science, technology, commerce and society in a series of courses for all university students." We have to move beyond the teaching of science as a separate discipline in universities and towards the adoption of an approach that fosters "scientific culture".

6.6. Building Centers of Excellence (COE) in Science and Technology

147. A continuing challenge is not only to improve overall quality of education and professional training in African universities but also to create COEs in post graduate training, post-doctoral exposure and research and development. Efforts geared towards this are notable at national, regional and international levels. The establishment of African Institute of Science and Technology (AISTI) and the proposed Pan-African University are initiatives intended to harness Africa's talent in a collaborative manner by utilizing limited resources effectively through concentrated endeavor in critical and strategic fields of development (Namata, 2012).

148. It is however, important to recognize that opinions are varied on value and modalities of operation of COEs in Africa. It is in this context that DAAD initiative to start five Africa-German COEs should be evaluated. The objectives of initiative are to pursue capacity building, strengthening educational quality and improve research output in the cooperating universities. These efforts are bringing German experiences in a number of African universities- to build capacities in Micro-finance in DRC, Logistics and Transport in Namibia, postgraduate studies in Law in Tanzania, Research and Criminal justice in South Africa and Development Studies and Health Research in Ghana.

149. A study focusing on the concept of COE and experiences gained in the five collaborative projects has been prepared for the 2012 Triennale hopefully to stimulate vibrant discourses and sharing around the idea of how COEs can strengthen African universities' capacities in research and post graduate training. Where these initiatives have taken, a lingering question is how to measure their success. Indicators of success, like in any other S&T institutions, should be worked out to accompany the interventions.

150. The idea of centers of excellence is alive and it is hardly settled despite the many and varied exchanges on the continent (Nordling, 2009; Mugabe, 2008; AU/NEPAD, 2007; Urama et.al, 2010)

6.7. University-Industry Linkages: The Challenge and the Promise

151. A great deal of interest has emerged on the issue of linking universities to productive sectors of the economy (Kruss, 2006, AAU&AUCC, 2011). Two contributions were prepared on this topic for the Triennale; AAU and AUCC prepared a paper entitled "*Strengthening Linkages between Industry and Higher Education Institutions in Africa.*" and a team headed by Paschal Mhiyo prepared a contribution entitled, *The Role of Tertiary Education Institutions in the Development of Technical and Technological Capabilities for Employment Creation in Eastern, Southern and West Africa: selected Case Studies*. Both studies focus on various dimensions of this complex relationship. The few findings are noted:

- A definition of what constitutes university-industry linkages should be tailor-made to African economies, especially the informal sector where the size of industries is often small and producing for a limited market. However the interests of various players: government, universities and economic actors should be incorporated the relationships.
- University-industries linkages were most notable in agriculture and agribusiness, ICTs, environmental management, computer engineering, and banking. The studies noted there was less collaboration in manufacturing, pharmaceutical, mining and entertainment sectors.
- While oil and mineral extraction activities account for a large proportion of productive sector activities of number of African economies there practically no discernible university-industry linkages.

- Few universities have established science parks and technology incubators where they could showcase their research findings and innovations to interested entrepreneurs.
- Universities should articulate policies and rules to guide and govern the complexities of the relationships between them and productive sectors.

152. The papers have also recommended radical changes on how universities relate to various players in the economic sector to improve collaboration, dissemination and adoption of innovations emanating from research findings. This synthesis cannot do justice to the insights the two studies have given to this important topic. However we would like to draw attention of policymakers and researchers the changes required in policies, mindset and management structures in the universities to facilitate dialogue and sharing of experiences with the productive sectors of the economy in order to enrich linkages between universities and key players in the economy. The study by AAU and AUCC has thus argued:

Creating a conducive, enabling environment for supporting linkages with the productive sector requires a multidimensional approach... Strengthening linkages with the productive sector should ideally go hand in hand with parallel efforts which include inter alia strengthening research governance and management, science and mathematics education, and graduate training at doctoral degree level. On the private sector side, industries also need to be brought on board as more active partners, while governments need to take responsibility for architecting a national innovation system with appropriate frameworks and policies to govern and incentivize university-industry interactions (AAU and AUCC Study, 2011)

153. Farouk Kamoun (2011) strongly argued that education and research institutions and the production sector constitute two critical components of the national innovation system. Hence building linkages between them should be closely cultivated and nurtured rather than left to chances or whims of a few researchers!

154. There must be no break in continuity between academic teaching and the teaching of technology or between higher education, including all its sectors, and the productive sector. In the approach to differentiation that leads not to a fragmentation of teaching institutions but on the contrary to greater complementarity between them. Moreover, the opening up of higher education to the needs of the labour market must be reflected in teaching and research that is more relevant.

155. In other words, ST&I development demands greater innovation at every level of the production, from knowledge production to economic production. This greater relevance must necessarily be reflected in a reinforcement of lifelong learning. Just as researchers must focus their research on what the market needs, technicians must be able to master the skills necessary to adapt the results of research and to convert them into practice capable of influencing all actors in the productive sectors.

6.8. Transfer of Technology

156. A simple definition of technology transfer is the “transfer of the results of academic research with the aim of marketing new products and services.” It is therefore possible to refer to technology transfer as the objective of any programme to reform the structures of higher education in order to make it the main driver for sustainable development. The expression “lifelong acquisition of scientific and technical skills for the sustainable development of Africa in the context of globalisation” covers the concept of technology transfer as an approach that makes scientific research a genuine contribution to palpable technological progress that can be converted into real innovation in every domain linked to development.

157. In the African context, technology transfer has often been seen as an impediment to the introduction of national systems for innovation, technology” has been equated with technology imported from developed countries. In that sense, technology transfer means African dependence on technology-producing countries. Technology transfer is generally seen as a one-way process whereby the developing world gains access to products or expertise produced and owned by the developed world. However, there is nothing to stop Africa producing its own research and transforming it into an engine for development by turning it more towards technological production.

158. For transfer to be complete it is not enough for it to occur at the level of knowledge; it must also include the transfer of expertise. The development of the non-formal and informal sectors of education and the promotion of the lifelong acquisition of scientific and technical skills are necessary to the success of a TT plan. An example of this is the introduction of technology transfer in the agricultural sector, which involves transfer to a population group that is often a stranger to technological and scientific sectors. “The low productivity in the agricultural sector is due to low levels of adoption of technologies and their ineffective application, essentially because of insufficient mastery. These problems are directly linked to ineffective and inefficient mechanisms of technology transfer rather than the total absence of appropriate technologies. This situation makes it necessary to identify, explore, understand and control the interaction between a proposed technology and the physical, economic and social environment in which it will be used.”

159. Given the high cost of TT in specific areas of science,(along with market research, marketing operations), African countries, with limit resources, wishing to introduce a technology transfer system can opt for the creation of a consortium of institutions in which the member countries share a central office (TTCO).

160. South Africa’s experience offers an example of the way political will can guide scientific research towards the creation of a TT system. The government introduced a new strategy for R&D to build robust links between its emerging system for technology transfer and its research system. This lead to the building of a new culture of innovation in every research community and ensure that all the benefits of research (including those that are social rather than commercial) were understood and used. The Southern African Research and Innovation Management Association was set up with the aim of being at the cutting edge of the national research and innovation capacity-building effort

6.9. Expected Action Points

- Increase strategic investments in higher education by governments in partnership with private sector in science and technology. Incentives and funding should target for students and institutions moving into strategic fields in socio-economic development.
- Revitalize universities’ research functions and capacities, maintain reliable EMIS and institute collaborative platforms to promote innovations and entrepreneurship
- Build collaborative partnerships with industry/ economic productive sectors to build and strengthen capacity to utilize STI for sustainable development
- Establish interdisciplinary research and training centers of excellence within and outside universities with emphasis on S&T and articulate benchmarks to be achieved
- Increase support for post graduate training programmes and postdoctoral fellows in S&T
- Promote knowledge and best-practice transfer
- Build capacities of universities and other tertiary institutions to raise, manage and utilize research funds. This would bring into research and development process efficiency, accountability, effectiveness in utilization of the available resources for research, innovation and transfer of technology.

6.10. The Way Forward

161. The requirements for accelerated socio-economic development in Africa bring into focus multiple challenges facing tertiary education. First, the traditional concept of university inherited at independence must be interrogated and expanded to embrace new ideas as well as the increasing numbers of secondary school leavers desirous of accessing higher education. Serious reforms are required at the tertiary level in the context of limited resources and challenges of the rising unemployment among university graduates. Secondly the style and structures of governance and management of tertiary institutions has to change to bring in accountability, effectiveness and efficiency in utilization of the available resources. Thirdly, learning and teaching processes and the courses offered have to be reorganized to give priority to acquisition of scientific and technological knowledge and skills for innovation and value addition to African natural resources. Fourthly, increased and diversified resources for tertiary education and training are needed. Hence strong public-private partnerships (PPPs) need to be forged to improve quality and relevance of programmes offered and research undertakings. Dynamic partnerships to link universities to productive sectors are critical in bringing products of research to the service of society. In addition, there are a number of gaps between research and policy that must be bridged such as (i): Limited policy relevant research; (ii) Insufficient access to research; (iii) Ineffective communication by researchers; (iv) An under-emphasised but very important area is the limited understanding by policy makers, politicians and incapacity of overstretched bureaucrats to absorb research and (v) improving the demand for evidence in a systematic and rigorous way (B. Jones: Linking research to policy, AfDB working paper ,2011).

162. Fifth, the initial formation of teaching and research staff should be treated as a priority, to be complemented thereafter by continuing education to re-engineer, retool and sharpen their capacities to meet the rapidly changing needs in research, knowledge and skills.

163. Finally, student orientation and learning habits need also to change so that they can acquire critical skills and abilities to continue learning even beyond their tenure in the tertiary institutions. These initiatives and programmes should however be fully anchored in credible mechanisms for quality assurance, evaluation and assessment.

7. EXCLUSION AND INEQUALITIES IN ACCESS TO SCIENCE AND TECHNOLOGY.

164. The equalities in access to education and subsequently to science and technology related fields tend fall into three broad categories: gender, regional and socio-economic status. These equalities are intertwined and tend to reinforce each other. This synthesis however gives more attention to gender inequalities as other forms of exclusion require focused policy and research attention to generate better and systematic data.

165. Studies by the Forum for African Women Educationalists (FAWE) entitled, Strengthening Gender Research to Improve Girls and Women’s Education in Africa and FAWE Gender in Higher Education Research Synthesis for ADEA Triennale form key contributions to the Triennale debates on the issues of gender access to scientific and technological opportunities. The studies provide useful data and analysis.

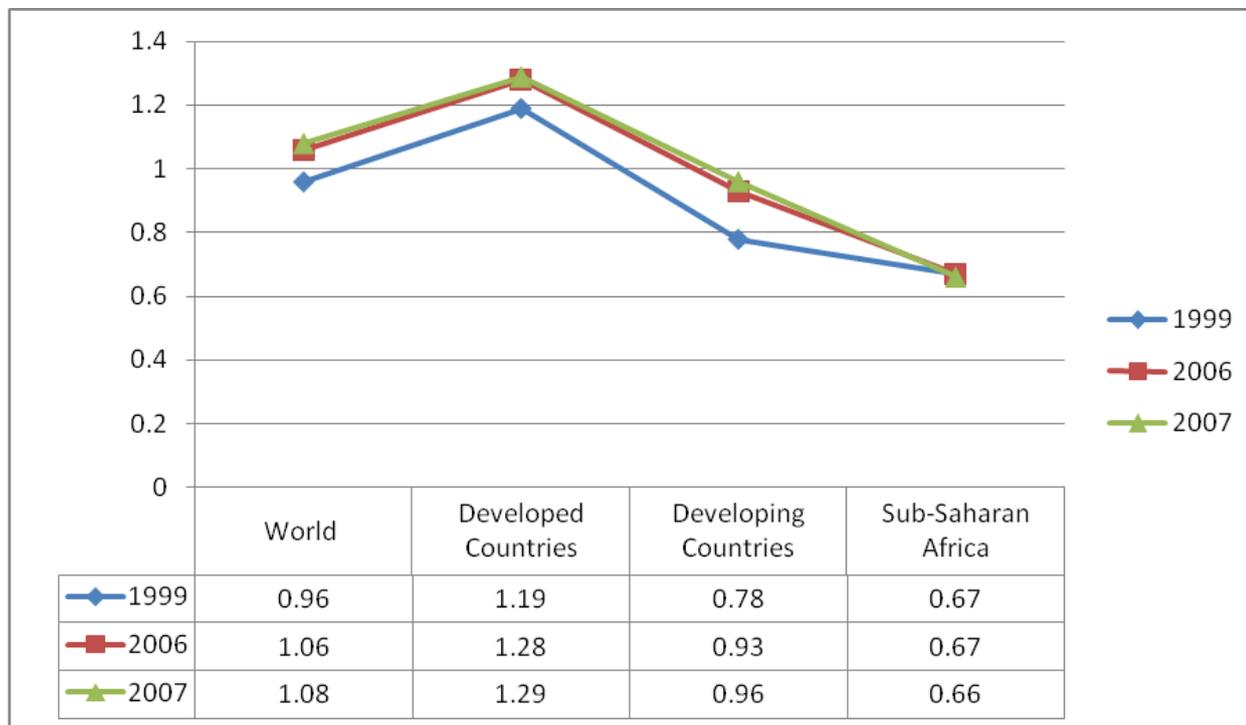
166. Other forms of inequalities have not received the same systematic and intense policy and research attention. Anecdotal evidence seem to suggest that these forms of exclusion are becoming solidified especially in the higher echelons of the education system and are likely finding manifestation in the way opportunities and incomes are distributed in the society.

7.1. Gender Inequalities

167. The last two decades have witnessed remarkable expansion of higher education opportunities in Africa as well as other regions of the world. Globally, recent expansion of places in tertiary education went to women (World Bank, 2011b). However in Africa this has not been the case. The expansion has hardly dented gender inequalities in most of African countries, with exception of four countries, Cape Verde, Mauritius and Namibia. The enrollments in these countries have surpassed gender parity indicating more women are being enrolled at the tertiary level (AfDB, ECA, UNDP and AU, 2011).

168. Table 4 below shows global trends in gender parity in the period 1999 to 2007. The data indicates that while developed countries have achieved gender parity in tertiary education, developing countries still have some catching up to do before reaching this benchmark. It is obvious that the expansion and interventions which have been undertaken have not made great headway from a regional perspective. However, differences between countries are discernable. It is in this overall context that gender inequalities in science and science-based professions should be analyzed and evaluated.

Table 4: Gender Parity Index (F/M) in Tertiary Education (1999, 2006 and 2007)



Source: UNESCO EFA Global Monitoring Report, 2009 and 2010b

169. Below we shall summarize the existing and emerging patterns utilizing data and experiences gained from studies undertaken by FAWE in Ethiopia, Kenya Lesotho, Nigeria, Senegal and Zimbabwe. These however shall be supplemented the findings and insights from other studies and reports.

170. Since inception of FAWE two decades ago and other advocacy initiatives, gender inequalities in education have received a great deal of attention in policy debates, research and literature. It is not possible to summarize the intense and very rich debates that have gone on or the tremendous achievements made, but we would like to highlight the emerging patterns of gender inequalities in access to science and science-based courses in tertiary education institutions. The purpose is to indicate how these patterns influence access to scientific and technological careers and research.

171. Enrollments patterns in Lesotho and Swaziland (Table 5) are almost similar, while those of Kenya and Zimbabwe take a pattern of their own. University women enrollments in Lesotho and Swaziland show strong presence in social sciences, education and health care (above 50 percent). In Kenya and Zimbabwe women enrollment in these programmes are below 50 percent indicating continuing male dominance in these fields.

172. In the sciences Lesotho and Swaziland enrolment have a strong show for women with a third being female, while in Kenya and Zimbabwe the proportions are about a quarter, showing serious exclusion of women. In every programme analyzed, women fare badly in Kenya and Zimbabwe than their counterparts in Lesotho and Swaziland.

173. Admission data to Kenyan universities in the last four years show the same pattern in terms of low enrollment in science-based professions like medicine, bachelor of education (science), computer science and engineering.

Table 5: Enrollments in Various Courses and Programmes of Study by Gender

Field of Study	Country			
	Lesotho	Kenya*	Zimbabwe	Swaziland
	Female (%)	Female (%)	Female (%)	Female (%)
Social sciences	50.0	47.0	38.7	46.0
Education	68.0	47.7	46.7	55.0
Sciences	30.0	23.5	25.3	30.0
Agriculture	46.0	30.0	28.8	41.0
Health and welfare	94.0	41.2	n/a	51.0
Engineering	n/a	15.0	6.2	n/a

Sources: UNESCO, 2005; FAWE Studies, 2011

N/A Data not available

*Data based on two institutions (Jomo Kenyatta University of Agriculture and Technology and Kenyatta University- FAWE Studies)

The data provided above, is to a large extent consistent with data from two higher education institutions in Kenya, Kenyatta University and Jomo Kenyatta University of Agriculture and Technology (FAWE, 2011).

174. The patterns to note in higher education enrollments are the low women enrollments across board in tertiary institutions in most African countries. This is a reproduction of the disparities at secondary school level and poor transition rates from secondary to tertiary level (UNESCO, 2007b). The low enrollments in tertiary courses that require mathematics and sciences are a consequence of low enrollments and poor performance in these subjects at secondary school level. In this way, gender inequalities in tertiary education in many African countries have persisted despite an increase in the number of tertiary institutions and increased enrollments at this level. This is indicative the persistent exclusion of women to the existing limited opportunities for tertiary education and in particular courses and professions that require science and mathematics for admission.

175. Consequently the proportion of women entering graduate schools is limited, and hence their chances in careers fields of science and technology in Africa (Jeanne, 2011).

176. The key here is to improve girls' performance in mathematics and sciences at lower levels of the education system, and thereby accelerate increased enrolments in higher education and in particular science and technology related courses (ASSAF, 2011).

7.2. Underrepresented and Underutilized Potential

177. The second observation to make is that women are underrepresented in the fields related to scholarship, research and development (UNESCO, 2010; Adam et.al 2010; AU-NEPAD, 2010; UNESCO-UIS, 2006; World Bank, 2011b). It estimated that 29 percent of African researchers are women. Only in a few countries such as Cape Verde, Lesotho, South Africa, Seychelles, Uganda where proportion of women researchers is over 35 % (UNESCO, 2010). In countries where women are underrepresented in careers, they are also underrepresented in access to research and development disciplines. Consequently, women remain underutilized resource in scientific and technological endeavors, including innovation, robbing Africa the potential and talent of women. (Dickson et.al, 2011; Jeanne, 2011; ATPS, 2009).

178. The situation is more severe for female youth, particularly in North Africa. In Tunisia, unemployment is higher for women (51% vs. 35% for males) especially for female graduates in Law estimated at 68% (Tunisian Ministry of Employment and Professional Integration). In Egypt unemployment rates for females are close to 50% as compared to less than 20% for males. On average, labor force participation rate in Africa is 78.3% for men vs. 61% for women. There are however large disparities in female labor force participation within Africa.

179. Participation tend to be much higher in West Africa (80% and higher in Burkina Faso, Burundi, Gambia, Ghana, Guinea, and Sierra Leone) and lower in East Africa (under 40% in Ethiopia, Kenya, Malawi, Uganda) (Arbache, J. et al (2010). More strikingly, the share of female participation in the labor force in North Africa is almost half that of Sub-Saharan Africa (Figure below). In addition, female youth in Africa may be at a greater disadvantage as they face more family constraints. In Mozambique, Malawi, Niger, Chad, Uganda, and Gabon between 40-50% of female youth (15-24) had already given birth at least once (World Bank, Africa Development Indicators 2008/09).

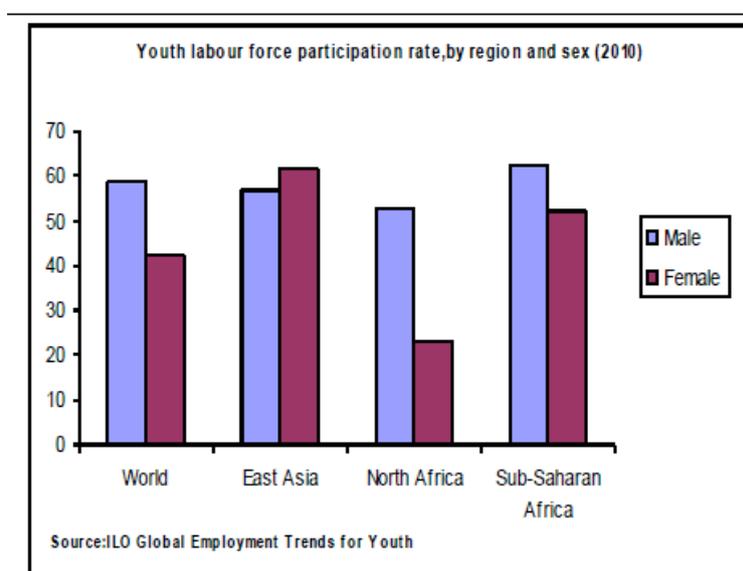


Figure 3. Youth labor force participation, by region and sex (2010)

7.3. Other Forms of Exclusion

180. While gender inequality in access to higher education is a subject to many studies, policy debates and comments, it should nevertheless be recognized that other forms of inequalities do exist at this level. The most obvious is the increasing marginalization of children coming from poor households accessing tertiary education. In the first instance, children coming from poverty conditions, at initial stages have problems of accessing basic and secondary education, continuing to the next level and performing well to be considered for the very competitive access to tertiary education, and in particular access to science related courses and professions (PUIB, 2006).

181. However there is limited reliable data to indicate the current trends in terms of chances of various social groups access to tertiary education opportunities, leave alone science related courses and professions. The chances of succeeding once enrolled are not known. In absence of reliable data, it is recommended that empirical studies focusing on who gets into tertiary education should be undertaken as a matter of routine to ascertain which social groups are being excluded or marginalized in higher educating institutions.

7.4. Expected Action Points

182. A stronger focus on education and training for women is needed, but it must be directed toward quality and labor market relevance. To make women competitive and confident labor market participants, their school subject choices and training/certification beyond school should result in their having skills that match demand rather than traditional job norms.

183. To improve the access and conditions of women in higher education it is important to increase resources for gender mainstreaming and implementation of national policies and international commitments (EFA) and MDGs). Countries like Kenya and Rwanda have formulated gender policies which mandate all public institutions to have at least a third of membership women. Secondly, it is important to improve the socio-economic environment for girls and women to remain in school, to undertake science related subjects, perform well and thereafter succeed in tertiary education. Countries lagging behind should establish national gender observatories to spearhead capacity building for women and to facilitate institutions to mainstream and cater for participation of women in scientific and technological endeavors.

184. Tertiary institutions can also improve the environment consciously working towards gender parity in enrolments and by collaborating with gender stakeholders to initiate programmes to mentor women who chose to enter into fields of science, technology and innovation.

185. The gender inequalities observed in tertiary education and R&D can be traced to how science education is promoted in primary and secondary schools. Hence teaching and learning of science by girls is very critical to their success later on. Since this is the real foundation for women access and success in higher education and eventually moving to scientific and technological careers. The teaching and practice of science in the lower levels education should be enriched by mentoring and promoting change of attitudes among the learners and the teachers. FAWE studies have underlined these aspects.

186. The attitudes of parents are also crucial in this respect. At the household level and in schools the prevailing myth about learning mathematics and science should be dispelled by well orchestrated public awareness and through utilizing models of successful women scientists. Whenever possible, scholarships and other incentives should be provided to encourage girls and women access science-based professions and careers. While affirmative actions are required it is the change in mindset among girls, parents and women that can transform the current gender inequalities in education, and specifically mathematics and sciences related professions.

187. As indicated, one of the shortcomings of analysis of the emerging trends of girls and women access to mathematics and science-based disciplines is lack of reliable and up-to-date data. It is therefore very important that the countries and tertiary institutions maintain systematic and reliable data which is updated on regular basis to enable policy makers, researchers and other stakeholders have reliable data for policymaking, interventions and advocacy.

188. The point on data also relates to other forms social exclusion. Institutions should maintain data on student family and socio-economic background. This could be supplemented by on regular bases with quantitative and quality empirical research.

8. ICT FOR SCIENTIFIC AND TECHNOLOGICAL CAPABILITIES AND INNOVATIONS.

8.1. Introduction

189. In the last two decades, African countries have experienced dramatic growth in the use of ICT, and especially internet and telephony (ITU, 2010; Grosskurth, 2010; UNECA/IST, 2010 UNESCO, 2010). Africans have realized the power and benefits that accrue with adoption and utilization of ICT in education, lifelong learning, trade and commerce and participation in the global economy competitively. To support and tap into the rising demand, and continue to broaden ICT accessibility and utilization on large scale on the continent, service providers and corporation have used the window regional cooperation to established systems, operating mechanisms and networks in all regions of Africa.

190. Since ICT is a major feature of globalization, rapid technological changes, democratization of communications and socio-economic transformation, it is also perceived as critical to the realization of the continental, regional and national aspirations, policies and programmes on STI. Investments in ICT have therefore become a priority for governments, corporate entities and individuals.

191. Ordinary people have also embraced ICT in their social interactions, learning and business. A case in point is ICT based innovation for money transfer using mobile phone called M-Pesa which has been adopted in Kenya with a lot of success (see Box 1). The enormous growth of ICT in Africa has led to development of new products to address the needs of the mobile users and overall sustainable development.

8.2. Challenges of ICT in Africa

192. Despite an encouraging growth of ICT, African countries face numerous challenges to fully embrace ICT applications and seize opportunities presented in general. Key challenges are: (i) articulation of ICT policies and strategies (ii) development of ICT infrastructure; and (iii) capacity building.

8.2.1. Articulation of ICT policies

193. Many African governments have developed economic blue prints that have identified science and technology as a platform for economic and societal transformation and recognize ICT as a catalyst for change. The existing development plans and vision documents have underline the observation that the future of African socio-economic development will largely depend on embracing the use of ICT on a wide range of activities, such as education, agriculture, financial services and health care. Consequently, many of them have formulated and adopted national ICT policies. Others are in the process of establishing ICT parks (AU/NEPAD, 2007; UNESCO, 2010)

194. However the opportunities that come with articulation of policies and adoption of national ICT strategies in Africa will not be realized unless implementation becomes a priority and adequate funding by governments in partnership with the private sector is secured. National governments have shown leadership in development of the required infrastructure, legal regulatory frameworks, transparency and accountability in allocation of opportunities and in building capacities (Farrell and Shafika, 2007)

195. African countries should articulate policies to safeguard intellectual property rights of local innovators in this field, and where policies in place ensure awareness of them and strengthen mechanisms for their enforcement

196. The integration of youth into ICT policies and programmes need to be expounded clearly and measures taken to implement them to avoid continued youth and marginalization. Youth policies need to embrace measures that would tap into their enormous energies and ingenuity to create innovations that will contribute to the development of African economies.

Box 1: M-Pesa: Mobile Money Transfer Service

M-Pesa is ICT based innovation which enables transfer of money using mobile phone. It was launched in Kenya, by the dominant mobile operator, Safaricom in March 2007. The product revolves around depositing money with mobile operator and then the operator facilitating money transactions without the mediation of financial institutions. This has eased financial transactions in a fundamental way. It involves registered subscribers, the mobile operator and outlet agents in various business locations in including rural areas.

The service had 14.3 million subscribers in June, 2011 and 17,653 agents. On average the mobile telephone operators facilitate transacts of about a billion Kes daily. Since inception in 2007, the service has had an exponential growth, bringing convenience and ease of transfer money to millions of Kenyans.

It is a widely used money transfer service in Kenya, Tanzania and Afghanistan. Most banks in Kenya have entered into partnership with M-Pesa service provider to anchor their money transfer services on the platform. The financial services provided have the approval from Central Bank of Kenya.

The impact of this innovation in Kenya has been remarkable and has proved very popular with the ordinary people not well served by banks or financial services. Bank customers save time by not making trips to banks to transfer funds. This service enables any customer anywhere in Kenya to transact business in the country regardless of the status of transport and banking infrastructure in his locality. A customer only needs a working telephone network.

The success of M-Pesa is well documented and has spurred other innovations such as Ushahidi. It has also fired imaginations of Kenyan youth to search for similar innovations to serve other sectors such agriculture, education and health.

Sources: Gidoomal, S. 2011; *The East African*, 2011; Safaricom Annual Report 2010; Omwansa T, 2009; www.safaricom.co.ke Accessed on December 15, 2011

8.2.2. Strengthening ICT Infrastructure

197. ICT infrastructure is a major factor in accelerating development in the 21st century. In the past Africa has lagged behind because it neglected modernizing its technologies. There is still a major digital divide between Africa and the rest of the world that could continue to widen if Africa does not invest heavily on ICT infrastructure to tap into existing potential for development (UNESCO, 2010).

198. In rural and remote communities, the infrastructure is still in poor state and need to be upgraded for communities to leap full to benefits of ICT. Schools and other institutions in these areas face the shortage of educational resources, and especially science and technology teachers. With ICT infrastructure in place these institutions could access to materials they need and network to improve their knowledge and skills.

8.2.3. Enhancing ICT Capacity

199. Having quality capacity as well as quantity particularly on ICT is critical to building a creative and innovative knowledge society for sustainable socio-economic development. Building a scientific

capacity requires not only adequate funding and infrastructure but also effective linkages where information and experiences are shared and learned. National governments that have embraced ICT in their economic development plans and vision documents need ICT professionals to oversee implementation of agreed policies and plans (UNESCO, 2010).

200. The shortage of professionals is real, and those in place overworked and underpaid. The few trained and skilled professionals tend to seek other alternatives elsewhere to improve their incomes and professional careers (Hooker, 2010). This leads to brain drain in a field where shortages are likely to slow the much expected accelerated development. A major player in ICT in East Africa when asked the key challenge in doing in Africa answered:

We face many challenges and one major one is finding highly skilled individuals. Our focus is to continuously develop in-house capacity to produce world-class programmers, consultants, project managers, R&D engineers and others. There are many hidden talents in Africa and what they need is training, industry exposure, certifications and relevant assignments to bring them in line with the rest of the world. We have decided to open research and development software centre in Nairobi this year which will be the first of its kind in East Africa. The centre is expected to employ 100 plus consultants during the first year.

I strongly believe that in the next 20-30years Africa will be a force to reckon with in the area of technology and it will also become a great source of manpower to the world. Governments must look beyond building infrastructure and start investing in building local content. I believe Africans can provide the best solutions to African problems. There is no dearth of talent here.

(Manjo Shanker, CEO, Techno Brain, The East African, January 2-8, 2011)

201. ICT cannot be fully embraced and enhanced in all sectors of the economy where capacity is weak and limited. The youth bulge in Africa provides a unique opportunity for training and building capacity of the next generation of professionals and innovators.

8.2.4. ICT and Employment

202. ICT also relates to the economy and employment. Six of the world's most influential, profitable and prestigious firms in 2011 are in the ICT sector, with Google and Microsoft ranking first and second respectively. It is true that Africa has other priorities than ICT development: priorities such as health, education and food. Nevertheless, ICT can make improvements in these fields easier by providing more accessible information and facilitating contacts between research centres. Reduced transaction costs due to lower telecommunications expenses are leading to a phenomenon seen in recent years: the stimulation of subcontracting and the relocation of numerous services to certain countries in the South: call centres, secretarial services, publishing, data entry, banking and insurance services, IT services, among others.

203. In some African countries, Morocco, Tunisia and Senegal, such activities have undoubtedly made it possible to create jobs for many young graduates with little interest for, or excluded from the local labour market (Ahmed Dahmani, "Les TIC : une chance pour l'Afrique?"). This is a sector more reliant on qualified human resources than on equipment, which represents an opportunity for the developing world, one that has been grasped by countries like India, where the emphasis has been on software. ICT does not "require massive, costly investment in installations and infrastructures. Moreover, ICT is available in highly competitive markets that transfer rapidly to any

country.”(A.Dahmani, Ibid) In addition, since it is highly dependent on qualified labour, ICT can help mitigate the brain drain.

204. In order to improve the infrastructure required for ICT development, there have been regional cooperation programmes such as those that led to WACREN, the West and Central African Research and Education Network, and UbuntuNet Alliance, a similar network for Eastern and Southern Africa. In 2005 UbuntuNet Alliance began regional cooperation by launching five national research and education networks in Sub-Saharan and Eastern Africa: KENET in Kenya, MAREN in Malawi, MoRENet in Mozambique, Rwednet in Rwanda and TENET in South Africa, and encouraging their neighbours to join the project. UbuntuNet Alliance now has 12 members, ranging from Sudan and Ethiopia to Mozambique and South Africa. Such regional efforts have been consolidated by a European initiative, AfriConnect, the purpose is to enhance interconnectivity between African teaching and research networks and between the latter and global research and education resources via GEANT, the European multi-gigabit research-dedicated network.

8.2.5. ICT and the Africa’s cultural systems

205. The NEPAD stresses the need to develop software whose content is close to Africa’s cultural systems. The present need is for ICT development to cease to be dispersed across separate institutions; it should be organised at regional level under a plan for cooperation between the centres of excellence in the various regional countries. One domain which could bring Africa into the ICT revolution and which could benefit higher education in Africa is innovation in the development and maintenance of free and open-source software (FOSS). Firstly, the cost of software-centred projects is relatively low and can be affordable for countries whose resources are fairly limited as is the case for those in Africa. Secondly, software can have a significant impact on development without being particularly costly. Free and open-source software can also facilitate access to innovation and encourage collaboration and intensive resource use. And lastly, the various types of software have common features and for this reason it is possible for skill development in this area to lead on to the development of critical capacities essential to the development of research. With this in mind, the aim for African countries must be to put in place cross-border networks for ICT development and projects that produce software with African content. The need is also to guide this effort in the direction of two specific domains: the production of e-learning software and the development of e-learning capacities.

8.2.6. Expected Action points

- National governments should give priority to improvement of ICT infrastructure by increasing bandwidth and connectivity and at the same time paying attention to affordability, reliability and penetration. This will create an enabling environment for acquisition and utilization of scientific and technological knowledge, skills and competence by policymakers, students, youth, teachers, researchers, innovators and techno- entrepreneurs. For these broad objectives to be realized a partnership of stakeholders is required (public sector, private sector, civil society and development partners).
- Most of ICT infrastructures are concentrated in urban areas particularly in the cities leading to regional disparities. To reduce these disparities, national governments with support and in collaboration with stakeholders should invest increased resources to improve ICT infrastructure in rural and remote areas to promote digital inclusion.
- To increase ICT literacy and enhance internet accessibility among the learners and teachers, national governments and ministries of education should incorporate ICT learning in school curriculum as one of the core competences. Ownership and access to computers and internet by institutions and individuals are critical elements to realization of this goal. Africa can learn a great deal from the Korean experience in this respect.

- To cultivate a culture of innovation and entrepreneurship among the youth, there is need to strengthen and expand ICT hubs and centers as platforms where young people can explore new ideas. These centers should not only expose young people to new technologies, but also nurture their entrepreneurial skills and creativity. Public and private sector partnership is critical to the success of such hubs.
- A lot of inventions and innovations within Africa are either underreported or pirated due to lack of clear guidelines on how to apply for patent rights. Clearly articulated guidelines on issues of patent rights will help young African innovators to participate effectively and beneficial manner in the national science, technology and innovations systems, Africa national governments with support of global agencies such as WIPO should ensure intellectual property rights of local innovators are safeguarded

8.2.7. The Way Forward

206. Countries in Africa should go beyond articulating policies and investing in ICT infrastructure; to build critical mass of professionals to spearhead changes required to realize MDGs and sustainable development in the context of emerging technologies and innovations.

207. ICT is not just a means of facilitating research, teaching, and development. It's also a fully-fledged sector of the knowledge economy, whose development is integral to economic development itself. This was proved by some Asian countries, such as India, for example. All these reforms require a long-term strategy culminating in the creation of a technology transfer system through which Africa will cease to simply adapt to the technology produced by others.

9. GALVANIZING PUBLIC SUPPORT FOR SCIENTIFIC AND TECHNOLOGICAL DEVELOPMENT.

9.1. Political Leadership and Ownership of STI

208. Strong political will is needed in each country for appropriate policies and programmes to be adopted, institutions created, capacities built and resources provided for R&D, adoption of innovations and their dissemination into the productive sectors of the economy. Hence scientific and technological agenda for research and innovation need to have concrete support and ownership by a broad spectrum of stakeholders (politicians, policy makers, scientific community and professionals, civil society, private sector and the general public).

209. Public ownership of policies and programmes can be fostered and garnered through the processes followed in articulating national visions and strategic plans. Participation and engagement of the public and interested stakeholders in ensuing debates and crafting national policies is critical in building a sense of ownership and appreciation of the benefits expected in adopting appropriate scientific and technological policies, institutions and strategies.

210. Political leadership is also required in mobilizing the public and other stakeholders to support national agenda for science and technology. Such support is necessary in allocation of resources and working out strategies for integration of regional and international commitments into national visions and plans. Collective actions are also needed in implementation, monitoring and evaluation of national agenda for science and technology.

211. The political will to promote scientific research and technological innovation seems to exist. Countries with the most successful innovation record are those that have been able to ensure consistency between their policies and actions. They are also often those that have managed to ensure continuity in the long run. The examples of Korea, Finland and Japan are striking in this respect: in these three countries, technological progress was a national imperative for half a century, innovation policy was a fixed strand of government action. National experts have insisted that this continuity was guaranteed when there were changes in governments, which did not question these aspects of policy.

9.2. Building Public Awareness

212. A recent study entitled, “*Use of scientific and technological evidence within the Parliament of Uganda*” carried by UK Parliamentary Office of Science and Technology, the Parliament of Uganda, and the Ugandan National Academy of Science focused on Uganda parliamentarians’ knowledge and awareness of issues pertaining to development of science and technology in Uganda (Chandrika, 2011). The study is instructive in terms knowledge gap among a critical segment of policy makers. Indications were that politicians are not well versed in the intricate and complex factors that need to be taken into consideration when formulating science and technology policies. The study underlined the need for building awareness among parliamentarians, policy makers and others responsible for formulation and implementation of national science and technology agenda (Chandrika, 2011).

213. Since science, technology and innovation are critical to the realization of MDGs and harnessing of national resources for socio-economic development, it is important that public awareness among all stakeholders is provided for. Various mechanisms (teach-ins, seminars, conferences and workshops, etc) could be organized for this purpose. In this way, the existing gaps of knowledge and support

between political intentions, the needs of research communities and other players could be minimized. This could also pave way for better utilization of existing capacities, resources and infrastructures.

214. An enhanced dialogue between policy makers, scientists, technologists and other stakeholders is therefore needed. Space should be accorded in particular to private sector, local communities and civil societies to express their views and indicate priority areas and what would constitute the responsibilities of each stakeholder in realizing goals of national project for STI.

9.3. The Role of Media in Science and Technology

215. The critical role of print and electronic media in educating the public and other stakeholders on what is entailed in scientific and technological policies and programmes need to be recognized. These channels can be utilized to educate public on how adoption and implementation of STI policies and strategies would impact on poverty alleviation, health improvement, quality of education, employment creation, enhance global competitiveness and overall sustainable development. Media is therefore a critical partner in any country in advancing scientific and technological agenda for social economic development. It is vital that the media institutions recognize and understand this role, and utilize the available spaces and capacities for building public awareness as well as engaging the various players in informed discourses on development and utilization of scientific and technological capacities for national level. We need to recognize and appreciate the contribution Science and Development Network is making this regard (www.scidev.net).

216. Additionally, media can bring issues of acquisition, adoption and utilization of scientific and technological knowledge and skills in socio-economic development into constant limelight for debate, assessment, evaluation and reform.

217. Hence a broad a partnership and collaboration is required at the continental, regional, national and institutional levels between politicians, policy makers, educators, funding agencies, knowledge producers, innovators and product developers and users in the various sectors. In this way political support, resources, capacities, public and private sectors goodwill and awareness can be galvanized for development and sustaining vibrant and productive scientific and technological communities in Africa.

9.4. Expected Action Points

- Portrayal of science and technological issues need a close study with a view of improving the image of S&T in the public domain
- Creative engagement with media is necessary to improve reporting and portrayal of research, science and technology projects, dissemination and utilization of innovations in productive sectors
- Build public awareness among all stakeholders on the usefulness of S&T in value-addition to natural resources, industrialization and sustainable development.
- Create a consensus among different actors of innovation with policy makers and public opinion. The consensus facilitates consistency and continuity of policy. The existence of such a consensus is an important asset for all countries that succeed or at least come close, such as Japan (where it is virtually enshrined in law) or the Netherlands (where even the “users” of research are involved in many sector councils).

10. STRENGTHENING REGIONAL COOPERATION AND INTERNATIONAL ENGAGEMENTS.

10.1. Introduction

218. Continental, regional and national policy documents reviewed in this synthesis indicate full awareness of the benefits of regional cooperation. Regional structures have been created to accelerate integration of markets, improve trade and develop energy and infrastructure. A number of institutions to advance scientific and technological research and capacity have also been established and located in various regions. These are in addition regional institutions established well before AU/ NEPAD initiatives. It is also noteworthy that countries have not only articulated their national strategies for scientific and technological development but also indicated possible areas for regional cooperation to harness region potential, resources and limited scientific and technologic capacity in each African country (AU/NEPAD, 2007; ATPS, 2010; Kamoun,2011).

219. The development of quality institutions for development of science, technology and innovation requires enormous resources (financial, infrastructural, and human) which can be brought together through regional initiatives. Advanced research all over the world is expensive; hence regional cooperation and international collaboration can garner much needed funds, maximize limited resources and capacity and draw upon a wide range of experiences and expertise available beyond national boundaries. Regional approach to research stems from recognition that some of African problems defy national boundaries and are manifested across many countries and regions. Problems related to health, agricultural and livestock development, drought and climate changes are regional in character and require cooperative efforts to get solutions.

220. While AU/ NEPAD, UN agencies and RECs have been in forefront in articulation of regional agenda for advancement of scientific and technological research and capacity, the persistent problem is that of implementation. Turning intentions into actions and programmes remain the main obstacle to pursuing policies and programmes which African countries have collectively committed to undertake. Lack of systematic funding of regional entities and nationalism has often bogged down at efforts at regional cooperation.

221. This idea of regional cooperation and collaboration is not new but has been embraced by African countries since independence and the establishment of the Organization of Africa Unity (OAU). The Lagos Plan of Action was one such a document that recognized science and technology as necessities for Africa's development and self-reliance and the imperative of cooperation and collaboration among African countries and institutions. The AU/ NEPAD's CPA has followed closely in this visionary thrust. The question is whether this agenda will receive political goodwill and financial backing to succeed.

222. In West Africa, the African and Malagasy Higher Education Council has acted as a coordinating agency to permit cooperation between the universities of 17 French-speaking countries in the fields of quality control, research results dissemination and staff mobility. Indeed, there are several indications that a number of African countries are turning towards regional or sub-regional cooperation. A stronger trend in this direction will be necessary if African researchers are to be taken out of their isolation and helped to overcome the difficulties posed by the physical (and political) circumstances that characterise many universities and research centres.

10.2. Building on the Strength of Regional Institutions

223. Africa has a number of excellent regional science and technology institutions and networks spread all over. The challenge is built on this regional architecture of institutions and experiences. While national governments shoulder the responsibilities of hosting these institutions, they recruit their staff internationally thereby attracting talent wherever they can get it. Funding is also international. While their international profile is usually high, their interaction with national research communities and institutions is not always good (PUIB, 2006). This is a challenge given the need for local communities to see benefits of the research and innovation emanating from these institutions.

224. While the intentions and regional cooperation agreements are well articulated, implementation is a continuing challenge at both national and regional levels. Even where African countries have well developed scientific capacities and national research systems, (Egypt, Kenya, Nigeria, Morocco, Tunisia and South Africa) implementation of continental agreements is problematic. For instance most countries have found it difficult to allocate one percent of their GDP to research and development. Incidentally only South Africa has done so.

225. The regional cooperation has been fostered by the proliferation of new forms of ICT, especially the Internet, and the development of new universities. Some African universities have been catalysts for quality and have won reputations as centres of regional excellence. This has been the case for Cheikh Anta Diop University in Dakar, the University of Cape Town in South Africa and the private Africa University in Zimbabwe, which has educated the students from twelve African countries.

226. It is however necessary to appreciate that African countries have worked closely within the framework of international bodies to developing their national scientific and technological capacities. For instance, UNESCO, the World Bank, and UNECA had individually and collectively been a positive influence on development of ideas and programmes related to advancement of science and technology in Africa (AU/NEPAD, 2007; UNESCO, 2010).

227. Bilateral agencies have also contributed greatly to development of science and technology institutions and capacities in Africa through agencies such as Japan International Cooperation Agency (JICA), International Development Research Centre (IDRC), The German Academic Exchange Service (DAAD), Swedish International Cooperation Development Agency (SIDA), Department for International Development (DFID), and United States Agency for International Development (USAID), etc).

228. In addition private foundations have provided funding for training, research and infrastructure development in the region. The contributions of private philanthropy represented by foundations such as the Ford and Rockefeller, Bill and Melinda Gates are well known in critical fields such as agriculture, water, health, micro-finance, higher education, ICT etc.

229. These and other likeminded agencies have supported national and regional research institutions to develop and utilize science and technology capabilities to address Africa's socio-economic and environmental concerns. Some have been critical in helping to retain and attract talent to Africa (Mugabe, 2009; Barugahara and Tostensen, 2009; Banji, 2005).

10.3. Utilizing African Diaspora

230. African Diaspora has become a force to reckon with, especially because of the enormous resources coming to the continent through their remittances. Tapping the trained and qualified human resources base in Diaspora to support the development of science and technology in Africa is a big challenge and also an opportunity

231. A policy to stem the brain drain is urgently needed. If qualified Africans are to be kept in Africa and those currently based in the developed countries brought back, it is not enough to offer attractive rates of pay, since it is unlikely that African countries can compete with the developed world where research salaries are concerned. The situation in post-revolutionary Tunisia has shown that a project for the democratisation can attract qualified individuals. Since the revolution of 14 January 2011, a number of qualified Tunisians have returned to the country, driven by the desire to participate in a project of national construction. Several ministers in the three post-revolutionary governments are qualified individuals with international reputations returned and participated in national reconstruction. Such “symbolic” motivations are a major factor and must not be neglected.

232. The experts often assess the feasibility of a development project by the availability of resources or skills, but the reconstruction of a nation must be the centre of any development project. Most of the studies on R&D skill development stress the need to turn research and development in the direction of community-based projects. However, for communities, and individuals, to be able to play an active part in the development of their country, African countries must succeed in recreating the energy that drove their construction after winning independence. The Sustainable development is not possible without adding value to the human capital.

10.4. Expected Action Points

- Political support is critical not only in articulation of policies and programmes but also pushing for implementation of the agreed regional agenda, targets and timelines. This should be coupled with mechanisms for evaluation and monitoring of desired outcomes.
- Build on experiences existing in African institutions and networks. There are useful experiences from both sciences and social sciences, for example ILRI, ICIPE, ATPS and CARTA, AERC, University, Science, Humanities and Engineering Partnership in Africa (USHEPiA) , AIMS etc
- Turning good intentions into strong programmes, institutions and capacity for implementation by setting up regional and national targets, strategies and follow-up mechanisms. The key is to strengthen implementation strategies at national levels to realize both local and regional agendas.
- Increase funding for regional institutions and strengthen capacity building efforts through post-graduate programmes and postdoctoral fellowships, while providing incentives for attracting regional mobility of qualified labour and Diaspora. Strengthen staff exchange in Africa to maximize STI capacity, while intensifying South- South exchanges and mutual learning
- Building on existing cooperation and collaborative initiatives and programmes among African universities, especially in carrying out research on common regional problems such as health, water, agriculture and climate changes.
- RECs, African universities, regulatory bodies and networks should strengthen cooperation and collaboration on issues of quality assurance, harmonization of degree programs, graduate studies and exchange of staff and students.

10.5. The Way forward

233. Problems of marginalization in science and technology, globalization and sustainable development, cut across all African countries. On the other hand opportunities for turning the vast natural resources in Africa into a platform of economic growth, industrialization and employment creation are spread into the entire continent. To change the current situation, and utilize the existing opportunities, Africa requires solid and consistent regional and international cooperative and collaborative strategies for ST research and innovations.

234. Given the disparity between the various academic institutions and countries in terms of their budget allocations, the regional cooperation in the area of scientific research must combine effective

universities with less effective ones to allow them to improve. According to the Annual Report of the African Network of Scientific and Technological Institutions (ANSTI), universities in Sub-Saharan Africa have resources to allow them to play a role as training centres. Hence the necessity of identifying clusters of excellence – as emphasised in the AfDB strategy — in order to permit effective cooperation between institutions and countries and between regions and the international scientific community.

235. Regional cooperation in tackling the conundrum makes social, economic, financial and intellectual sense. Hence a close partnership of national governments, regional entities and networks, international organizations, private sector and civil society institutions is critical to unraveling African potential.

11. CONCLUSION.

236. Africa has many assets to build on: first, the youth bulge which is becoming increasingly educated, it is vast natural resources, the diversity of its tropical lands and its cultural and spiritual optimism. At the same time faces what seems indomitable challenges of poverty, health (HIV/AIDS, Malaria, TB and emerging life style diseases, etc), unemployment, food security, climate change, energy, conflict and wars, and sustainable development.

237. The continent needs to turn the assets into opportunities to deal with its myriad problems. This is where acquiring and utilizing scientific and technological capacity comes in handy. As Mohamed Hassan has argued, “*Africa does not have scientific, technological or innovative capacity to effectively address the challenges it confronts*”(Hassan, 2009)This synthesis confirms this observation, but makes a number of bold suggestions on critical action points to transform the existing situation into opportunities for vibrant socio-economic growth. This entails going beyond articulation of appropriate policies, programs at continental and national levels, to implement far reaching reforms and create requisite capacities at national and institutional levels. The synthesis paper has also recognized a number of areas where changes are required, including: teaching and learning of mathematics and sciences at all levels of education system, building scientific and technological capacity of the youth, revitalizing research and innovative capacities of the universities and linking them to productive sectors of the economy, ensuring inclusion of girls and women and marginalized groups in the development of scientific and technological capacity as well as building and strengthening ICT infrastructure and capacity as a platform for change and innovation.

238. There is arising optimism in Africa buoyed by recent high rates of economic growth, democratic and governance reforms, rapid adoption of ICT, increasing local and foreign investments, impact of Diaspora remittances and the rising levels of education achievements and aspirations of the African youth (Economist, 2011; Mckinsey,2010; AfDB,2011; African Commission, 2009; Miguel,2011).

239. The promotion of innovation cannot be confined to the sciences and ignore the other vital sectors of culture. In a process of lifelong learning, the key factor is human capital. And value can be added to human capital only by adding value to the human factor *per se*, a process that necessarily requires greater value to be attached at the outset to a sense of citizenship.

240. Building on the current optimism Africa needs to recognize that it is not a matter of running, but running much faster to catch-up on socio-economic development. In short, it has to win the global marathon of sustainable development.

12. BIBLIOGRAPHY

- Academy of Science of South Africa (ASSAF).2011. *Inquiry-Based Science Education: Increasing Participation of Girls in Science in sub-Saharan Africa* Policy- maker's Booklet, ASSAF, South Africa
- Association for Development of Education in Africa (ADEA). 2011. "Report on the Youth Consultation Forum". November 11, 2011
- Adams Jonathan, King Christopher and Hook Daniel. 2010. "Global Research Report Africa". Thomson Reuters
- Arbache, J. et al (2010). *Gender disparities in Africa's labor markets*. World Bank, Washington, D.C.
- African Development Bank (AfDB).2008. *Strategy for Higher Education, Science and Technology*. Operations Policies and Compliance Department (ORPC), Human Development Department (OSHD)
- AfDB. 2011. *Africa in 50years' Time: The Road towards Inclusive Growth*.
- .AfDB, ECA, UNDP and AU. 2011. MDG Report 2011. *Assessing Progress in Africa toward the Millennium Development Goals*
- AfDB, ECA and AU.2008. "Achieving Gender Equality and Women's Empowerment in Africa Progress Report. The 6th African Development Forum (ADF VI) 19-21 November 2008, United Nations Conference-Ethiopia
- Africa Commission.2009. "Realizing the Potential of Africa's Youth". Ministry of Foreign Affairs of Denmark
- African Technology Policy Studies Network (ATPS). 2009. "Young Professionals and Women in Science Competitions: Improving Agricultural Performance in Sub-Saharan Africa" Technical report of the CTA/ATPS/AGRA/FARA/NEPAD/RUFORUM
- African Union (AU). 2007. "Strategy to Revitalize Technical and Vocational Education and Training (TVET) in Africa"
- Altbach G.Philip and Salmmi, Jamil (Eds). 2011. *The Road to Academic Excellence: The Making of World Class Research Universities*. The World Bank
- AU-NEPAD. 2010. *African Innovation Outlook 2010*. AU-NEPAD, Pretoria
- AU-NEPAD.2007. *Africa's Science and Technology Consolidated Plan of Action*. Pretoria
- Adedeji, Adebayo .1985. "The Monrovia Strategy and the Lagos Plan of Action: Five Years After." In A. Adedeji and T. Shaw, eds., *Economic Crisis in Africa: Perspectives on Development Problems and Potentials* Boulder, Colorado: Lynne Rienner Publishers).
- Pouris Anastassios and Pouris Anthipi. 2009. *The State of Science and Technology in Africa (2000-2004): A Scientometric Assessment*. Scientometric, Vol 79(1)
- Banji Oyelaran-Oyeyinka.2005. "Partnerships for Building Science and Technology Capacity in Africa" Paper prepared for The Africa –Canada-UK Exploration: Building Science and Technology Capacity with African Partners. 30 January-1 February 2005, London UK
- Barugahara N.I and Tostensen. A. 2009. *Science and Technology for Development: The Institutional Landscape in Africa and Europe*. CAAST-Net
- Dahmani Ahmed, "Les TIC : une chance pour l'Afrique?", http://www.iut-orsay.u-psud.fr/modules/resources/download/orsay/Laboratoires/AMETIS/Programme_de_recherche_sur_TIC_et_Developpement/Les_TIC_une_chance_pour_l_Afrique.pdf
- Benjamin Mkapa. 2004. "Indigenous Knowledge—a Local Pathway to Global Development" in *Indigenous Knowledge: Marking Five Years of the World Bank Indigenous Knowledge for Development Program*. The World Bank
- Brok, Derek. 2003. *Universities in the Marketplace: The Commercialization of Higher Education*. Princeton University Press
- Chandrika Nath. 2011. "Use of scientific and technological evidence within the Parliament of Uganda". A joint report by the UK Parliamentary Office of Science and Technology, the Parliament of Uganda, and the Ugandan National Academy of Sciences.

- Chinguta, Francis. 2002. "The Socio-Economic Situation of Youth in Africa: Problems, Prospects and Options". Paper presented in Alexandria Summit, September 2002, Egypt.
- Comaroff, Jean and Comaroff, L.John.2005. "Reflections on Youth from the Past to the Post colony". In *Makers and Breakers: Children and Youth in Postcolonial Africa*, eds Alcinda Honwana and Filip De Boeck. James Currey, Oxford.
- Diarra Mohamed.Chérif. 2011. "Invest in Science and Technology or Perish: The Challenges faced by Faculties of Science and Technique, Schools of Engineering & Polytechnics at the age of the Knowledge Economy" .Cases Studies of Nigeria and Senegal. Unpublished
- Dickson David and Jeanne ThereseH.Andres .2011. "Women in science: still untapped resource" Available at <http://www.scidev.net/en/editorials/women-in-science-still-an-untapped-resource-1.html> Accessed on June 28, 2011
- Diouf, M.2003. "Engaging Postcolonial Culture: African Youth and Public Space". *African Studies Review* 46 (2), pp.1-12
- Durham, Deborah.2004. "Disappearing Youth: Youth as a Social Shifter in Botswana". *American Ethnologist* 31(4), pp.589-605
- Farrell, Glen and Shafika Isaacs. 2007. *Survey of ICT and Education in Africa: A Summary Report, Based on 53 Country Surveys*. Washington, DC: infoDev / World Bank. Available at <http://www.infodev.org/en/Publication.353.html>
- FAWE.2011. *Strengthening Gender Research to improve Girls' and Women's Education in Africa*. FAWE Research series Vol 1-2010
- Gavin, Michelle. 2007. "Africa's restless youth" in *Current History*, May 2007, pp 220-226.
- Gidoomal,Shalini. 2011. "Technology Innovation: Pioneering", *Msafiri Edition* 77 September-October 2011.Gecko
- Grosskurth, Jasper. 2010. *Future Technologies of Africa*. STT, Den Haag, Netherlands
- Hooker, Mary. 2010. "Concept Note: Building Leadership Capacity for ICT and Knowledge Societies in Africa". GeSCI
- Holbrook, Jack.2009. "Meeting Challenges to Sustainable Development through Science and Technology", *Science Education International*, Vol.20,No.1/2,December 2009
- Honwana, Alcinda and Boeck De Filip.2005. *Makers and Breakers: Children and Youth in Postcolonial Africa*. Oxford, James Curry
- International Telecommunication Union (ITU).2010.*World Telecommunication/ICT Development Report 2010: Monitoring the WSIS Targets. A mid-term review*.
- International Labor Organization *Global Employment Trend* , 2011, Geneva, The challenge of recovery, ILO Geneva, 2011
- Jeanne Therese H.Andres. 2011. "Overcoming gender barriers in science: Facts and figure" Available at <http://www.scidev.net/en/feature/overcoming-gender-barries-in-science-facts-and-figures-1.html> Accessed on December 14, 2011
- Joanna Chataway, James Smith, David Wield. 2005. *Partnerships for Building Science and Technology Capacity in Africa: Canadian and UK Experience*. Paper prepared for *The Africa – Canada-UK Exploration: Building Science and Technology Capacity with African Partners*. 30 January-1 February 2005, London UK.
- Basil Jones: *Linking research to policy*, AfDB working paper no 131- June 2011
- Juma, Calestous and Lee Yee-Chong. 2005. "Innovation: applying knowledge in development" UN Millennium Project Task Force on Science, Technology, and Innovation 2005, Earthscan, UK and USA
- Kerre, B.Wanjala.2000. "Science and Technology Teacher Education in Africa: Issues in the promotion of Scientific and Technological Literacy" <http://portal.unesco.org/education/en/files/52553/11725002665Kerre.pdf/Kerre.pdf> Accessed on October 2011
- Kamoun, Farouk. 2011. "Is Innovation the Key to Industrial Development in Africa?" A Paper prepared for Second Session of the Committee on Development Information, Science and Technology (CODIST-II) Addis Ababa, Ethiopia, 2-5 May 2011

- Kuria, Mike, Harnsert Christopher and Nkunya Mayunga. 2011. "Regional Cooperation for Quality Assurance: The IUCEA/DAAD East African Quality Assurance Initiative" .GIZ
- Krus,Glenda. 2006. "University-industry links: Lessons from South Africa" Available at <http://www.scidev.net/en/opinions/universityindustry-links-lessons-from-south-afri.html> Accessed on July 25, 2010
- Mamdani, Mahmood. 2007. *Scholars in the Marketplace: The Dilemmas of Neo-Liberal Reform at Makerere University, 1989–2005.*, Dakar, Senegal: CODESRIA.
- McKinsey Global Institute. 2010. *Lions on the Move: The Progress and Potential of African Economies.* McKinsey & Company
- Mercy Tembon and Lucia Fort (Eds). 2008. *Girls' Education in the 21st Century: Gender Equality, Empowerment and Economic Growth.* The World Bank
- Michael Hörig.2011. "Offering relevant higher education qualifications in the context of globalization: Discussing the concept of the 'Centres of African Excellence'" A Background paper for ADEA 2012
- Miguel Edward. 2011. "Africa Unleashed: Explaining the Secret of a Belated Boom". *Foreign Affairs* November/December 2011, Vol 90, No 6
- Mohammed H.A.Hassan.2009. "Promoting Science, Technology and Innovation for Sustainable Development". Executive Summary prepared for First Session of the Committee on Development Information, Science and Technology (CODIST-1), ECA, Addis Ababa, Ethiopia 28 April-1 May 2009
- Mugabe, John. 2009. "Knowledge and Innovation for Africa's Development Priorities, Policies and Programmes". The World Bank
- Mugabe, John. 2008. "Centers of Excellence in Science and Technology for Africa's Sustainable Development: Towards New forms of Regional and Sub-Regional Networks" Available at http://www.nepadst.org/doclibrary/pdfs/doc08_112003a.pdf Accessed on June 15, 2011
- Namata, Berna. 2012. "Pan African University officially launched". *The EastAfrican*, January 2-8, 2012, p 31. Nairobi
- Ngethe, Njuguna, Subotzky,George and Afeti George. 2008. *Differentiation and Articulation Tertiary Education Systems: A Study of Twelve Countries.* World Bank
- Nicolas Gorjestani. 2000. "Indigenous Knowledge for Development: Opportunities and Challenges". The World Bank
- Nordling, Linda. 2009. "Africa Analysis: Does Africa need a pan-African university?" Available at <http://www.scidev.net/en/opinions/africa-analysis-does-africa-need-a-pan-african-uni.html> Accessed on July 25, 2010
- Omwansa, Thomas. 2009. M-Pesa: Progress and Prospects" innovations / Mobile World Congress 2009. Pg 107-123. <http://www.strathmore.edu/pdf/innov-gsma-omwansa.pdf> or http://www.gsmworld.com/documents/INNOVATIONS-GSMA_FINAL-01-22-09.pdf accessed on December 12,2011
- "Q&A With Manoj Shanker: Tailor-made African IT solutions way of the future for industry". *The EastAfrican*, January 2-8, 2012, Nairobi
- Partnership for Higher Education. 2008. "Developing and Retaining the Next Generation of Academic". Report of the Second University Leaders' Forum, November 2008
- Paschal B. Mihyo, Abeeku Brew Hammond, Anselmo O. Makhoka and Mr. Uirapi G. Tjihenuna. 2011. "The Role of Tertiary Education Institutions in the Development of Technical and Technological Capabilities for Employment Creation in Eastern, Southern and West Africa: Selected Case Studies". Report Submitted on the 12th December 2011 to ADEA for the ADEA Triennale 2012
- Public University Inspection Board. 2006. *Transformation of Higher Education and Training in Kenya to Secure Kenya's Development in the Knowledge Economy.* Report of the Public Universities Inspection Board. Nairobi: Republic of Kenya
- Sabaya.W. 2004. Quality Assurance, Accreditation and Recognition of Qualification in Africa. Available at <http://www.aau.org/wto-gats/papers/sabaya.pdf> Accessed on August 29,2011

- Safaricom. 2010. 2010 Annual Report. "Business Overview". Available at <http://www.safaricom.co.ke>
Accessed on December 15, 2011
- Society for International Development (SID). 2011. *East African Integration: Dynamics of Equity in Trade, Education, Media and Labour*
- Sommers ,Marc 2001. *Fear in Bongoland: Burundi Refugees in Urban Tanzania*. Berghahn Books, 2001
- Ssebuwufu, John and Ludwick ,Teralynn. 2011. "*Strengthening Linkages between Industry and Higher Education Institutions in Africa*". Association of African Universities (AAU)
- Association of Universities and Colleges of Canada (AUCC)
- Stampini, M. &Verdier A. "Labor market dynamics in Tunisia: The issue of Youth Unemployment", Working Paper No 123 February, 2011 (Tunis: The AfDB)
- The Economist. 2011. "Africa rising", The Economist December 3- 9, 2011
- Tunisian Ministry of Employment and Professional Integration and World Bank (2008).
- United Nations Educational, Scientific and Cultural Organization (UNESCO). 2011. EFA Global Monitoring Report. The Hidden crisis: Armed conflict and education. Paris
- UNESCO. 2010a. UNESCO Science Report 2010: The Current Status of Science around the World. UNESCO
- UNESCO. 2010b. EFA Global Monitoring Report. Reaching the marginalized. Paris
- UNESCO.2009. EFA Global Monitoring Report. Overcoming inequality: why governance matter. Oxford University Press, UNESCO
- UNESCO.2007a. "Teacher Education Policy Forum for Sub-Saharan Africa" UNESCO Headquarters, Paris, 6-9 November 2007
- UNESCO. 2007b. Science, Technology and Gender: An International Report. UNESCO
- UNESCO-UIS. 2006. "Women in science: Under-represented and under-measured".UIS Bulletin on Science and Technology Statistics, Issue No. 3 November 2006
- UNESCO.2005. EFA Global Monitoring Report. Literacy for Life. Paris.
- United Nations Economic Commission for Africa (UNECA). 2011 .Africa Youth Report 2011.Addressing the youth education and employment nexus in the global economy. Addis Ababa, Ethiopia.
- UNECA/IST.2010. A Technology Resurgence? Africa in the global flows of technology, UNECA Series of technology Transfer for Africa's Development, UNECA, Addis Ababa, Ethiopia
- UN. 2010 World Programme of Action for Youth. Economic and Social Affairs
- UN.2007. World Youth Report 2007: Young People Transition to Adulthood: Progress and Challenges. UN.
- United Nations Population Fund (UNFPA). 2011. State of World Population 2011: People and possibilities in a world of 7 billion.UNFPA
- UNFPA. 2010. State of World Population 2007: Unleashing the Potential of Urban Growth. UNFPA
- Urama, Kevin., Ozor, Nicholas and Mwangi, Wairimu (Eds).2010.The State of Science, Technology and Innvation in Africa: Implications for Achieving the Millennium Development Goals. ATPS
- Varghese. V.N.2008. "Globalization of Higher Education and Cross-border Student mobility".IIEP. Available at <http://www.unesco.org/iiep/en/publications/pubs.html>
- Watkins, Alfred and Ehst, Michael(eds). 2008. Science, Technology, and Innovation Capacity Building for Sustainable Growth and Poverty Reduction. The World Bank
- World Bank Group. 2007. "Developing Science, Mathematics, and ICT Education in Sub-Saharan Africa: Patterns and Promising Practices". World Bank Working Paper No. 101, Africa Human Development Series. Washington DC, USA.
- World Bank. 2011a. "Learning for All: Investing in People's Knowledge and Skills to Promote Development". World Bank Group Education Strategy 2020-Executive Summary
- World Bank. 2011b. World Development Report 2012: Gender Equality and Development**
- World Bank. 2009a. *Africa Development Indicators 2008/09: Youth and Employment in Africa. The Potential, the Problem, the Promise*. Washington, D.C.

World Bank. 2009b. *Accelerating Catch up: Tertiary Education for Growth in Sub Saharan Africa*

World Bank. 2003. *Lifelong Learning in the Global Knowledge: Challenges for Developing Countries*

World Bank. 2000. *Higher Education in Developing Countries: Peril and Promise*. The Task Force on
Higher Education and Society