PROCEEDINGS OF THE 6TH GLOBAL CONSORTIUM OF HIGHER EDUCATION AND RESEARCH FOR AGRICULTURE CONFERENCE

'Food, Health and Energy: Challenges for Sustainable Agriculture'

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INTRODUCTION

Agricultural universities worldwide face numerous challenges including increasingly limited resource allocations, declining enrollment, keeping up with advances in information and other technologies, remaining aware of and responsive to stakeholders, and the need to aggressively globalize their teaching, research and outreach programs. Although the scale of the problems and the local conditions vary across and among regions, there are remarkable similarities in the fundamental nature of these challenges.

The realization that these are shared challenges, combined with a political and economic climate that lends itself to the lowering of national barriers, presents an environment conducive to global networking and cooperation among universities.

GCHERA grew out of an international conference held in 1998 in Kiev, which marked the 100th anniversary of the National Agricultural University of Ukraine and the completion of a four-year university linkage project involving many institutions around the world and financed by the United States Information Service. The consortium was formed as a result of shared concern for the future of the planet and a conviction that higher education in agriculture should play a key role in solving problems associated with food security and environmental sustainability. The consortium aims to include and serve institutions with programs in agriculture, veterinary medicine, and natural resources management, including the biological, physical and social sciences dimensions of these fields. The founders designed the organization to be helpful to institutions worldwide that are working to make significant reforms in their systems of higher agricultural education. Currently, the consortium has approximately 400 members from more than 100 countries.

The consortium is governed by a regionally balanced Executive Committee and led by a President. Global meetings of the consortium are held every two years, the first having been held in Amsterdam (Netherlands) in 1999. Subsequent conferences were held in San Francisco (USA), Kiev (Ukraine), Hangzhou (China) and San Jose (Costa Rica). This book of proceedings reports on the 6th GCHERA conference held in Nairobi, Kenya.

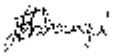
FOREWORD

It is with profound pleasure that we unveil the proceedings of the 6th GCHERA Conference that was held in Nairobi, Kenya.

The five-day conference featured eleven technical paper presentations, group discussions, exhibitions and field excursion under the theme "Food, Health and Energy: Challenges for Sustainable Agriculture".

The Organising Committee of the Conference spent long hours to ensure the conference was a success. The challenges faced in organising the conference served as a learning experience for many in the committee. We mainly derived our resilient working spirit from awareness of the fact that it would indeed be a great honour to play host to some of the world's most celebrated agricultural trainers, researchers, policy makers and technology disseminators as they reflect on how to make the discipline more responsive to the needs of our ever changing world.

Let me thank the University management, conference organisers, sponsors, participants, the Government of Kenya and all other stakeholders for their valuable contributions towards the success of the forum. Finally, I thank His Excellency Hon. Mwai Kibaki, CGH, MP, President and Commander-in-Chief of the Armed Forces of the Republic of Kenya for officially opening the conference.



Prof. Esther Murugi Kahangi
CHAIRPERSON, 6TH GCHERA CONFERENCE ORGANISING COMMITTEE

MESSAGE FROM THE VICE CHANCELLOR

It gives me much pleasure to witness a major milestone for us all - the publication of the Proceedings Book for the 6th Global Consortium of Higher Education and Research for Agriculture Conference, which was hosted by Jomo Kenyatta University of Agriculture and Technology (JKUAT) on 23rd to 27th November 2009. The success realised in organising and hosting the conference went a long way to not only showcase JKUAT as a major centre of agricultural research and technology, but also the continent of Africa as a rich reservoir for agricultural activity.

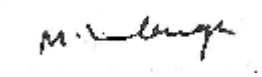
I wish, on behalf of the entire JKUAT Community, to take this opportunity to thank all those who contributed in one way or another towards the success of the conference. I particularly note the role of the various paper presenters who tabled well-researched and highly relevant presentations, and the GCHERA Executive Committee together with the Conference Local Organising Committee for the long hours spent to ensure the success of the conference. My sincere thanks also go to the conference sponsors, namely the Bill and Melinda Gates Foundation, Alliance for Green Revolution (AGRA), the German Academic Exchange (DAAD) and the Kenya Institute of Management, for the very generous assistance towards the organisation of the forum. Our institution is also grateful to the Government of Kenya, through the Ministries of Higher Education Science and Technology, and Ministry of Agriculture for much logistical support that saw the conference proceed without hitches. I in this regard particularly thank His Excellency the President of the Republic of Kenya, Hon. Mwai Kibaki for finding time to open the conference.

Continued consultations and cooperation of all parties mentioned above ensured that at the close of the day, the first GCHERA conference in the continent of Africa was indeed a remarkable success. Thank you once again and maintain this working spirit.

For all participants, I wish to reiterate the oft-repeated reminder that this and other similar conferences should rise above being mere talk-shops. It is now time for us to consolidate the various findings with a view to making the ordinary farmer – and indeed the entire agricultural sector – more useful to humanity through ensuring food security and therefore reduction of poverty. It is we researchers and professors in institutions of higher learning that will provide the ultimate solution to the myriad of problems that continue afflicting the agricultural sector day after day.

Finally, I wish GCHERA continued success in the arduous attempt to change the face of agricultural training for the better, all over the world. With this, it is also my prayer that the new President, Prof. Phillipe Choquet, gathers enough strength to steer the consortium to greater heights.

Thank you.



Prof. Mabel O. Imbuga

VICE CHANCELLOR, JOMO KENYATTA UNIVERSITY OF AGRICULTURE AND TECHNOLOGY, NAIROBI, KENYA

ACKNOWLEDGEMENT

The Organising Committee wishes to recognise with utmost appreciation the sponsors of this conference, key among them being the Bill and Melinda Gates Foundation, Alliance for Green Revolution in Africa, Kenya Institute of Management, German Academic Exchange (DAAD) and Jomo Kenyatta University of Agriculture and Technology. The advisory role and active participation of the GCHERA Executive Committee is highly appreciated, alongside the paper presenters, chairpersons of sessions, rapporteurs and exhibitors. We are also indebted to the management of Jomo Kenyatta University of Agriculture and Technology, particularly the Vice Chancellor, Prof. Mabel Imbuga, for moral and financial support during the organisation and hosting of the conference.

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WELCOMING REMARKS

Prof. Esther M. Kahangi
Chairperson, 6th GCHERA Conference Organising Committee

Ladies and gentlemen, on behalf of the Conference Organising Committee, I am pleased to welcome you to the Sixth Conference of the Global Consortium of Higher Education and Research for Agriculture (GCHERA), a gathering that brings together agricultural research scientists to share ideas on the role of agricultural universities worldwide in drawing solutions to such critical problems as food insecurity which are threatening the survival of humanity.

It is encouraging that the forum will also seek to address another major worldwide concern, the low enrolment in agriculture and related courses in institutions of higher learning.

I wish to take this opportunity to recognise with utmost appreciation the various sponsors of this conference, key among them being the Bill and Melinda Gates Foundation, Alliance for Green Revolution in Africa, DAAD, Kenya Institute of Management and Jomo Kenyatta University of Agriculture and Technology. Equally important are paper presenters in the various sub-thematic areas and exhibitors who are set to enlighten the congregation and indeed the larger society on burning agricultural and environmental matters of the day. I also thank the organisers of the conference for their tireless efforts that have culminated in the staging of today's ceremony.

Your Excellency, this conference – whose theme is "Food, Health and Energy: Challenges for Sustainable Agriculture" – will see, in the next four days, presentations touching on Agriculture and Food Security; Health and Agriculture; Renewable Energy for Agricultural Production; Training of Manpower and Motivation, and Climate Change. We have gone great lengths to invite acclaimed scholars globally renowned for their contribution in agricultural higher education and research. At the end of the conference, we are looking forward to drawing resolutions expected to directly address the many problems currently being witnessed in the areas I have highlighted. The conference will also propose viable strategies to institutions all over the world offering courses in agriculture, veterinary medicine and natural resources management, including the biological, physical and social sciences dimensions of these fields. We also intend to parade exhibitions highlighting innovations resulting from agricultural research.

Your Excellency Sir, agricultural universities and research institutions all over the world continue to play a crucial role in economic development and assurance of comfortable living for all. To this end, we are calling upon researchers to increase efforts in their various disciplines with a view to solving the ever rising challenges in the agricultural sector. Without doubt, research and development is the only way forward, especially for the developing world.

Finally, I wish all participants and guests a fruitful and educative experience during the conference. Welcome once again and thank you all.

OPENING REMARKS

Prof. Mabel Imbuga
Vice Chancellor Jomo Kenyatta University of Agriculture and Technology (host institution)

His Excellency Hon. Mwai Kibaki, the President and Commander-in-Chief of the Armed Forces of the Republic of Kenya, Cabinet Ministers, Permanent Secretaries, distinguished guests, ladies and gentlemen.

I am delighted to address you during the official opening of this conference**.** It gratifies even more that Jomo Kenyatta University of Agriculture and Technology has been honoured with the opportunity to host this very important forum. Indeed, this gathering gives me fond memories of a very enriching experience during my participation in the Second GCHERA Conference held in July 2001 at San Francisco, USA.

On behalf of the entire community of Jomo Kenyatta University of Agriculture and Technology (JKUAT), I wish to take this opportunity to warmly welcome you to the conference. I believe that the forum will provide the opportunity to examine various challenges facing universities offering agricultural training and research. We will also be able to share experiences and learn from one another and hopefully come up with concrete suggestions that will assist in addressing the hurdles we face.

Since its inception in 1981, JKUAT has played a pivotal role in the development of agricultural and technological development of Kenya and the wider region. Our Faculty of Agriculture - the oldest in the institution - has a track record of offering innovative solutions while addressing real challenges relating to food production, health and energy. Our graduates are to be found in all niches of the agricultural sector, being involved in production, extension services, generation of new knowledge through research and training at all levels.

As a public university, we are keen to provide the skills, knowledge and technology required to steer the country towards achieving the economic, social and political goals enshrined in national development instruments. JKUAT appreciates the global social dynamism and its impact on provision of higher education and is continually realigning its programmes to reflect the same. In this regard, we recently reviewed our strategic plan to align it to the national and international trends.

For JKUAT and other Kenyan universities, this conference could not have come at a better time. We are currently experiencing dwindling enrolment in agriculture-based programmes. This trend must be reversed to ensure food security and economic development. I am delighted that we have our counterparts from Wageningen University in the Netherlands and Pennsylvania State University from the USA, both institutions which have successfully reengineered their agricultural programmes to attract an increased student enrolment. We look forward to gaining from their experiences.

Apart from training, JKUAT is also keen on research and innovations, many of which happen to be linked to the sub-themes of this conference. For instance, to address the energy crisis, we are currently conducting biodiesel research. Also along the same

lines, pilot production of high-yielding rice and indigenous crops are ongoing. You will be able to see some results from these researches and many more when you visit the University.

Despite the enumerated areas of success and achievements, our institution continues to face various challenges arising from limited resource availability. It is no coincidence that the list of challenges we face paraphrase those identified by the founders of this consortium in 1998. Our involvement in GCHERA draws on the knowledge that by thinking globally, we can effectively act locally. Our institutional mission statement *"A university of global excellence of training, Research and Innovation for development",* calls for close cooperation with international organisations in the areas of education and agricultural research.

During this conference, you will have the opportunity to visit our main campus, which is not far from the City of Nairobi. I in this regard, wish to extend my personal invitation while encouraging you to take advantage of the Kenyan sense of hospitality by interacting with our staff and students.

Thank you and welcome.

GCHERA BACKGROUND

Dr. Ernst Lindemann and Dr. Dymtro Melnychuk
GCHERA Founder members

His Excellency Hon. Mwai Kibaki, President of the Republic of Kenya, GCHERA President Prof. Nick Wanjohi, members of the Executive and the Scientific Committee, the Conference Local Organising Committee, ladies and gentlemen.

It is a special honour for us, today, ten years after the founding of GCHERA, to speak to you about the development of the consortium, the challenges it has faced and its perspectives.

GCHERA was founded in 1998 and now has more than 400 members from more than 100 countries. The initiative to form GCHERA goes back to the celebrations of the 100th jubilee of the National Agricultural University, Kiev, Ukraine, in 1998. On that occasion, an international conference with the theme *"Global Reforms in Higher Agricultural Education and Research: Responding to Challenges to Quality and Safety of Food and Agricultural Products"* was held. After a year, the Executive Committee of consortium was elected and the name 'Global Consortium of Higher Education and Research for Agriculture (GCHERA)' adopted. Among the founders included Dmytro Melnychuk, and colleagues Jischke (President of Iowa State University) and Lindemann (Dean of the faculty of agriculture and horticulture of Humboldt University). The formation arose from the need to create a forum for the most important global economic and social factors, namely agriculture and related disciplines. Professor Martin Jischke was elected the first president of the consortium, with Professor Dmytro Melnychuk becoming the president-elect. This consortium covering the field of agricultural university education, and in the future possibly also of research, is unique and carries immense potential to all. It is an organisation that overrides national, political, religious and other barriers, as it seeks to harmonise education while communicating best practices.

The past few years have been very exiting for all of us, for Ernst Lindemann especially, because he became a pensioner. This new status allows him to concentrate more on issues he regards as important, one of them certainly being GCHERA.

Let us now enumerate what we deem necessary to improve our consortium. In this regard, we will refer to various GCHERA documents, and especially the speech by our colleague Maguire in Costa Rica, which, in our view, provided an excellent summary.

We are representing disciplines which hold the key to the solution of most problems which confront mankind on daily basis. Consider hunger und climate change. Can a non-governmental organisation like GCHERA play an active role in the solutions to these problems? We are not a small United Nations Organisation, and we don't have and will never have enough resources. We cannot indeed solve all problems merely by organising biennial conferences.

We are of the opinion, that we should not overstretch ourselves by aiming too high. We should instead strive to make small steps, and create common standards. This is the only way to become successful. Most of us are working in agricultural education, and

this is what we should concentrate. Everything done to adapt our study systems to present challenges will lead to progress. Students will become more flexible in accepting exchange programmes. The credits they gain will become more easily acceptable and their horizons will broaden, providing work opportunities. And if we include young scientists, professors and global economic players in these efforts, then this will show progress in research and the solution of global problems. We should encourage co-operation and exchange of knowledge at all levels, as we make small steps, and agree on issues which can be put into practice.

Our colleague Maguire had the same critical view. He suggested building regional consortia, whose results would be presented at the world conference every three or four years. These regional organisations could work on sub-themes such as curricula or research strategies. This work would be done, not by university presidents, but by well chosen experts in education and research. This will lead to efficiently made decisions.

All this work – as colleague Maguire suggested – should be co-ordinated by a permanent secretariat, with one position for a scientific co-coordinator and another for a secretary. Rooms and equipment for this can surely be found within many member universities. Together, both positions will cost approximately US$ 60,000. Divided among 100 members, and with increasing support from sponsors, this should indeed be feasible.

Future GCHERA conferences should take place every third year, so as to generate additional savings. Small workgroups could meet on a regular basis and publish their results in such publications as half-yearly GCHERA journal. Besides this, the internet presence should be enhanced. There could be chat rooms as well as news tickers, all managed by the secretariat. Less major conferences require more intensive inter-conference contact.

Let us save GCHERA by making it more effective. We cannot solve all the problems of mankind, but we can be efficient in solving problems in education and research, in supporting small members and in exchanging best practices for our universities.

We need countries such as China and India, but eventually every nation in our boat, because everyone is responsible for this planet, which – for the foreseeable future – will be the only one on which we can live.

We wish that this conference would decide about the proposals made in this speech. We look back over a number of talks and discussions amongst members. Our conferences have always brought countless impressions of the differing situations in our countries. Conferences should be consistently aimed at the exchange of progressive developments in the member nations. Secrecy, arrogance and discrimination of any kind, have never been characteristics of our consortium, and should never be.

In the last ten years, the optimism of GCHERA has somewhat decreased. Let us engender more enthusiasm, include more specialists, and work regionally. Then we will be taken more seriously in the future. This will also bring us more new members. Let us advertise GCHERA.

Finally, we would like to recommend the following:

(i) Executive Committee has to be re-structured as per our bylaws.

(ii) Consortium members should search for new members from related universities, private industry and the public sector.

(iii) A secretariat should be established before January 2010. We propose that the office be set up in Kiev, the birthplace of GCHERA, where excellent conditions can be found. The secretariat will have two officers who will be paid by GCHERA. The secretariat will operate as per GCHERA bylaws. It will report twice a year about its work and financing plan, and publish a biannual GCHERA journal.

(iv) Two working groups per continent should be established, led by an executive committee member. The working groups will include representatives from institutions in science, and those in practice as well as students. Education matters will have primacy in the work. The working groups will report twice a year to the secretariat. The reports will be published in the journal. The listing of agricultural universities worldwide will be regularly updated.

(v) During this conference, we should elect a new president. We recommend the Rector of Russian State Agrarian University named after K. A.Timiryazev, V. M. Bautin and Dean of the Faculty of Agriculture and Horticulture of Humboldt University (Berlin, Germany), Otto Kaufman, as suitable candidates for this position. Volodymyr Bautin is also a President of Higher Agricultural Universities of CIS countries, and Otto Kaufman is well-known in European Agricultural Education. We are sure they can perform their duties very well.

(vi) Because of the working groups, the cycle of conferences has to be discussed.

(vii) The Executive Committee should meet twice a year.

We are convinced, that GCHERA President Wanjohi and his Executive Committee, together with the Local Organising Commiteee will conduct a wonderful conference.

May the dawn of the African continent send impulses to GCHERA! Many thanks.

GCHERA PRESIDENT'S SPEECH

Prof. Nick G. Wanjohi
President, Global Consortium on Higher Education and Research for Agriculture (GCHERA)

His Excellency Hon. Mwai Kibaki, the President and Commander-in-Chief of the Armed Forces of the Republic of Kenya, cabinet ministers, permanent secretaries, distinguished guests, ladies and gentlemen.

On behalf of the Executive Committee of the Global Consortium on Higher Education and Research for Agriculture (GCHERA), I wish to extend a warm welcome to all distinguished guests and participants to this conference. For us in the Executive Committee, the opportunity to witness high level intellectual discourse on pertinent agricultural matters is always a remarkable landmark worth looking forward to. More importantly, the gathering underlines the increasing importance of GCHERA as a key player on agricultural matters around the globe. The committee remains faithful to the fact that the best way for agricultural institutions of higher learning to offer service to the masses is to provide workable solutions to challenges faced by those in the farming sector, this including providing guidelines on better productivity.

Your Excellency the President, GCHERA was formed out of a realised need for a collaborative global approach to solving problems bedeviling agriculture in different parts of the world. This was based on the premise that bringing together researchers who had met varying experiences would most certainly help in alleviating the many problems that are continually experienced in the sector. And true to this vision, GCHERA has over the years assisted agricultural universities, especially in the developing world, to update their curricula to get to the level of those that have proved successful elsewhere. The papers to be presented in this conference are clear evidence of this. There will be presentations from different disciplines, all with great relevance to institutions offering agricultural courses. We are also going to experience a rich exchange of research findings and experiences, especially in form of innovative ideas in solving the critical problems of food insecurity, ill health, poverty, and energy crisis. Climate change is another matter of grave concern to the whole world and is becoming a fixture for urgent deliberations in several international forums. In this conference, we will have a chance of sampling the severity of the effects of global warming in different parts of the world. In the same breath, we will figure out how some nations have succeeded in reversing food and water scarcity even as the world in general continues recording and adverse dwindling of these resources.

Your Excellency Sir, I wish, like the earlier speakers, to underline the importance of this conference being held in African soil for the very first time. As we are all aware, Africa makes up most of the underdeveloped and developing world, with food security – not technological advancement – being the matter requiring urgent attention. The conference will provide a chance to universities from these nations and by extension the nations themselves, to draw useful lessons on how to improve agricultural productivity, and therefore food security. Alternatively, African agricultural institutions that have registered success in specific sub-sectors will be able to showcase the same in the

conference. Our continent, being extremely rich in biodiversity, also has much to offer to the rest of the world.

Your Excellency, my attention now turns to participants. I call upon all players in this conference to follow very keenly the experiences witnessed in other parts of the world and see how the same can be tailored to suit our local environments. For Deans of faculties of agriculture who are in the conference, please study with passion any resolutions that will be drawn with a view to exploring ways of improving curricula in our institutions - and making them responsive to the national and regional needs. Crucially, all training and research should at all times be tailored to the needs of the environments we operate in.

With those remarks I once again welcome you all. Thank you

OPENING REMARKS

Hon. Dr. Sally Kosgei
Minister for Higher Education Science and Technology, Kenya

I am indeed greatly privileged to address this distinguished congregation of researchers and scholars drawn from all over the world, and brought together under the auspices of the Global Consortium of Higher Education and Research for Agriculture (GCHERA). There is no doubt that such a gathering is bound to come up with sustainable solutions to the various problems we meet in our daily lives.

We in the Ministry of Higher Education, together with all institutions of higher learning in Kenya warmly welcome all conference participants to the country. I also pay tribute to Jomo Kenyatta University of Agriculture and Technology for organising this conference, which, much to our pride is being held in Africa for the first time.

Your Excellency, it is gratifying that the majority participants in this forum, numbering slightly over two hundred, are actively involved in teaching and research in agriculture and related disciplines. This is important to us in Kenya since a large segment of our economy is agriculture-driven to the extent that good performance in the sector translates to improved overall economy. So important is the sector in our country that all our public universities offer agriculture and related disciplines in their curricula. In addition to encouraging results from our university researchers, the institutions of higher learning also continue to provide the skilled personnel crucial in supporting and accelerating agricultural production particularly in the rural areas.

As a ministry, we pledge to continue supporting research and innovation in our universities to accelerate national development. Indeed, my ministry is now encouraging researchers to integrate science, technology and innovation. This is particularly important within the context of demands for global economic competitiveness, sustainable development and equity concerns. It is in this light that the National Innovation System was establishment under the ministry. The system offers an opportunity for Kenya to acquire, exploit and defuse knowledge for the achievement of sectoral and collective national goal.

Once again, I wish to underscore the importance ministry attaches to such forums as this particular conference. The ministry views these as opportunities for scholars throughout the world to review emerging developments and challenges within their disciplines.

Welcome to you all, and, enjoy fruitful deliberations.

OPENING SPEECH

Hon. Mwai Kibaki, CGH, MP
President and Commander-in-Chief of the Armed Forces of the Republic of Kenya

Ladies and gentlemen, it gives me pleasure to join you for this opening ceremony of the Sixth Conference of the Global Consortium of Higher Education and Research for Agriculture.

I note that one of Kenya's most respected institutions of training, research and innovation in agriculture, Jomo Kenyatta University of Agriculture and Technology, has been granted the opportunity to host this global conference. I express our gratitude for the choice of Kenya as venue for this conference and warmly welcome you all to the country while wishing you fruitful deliberations and enjoyable stay.

Ladies and gentlemen, the Kenya Government appreciates the crucial role that university education, training and research plays in the production of high-level human resource needed for national development. For this reason, we have continued to increase investments in tertiary education.

As a result, in the last six years, the university sub-sector in our country has rapidly expanded. Today, we have 7 public universities, 24 private universities and 13 university colleges and campuses. All the institutions are engaged in dispensing knowledge and skills to the youth, carrying out research and professional training in many areas of strategic significance to the growth of our economy and national development.

It has been observed, however, that despite large investments in university education and research in developing countries, very few research findings reach the end users such as farmers, livestock keepers and small-scale business persons. I challenge universities and other research institutions to find ways of translating research findings into innovations applicable to the end users so that they can make a difference in their day to day economic and social activities. Thus, I urge lecturers and researchers in universities and other institutions to strive to narrow the gap between theory and practice. Society wishes to see more efforts directed at hands-on education in fields such as agriculture, science, engineering and management.

As you may have noticed, despite a lot of research work in Africa, large numbers of people still live in poverty under the perpetual threat of hunger, starvation and malnutrition.

The leading researchers should get more homegrown solutions to our basic problems so that our people are not only free from the threat of hunger, but are also empowered enough to embark on real wealth creation ventures. The answer to food security lies within the realms of the lead researchers and their ability to cascade their findings for implementation by governments, farmers and business persons.

Ladies and gentlemen, this conference is being held against the backdrop of a global economic meltdown, climate change, food insecurity, rising energy costs and many health challenges. I am pleased that the conference will address these and other challenges

and recommend practical steps that need to be taken to tackle them. The global economic instability has particularly affected the developing world, Kenya included. Some of the direct effects include reduced remittances from the Diaspora and a severe drop in earnings from tourism and agricultural exports. As a consequence, there has been marked drop in employment and productivity levels, thus adversely affecting the vulnerable members of society.

Although signs of economic recovery are being recorded, we are still far from coming out of the crisis and more concerted efforts still need to be made. The Government of Kenya is in this regard implementing an economic stimulus package that we hope will generate additional impetus into the economy. Much of this effort is in the area of agriculture with a view to developing mechanisms of responding to climate change.

Ladies and Gentlemen, our response is motivated by the experience of erratic weather patterns in the recent past due to climate change. This has triggered serious challenges to agricultural productivity as a result of a three-year long drought across the country. It has led to massive crop and livestock losses for farmers, leading to severe food shortages and poor performance of agricultural-related industries. There is now a sigh of relief as we are hopeful of receiving adequate rains during the current short-rain season. In the meantime, the Government has put in place appropriate measures to address emerging challenges and mitigate their severity.

Ladies and gentlemen, food insecurity remains a fundamental challenge to developing countries. Among key causes of food insecurity are population increase; adverse impact of climate change and environmental degradation, and changes in consumption patterns. To adequately address these challenges, a variety of interventions including improved governance, technological advancement and cultural adaptations are required. All stakeholders including Governments, private sector, university lecturers, researchers, financiers, farmers and consumers should be involved in the implementation of appropriate interventions. My Government has in this respect made efforts to encourage farmers to adopt modern farming methods, including the use of improved and drought-resistant varieties, high quality planting material and other inputs.

Agricultural biotechnology is a field that should seriously be considered in order to arrest the effects of famine in Kenya and Africa at large. In support of efforts to find even more effective solutions to problems facing Africa, the Kenya Government has enhanced resource allocation for science, technology and innovation. Particular areas of interest here include enhanced funding for universities and other research institutions, and the promotion of Private-Public Partnerships.

It is our hope that with all these measures in place, Kenya and the rest of Africa will achieve a reasonable level of food sustainability.

Ladies and Gentlemen, The global oil crisis has over the years exerted undue financial pressure on developing economies, leaving all other vital sectors, including agriculture inadequately attended to.

This is largely due to the high dependency on fossil fuels and hydro-electric power. Fossil fuels remain costly, while hydro-electric power is dependent on rainfall,

which is now erratic. This has impacted negatively especially on small scale farmers and food processors who are responsible for most of Africa's food production.

Scientists have gone a long way in the development of biofuels from plant products. But production of this form of energy still covers a very small percentage of energy requirement. Climate change also poses a major challenge to significant production of adequate quantity of plant materials to meet the biofuel needs.

I hope this Conference will come up with practical proposals on how to make bio-energy widely available to humankind.

Meanwhile, various Governments continue the search for alternative sources of energy. In Kenya, the Government is exploring alternative energy sources such as geothermal, solar, and wind.

Among other goals pertaining to energy, the Government intends to increase electricity supply in rural areas from 4 to 12 percent by the year 2012, a move expected to boost agricultural productivity and related activities.

In conclusion, I wish to commend the organisers of this conference at a time when everyone is looking for answers to the challenge of climate change on agriculture, health, energy and general survival of the human race. I wish you fruitful deliberations on these and other related issues.

Meanwhile, you are all invited to visit some of our renowned tourist attractions and enjoy the hospitality of our people. Do also interact with our farmers in the countryside.

With these few remarks, it is now my pleasure to declare the Sixth Conference of the Global Consortium of Higher Education for Research and Agriculture officially open.

Thank you and God bless you all.

SUB-THEME 1:
AGRICULTURE AND FOOD SECURITY

NEW DYNAMICS OF AGRICULTURE AND FOOD SECURITY IN THE WORLD

Prof. Mandivamba Rukuni
Founder and Director, Wisdom Afrika Leadership Academy

ABSTRACT

Of the more than one billion undernourished people in the world the majority are in developing countries with Africa at over 200 million. Consumers in high-income countries and transitional economies in South and East Asia are choosing to spend their additional income on some combination of increased quality, convenience, and variety of foods. Food delivery systems and consumption patterns in middle-income countries like China and Thailand are converging with those of higher income countries. Income growth is a primary force behind converging global consumption patterns, but globalization of the food industry is also contributing (IRIN, 2009, FAO, 2009). The world produces enough food to feed everyone. World agriculture produces 17 percent more calories per person than it did 30 years ago, despite a 70 percent population increase. This is enough to provide all at least 2,720 kilocalories (kcal) per person per day (FAO, 2002). Current world food price increases are allied with diminishing food stocks and difficulties in accessing food by some communities particularly in Africa. This is driven by a number of factors that include: oil prices; demand for higher input food; decreasing food stocks; climate change and environmental degradation; growing use of bio fuels; inelastic food production markets; population growth; and stock markets trends. Proposed solutions to this crisis are a combination of: increasing food supply through greater public sector budget support and investment in agriculture and policy reforms; institutional and governance capacity including addressing the climate change issue; and realigning the role of international trade (export, input and food aid) with sustainable development strategies. The root cause of Africa's ongoing food insecurity is the lack of investment in agricultural production. Whilst food aid has been increasing, aid for agricultural production in sub-Saharan Africa dropped by 43 percent in the 1990s.

1.0 INTRODUCTION

1.1 Food Security in Perspective

World hunger is increasing and global food security is facing the greatest challenge in modern history. IFRI (2008) notes that over 1 billion human beings in the world, mostly in developing countries, presently do not have sufficient food to meet their daily basic nutritional needs. The number of hungry people in the world increased by several million in 2007 and 2008 as a consequence of high food prices and is expected to go up by a further 105 million in 2009 because of the economic and financial crisis, which is affecting jobs and deepening poverty. Food security is central to poverty reduction, good public health, sustainable economic growth and world peace and security, as was witnessed in 2007-2008 with riots in 22 countries around the world, threatening government stability. There are still 31 countries in the world in a situation of food crisis requiring emergency assistance.

Food Security is defined by FAO as a situation that exists when all people, at all times, have physical, social, and economic access to sufficient, safe, and nutritious food that meets their dietary needs and food preferences for an active and healthy life. Following Schmidhuber and Tubiello (2007) this meaning posits four key dimensions which are availability, stability, access, and utilization.

As explained by Schmidhuber and Tubiello (2007), availability refers to overall ability of the agricultural system to meet food demand. It is underpinned by the agro-climatic fundamentals of crop and pasture production and the entire range of socio-economic and cultural factors that determine where and how farmers perform in response to markets. Stability relates to individuals who are at high risk of temporarily or permanently losing their access to the resources needed to consume adequate food access. It also covers access by individuals to adequate resources (entitlements) to acquire appropriate foods for a nutritious diet. Entitlements are the set of commodity bundles over which a person can establish command given the legal, political, economic, and social arrangements of the community of which he or she is a member. Thus a key element is the purchasing power of consumers and the evolution of real incomes and food prices. However, these resources need not be exclusively monetary but may also include traditional rights, e.g., to a share of common resources. Finally, utilisation integrates all food safety and quality aspects of nutrition. It therefore links to health, including the sanitary conditions across the entire food chain.

Ayalew [1](1992[2]), in a report entitled ‘What is Food Security and Famine and Hunger?’ reflects that in 1979 a World Food Programme Report conceptualized food security, equating it with an "assurance of supplies and a balanced supply-demand situation of stable foods in the international market." The report also emphasised that increasing food production in the developing countries would be the basis on which to build their food security. This would mean that the monitoring by famine early warning systems for food insecurity should focus on the availability of food in the world marketplace. Focus should also be on the food production systems of developing countries. The same author however notes that food availability in the world market does not ensure food security to any particular country. This is because what is available on the world market (or the surplus in the US or Canada) cannot be accessed by famine-affected

people in African countries. This is mainly because the economies of these countries, in general, cannot generate the foreign currency needed to purchase food from the world market.

Alayew (1992) in an argument also supported by Caritas Internationalis and CIDSE (2002) posit that the concept of food security would have more meaning if it were understood in line with the legal commitments of the United Nations. The Universal Declaration of Human Rights (1948) accepts the "right to adequate standard of living," including food. The International Covenant on Economic, Social, and Cultural Rights (1966), encapsulates insurance of “an equitable distribution of world food supplies in relation to need". The Universal Declaration on the Eradication of Hunger and Malnutrition (1974), declares that "every man, woman, and child has an inalienable right to be free from hunger and malnutrition." To date the Millennium Development Goals also precisely set a goal on eradication of hunger and malnutrition. Each of these tenets suggests implicitly or explicitly the distribution of world food to the needy.

A report on the Challenges Of Agricultural Production And Food Security In Africa (A Report Of The Proceedings Of An International Conference Organized By The Africa Leadership Forum Edited By Hans d’Orville In 1989) highlighted that food must not be seen just in terms of what is edible. It should also be seen in terms of the nutritional value, constituents and what the people in a defined area consume for energy, growth and sustenance. This draws essentially on the area’s natural endowments or available resources and capacity. It was agreed that African countries must avoid the trap of reliance on imported foods. This was such that food self-sufficiency can be defined in terms of the ability and capacity to produce or procure substantially, within the region, essential food items and constituents required by the people of Africa. The same issues still dominate any efforts to solve the food insecurity problems in some parts of the world.

The same report (Hans d’Oville, 1989) conceptualized food security at both national and household levels. National food security was defined within the context of national food self- reliance. It must imply adequate access by all people at national, local and household levels to adequate and largely domestically- produced food at all times. It involves regular and sustainable access without dependence on commercial and foreign exchange-consuming imports or food aid detrimental to local production in Africa. Back then, the leaders agreed that food security should not hinder intra-African trade as a policy instrument; rather it should encourage and emphasise the full utilisation of Africa’s productive food resources. These historical articles show that ‘food security’ is a situation in which all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active healthy life. However they also show that a global concept of food security does not guarantee food security at either the household or the national level.

Availability of food at the national level is but one factor for food security. Supporters of this idea try to work out a food balance sheet for a given country and, if food availability is more or less equal to the food needs of the country's population in general, they conclude that the country is food- secure. The assumption underlying this perspective is that whatever food is produced in the country will be evenly distributed to each region and to each household. But the facts are different. Those who failed to produce will have

access to the surplus in the country (through the markets) if, and only if, they have purchasing power. Access will also depend on the efficiency of the markets. The problem with many poor nations is that many of the hungry are located in areas where market failures are dominant. In most poor countries, however, many people do not have such power. National governments, too, often lack the necessary financial resources to purchase the surplus and to distribute it to those without, especially when millions become destitute. Therefore, food availability at the national level does not provide food entitlement to households and individuals.

Food security at the household level has been defined by Eide (quoted in Maxwell and Frankenberg, 1992) as "access to adequate food by households over time." This implies that each member of the household is secure, if the household in general has access to food. The assumption here is that household members' strong family ties would ensure that food is shared equally by each. Although food availability at the household level is a key issue, there are intra-household factors that may affect equitable and adequate access to food by all members. Maxwell and Frankenberger (1992) pointed out that "it is misleading to assume that household members share common preferences with regard to (a) the allocation of resources for income generation and food acquisition or (b) the distribution of income and food with the household." The head of the household may have more power in determining the use of food resources and may misappropriate it. Moreover, household members' nutritional requirements may vary, for example, if some exert more energy in work than others. Cultural factors can also deprive members of the household (i.e., women and children) from getting an equitable share. Thus, the concept of household-level food security, in general, does not fit into the accepted definition of food security.

Following the World Bank (1986) food security may be defined as access by all people at all times to enough food for an active and healthy life. This definition encompasses many issues. It deals with production in relation to food availability; it addresses distribution in that the produce should be accessed by all; it covers consumption in the sense that individual food needs are met in order for that individual to be active and healthy. The availability and accessibility of food to meet individual food needs should also be sustainable. This implies that early warning systems of food insecurity should monitor indicators related to food production, distribution, and consumption. The performance of these indicators, therefore, will detect whether a certain area or population is food secure or insecure in relation to the spirit of the above definition.

Given these broad definitions therefore, food security is affected by a complexity of factors. These include unstable social and political environments. These preclude sustainable economic growth, war and civil strife, macroeconomic imbalances in trade, natural resource constraints, poor human resource base, gender inequality, inadequate education, poor health, and natural disasters, such as floods and locust infestation, and the absence of good governance. All these factors contribute to either insufficient national food availability or insufficient access to food by households and individuals (USAID, 2009).

While the rest of the world has made significant progress towards poverty alleviation, Africa, in particular Sub-Saharan Africa continues to lag behind. The root

cause of food insecurity in developing countries is the inability of people to gain access to food due to poverty. Achieving food security in its totality continues to be a challenge not only for the developing nations, but also for the developed world. The difference lies in the nature and magnitude of the problem in terms of its severity and proportion of the population affected.

1.2 Brief Review of Historical Development

Main highlights:

(i) Agriculture has prospered until it was disturbed by actual hostilities affecting either supply or demand.
(ii) There have been sustained surpluses and increasing food stocks.
(iii) Real world food prices have maintained a sustained downward trend that reached a hundred year low in 2000.
(iv) Over the years, there have been changes in the factors or drivers determining world food supply and demand.
(v) Contemporary food security issues are characterised by declining food stocks and rapidly rising food prices.

Predictions and concerns about global food security historically heat up with rising grain prices and or diminishing food stocks (McCalla and Revoledo, 2001). The same authors note that one also needs to know the rate of income growth and have good estimates of the evolution over time of how food expenditure changes as incomes rise (demand side). Demand models would be even more conceptually complete if changes in income distribution could be included for all countries. On the other hand issues around world food supply have graduated from trend projections of land area and yields. They now recognise the need to project changes in production intensity, the relationship between yields and research investment, the degree to which stocks of resources—water, land, energy—potentially constrain output, and the impact of declines in fisheries on food security. These reflect the underlying factors determining historical global trends in food security.

The number of countries requiring analysis goes on rising, as does the demand for more complete commodity coverage. The early models (Malthusian) focused on a potential food gap by comparing rates of growth of population with land availability. Right after World War II the focus shifted to a requirements approach where minimum nutritional needs were multiplied by population to produce projected food needs. In the same period the potential of increasing yields of existing land was added to supply projections.

The late 1960s and 1970s led to further complicating issues. On the supply side, the Green Revolution focused us on favoured versus less favoured areas (McCalla and Revolado, 2001). It also began to raise environmental and social issues about rapid increases in crop yields. In addition, the 1960s showed that, while modern medicine was cutting death rates rapidly, birth rates remained high, leading to population growth rates never before experienced. Concerns about environmental issues and the depletion of non renewable natural resources also emerged in the 1960s and early 1970s. All of these issues—new varieties, population, and resource limits—were added to the issues of global food security (McCalla and Revolado (2001).

According to the FAO (2009), during the 1950s and 1960s it was widely believed that only industrial growth could deliver economic development. As a result, industry was protected while agriculture was heavily taxed or afforded low priority. By the end of the 1970s, there was increasing emphasis on the structural reform of economies. It was hoped that privatization, the liberalization of internal and external trade, lower taxes and reduced government intervention would produce higher economic growth and reduce the bias against agriculture.

To complicate the issue of global food security modelling further, the price instability of the early 1970s illustrated that earlier models' assumptions of constant prices were clearly inadequate. Prices affect both consumers and producers and therefore own- and cross-commodity relationships were needed both in demand models and in supply projections to reflect changes in prices and the resulting substitution among commodities. Moreover, the price run up illustrated that domestic policies significantly influence world markets. Therefore new models had to include domestic supply and demand, country by country, with appropriate cross commodity relationships embedded and explicit recognition of policy built in. Finally, it should be noted, that starting in the 1970s and strengthening in the 1980s and 1990s, there was expanded interest in poverty and income distribution. Given the prevalence of rural poverty in developing countries, linkages between food production and poverty became highlighted. Yet introducing explicit projections of poverty into models proved difficult. In sum, the number of issues related to the supply and demand sides of the food balance equations has significantly increased. Modelling approaches have grown more sophisticated, clearly much larger, and more expensive.

1.3 What were the Issues Driving Food Security Trends in each Period?

Table 1: Historical development of world food security and drivers

Period	*Shocks/drivers/key events shaping trend*	*World Food Demand /supply behaviour*	*World Food Price behaviour*
1920's	Effects of high Productive capacity built from emerging from world war one	Excess supply	Falling food prices
1930's-1940's	World depression	Inadequate world food demand and thus excess supplies This triggered domestic price support	Trade and price collapse
1950's-1960's 1965-1966	Korean war temporarily held prices higher Massive grain shipments to Asia (India) following two bad monsoons	Surpluses and surplus disposal Institutionalised International food dumping programs(food aid) e.g. USA public law 480 of 1954 as an international surplus dumping activity Growing food stocks Decreasing food stocks	Falling prices Rising food prices
1967-1970	Rapid introduction of miracle wheats and rices –the green revolution	Massive increases in world food supply	Steadying of world prices and maintenance of long term downward trend
1972-1974	Major Soviet Grain purchase	Supply shortfalls	Prices were back to their long term downward trend
1974-2000	Population growth(a billion added in each decade(IFPRI, 2006)	Increases in food supply	At 2000, real world food prices were at their 100 year low
2000-2009	New drivers becoming more evident(climate change, biofuels, etc)	Declining food stocks and increasing demand	Rapid increases in world food prices epitomise in 2008

Source: Compiled by author from various articles

1.4: Overview of World Food Security Policies

Paarlberg (2002) notes that the biggest contrast between rich and poor countries can usually be seen in the pro-farmer versus anti-farmer bias of agricultural policies. In wealthy industrial countries national policy has long tended to subsidize farming thus generating surplus production, whereas in poor countries governments have more often

imposed explicit or implicit taxes on farming, causing a slowdown in productivity growth. It is a perverse irony that governments in rich industrial countries, where farmers are few in number and already productive, tend to support investments in farming more than governments in poor agricultural countries where hunger persists and productivity is lagging.

The CIC (2007) note that some commodity analysts apportion part of blame for recent food price rises to US and EU agriculture subsidies. These are seen to have made agriculture unprofitable for various other countries e.g. Goldman Sachs (as highlighted by CIC, 2007): "The US and Europe were exporting agricultural deflation; now they're exporting agricultural inflation. This is on the back of growing imports in some areas. FAO (2008) also point out that developing countries will become increasingly dependent on imports of cereals, which are expected to nearly triple to some 270 million tonnes by 2030. Most of this will have to come from traditional exporters in North America, Western Europe and Australia. The Near East and North Africa will continue to account for the bulk of imports - nearly 40 per cent.

Net cereal imports for developing are actually projected to increase. There are a number food security related policies that have contributed in shaping the current trends and regional differences in food security. A rough division of the world into three categories that are developed countries, transitional countries and developing countries helps to see wide differences in the food security(and related) policies for each region. Table 2 shows the differences in agricultural tax/subsidy, import/export, support and spending for different regions.

Table 2: Differences in food security policies across different regions in the world

Policy variable	*Region*		
	Developed nations (mainly America and EU)	*Transitional economies (India, china, Asian economies)*	*Least developed countries*
Subsidy/tax on agriculture	Continued direct and indirect subsidies for agriculture	Some slowly moving away from taxing towards subsidies	Agriculture still taxed in most poor countries(seen as a source of income)
Food import export conditions	Export subsidies still very high, Effective Import barriers through high import duty and some stringent phytosanitary requirements	Export promotion, some rely on imports in times of disasters	Few food import restrictions and limited export support hence they are net importers of agricultural products
Agricultural support	All forms of support still effectively high	Improved agricultural support	Weak support for agricultural sector
Agricultural Technology development	Direct Fiscal support for local technology development(research and development)	Promotion of local and appropriate technologies	Limited fiscal allocations for local agricultural technology development
Spending on agriculture	Though small compared to other sectors, in comparison to other regions spending on agriculture still very high	Gradually increasing	Small proportions of budget spend on agricultural sector(majority of countries spend less than 10% on agriculture)

Source: Compiled by author

Spending in agriculture is one policy area that one would want to explore further. This is because there are large disparities between spending levels for developed nations and developing countries. It is quite evident that developed countries spend far more on their agricultural sectors although the percentages might be small owing to the sizes and level of diversification of their economies. Table 3 shows spending in agriculture by selected African countries.

Table 3: Spending in agriculture by selected African countries

Country	***Current public spending in agriculture at constant 2008(US$)***	***Share in total spending (%)***	***Headcount poverty rate in 2007(%)***
Angola	n/a		52
Cameroon	107	3.8	28.7
Ethiopia	360	13.6	38.9
Ghana	119	6.7	28.2
Kenya	174	4.2	61.3
Liberia	n/a		28.7
Madagascar	9	1.6	87.7
Malawi	22	2.7	64.6
Mali	205	14.5	61.2
Mozambique	66	4	41.7
Nigeria	934	3.2	77.4
Rwanda	21	4	67.2
Senegal	88	4.4	57.2
Sierra Leone	8	3.1	77.4
Tanzania	115	4.4	37.9
Uganda	99	5	29.4
Zambia	44	2.7	66.1
Rest of E. Africa	9	3	52
Rest of S. Africa	161	4.3	30
Rest of W. Africa	646	6.7	30

Source: IFPRI (2006) originally from Government finance statistics of the International Monetary Fund (IMF), supplemented by statistical appendix and poverty reduction strategy papers. The definition of agricultural expenditure is the standard definition used by the IMF in the GFS Manual (2001). Public spending on agriculture and total spending are updated to 2007 at 2008 US dollars using historical trends. Poverty rates are also updated using trends.

Whilst many of the poor households that are susceptible to hunger largely depend on agriculture, their country governments have devoted very small percentages to their agricultural sectors. This is on the back of weak private sector investment in agricultural support including technology development. Overall, this policy position by many African countries has contributed significantly to Africa's hunger. Further to this, foreign aid towards agriculture has been decreasing.

2.0 WORLD FOOD SECURITY TRENDS AND FOOD BALANCE

2.1 World Agricultural Production (Commodity Crop Production per Region)

According to IFPRI (2008) the index of total agricultural production from 1990 through 2006, the latest year for which comprehensive data are available, shows rising output for the world as a whole and most country groups, with the exception of developed countries, where output has been flat during most of the period. In per capita terms, output levelled off after 2004 for the world as a whole, and declined in the least developed countries in 2006 after nearly a decade of modest growth.

The world has experienced an unprecedented increase in population during the past century, with a billion people added every decade during the last three decades alone (IFPRI, 2001). Dramatic shifts in production and consumption of food have accompanied this population explosion, including a surge in grain production, a spectacular rise in meat production and consumption, and the emergence of an increasingly vital role for international trade. As indicated in earlier sections, high-yielding varieties of wheat and rice swept across much of Asia during the 1970s and early 1980s (Green Revolution), easing fears of imminent famine. Cereal yields have risen more modestly in recent years, but they have still outstripped gains in other crops such as cassava, potatoes, and beans (IFPRI, 2001).

In the mid-1990s world cereal prices rose dramatically as cereal stocks fell sharply, and some observers foresaw a starving 21st century world unable to meet growing food demands from a deteriorating natural resource base. Worries eased in the late 1990s as global cereal production hit record levels in response to high prices and falling stocks, while declining incomes due to the East Asian economic crisis reduced the demand for food commodities. As cereal prices plummeted in response, the policy focus in much of the world shifted from concern over long-term food supply and demand problems to concerns about subsidy provision to financially distressed farmers (IFPRI, 2001)

There were improvements in world food production between 2008 and 2009. The improvement has largely concerned cereals, the critical sector for food security, after production in 2008 overshot prior expectations, yielding even larger crops than originally forecast. The increased global production was sufficient to meet demand for food and other uses but also facilitated a replenishment of global reserves to pre-crisis levels. With the new 2009/10 marketing seasons commencing, prospects continue to be positive, as world cereal production is expected to be the second largest ever, after last year's record (FAO/GIEWS, 2009).

In spite of strong gains in recent weeks, international prices of most agricultural commodities have fallen in 2009 from their 2008 heights, an indication that many markets are slowly returning into balance, in sharp contrast to what was witnessed this time last

year. The apparent easing of market conditions is reflected in the benchmark FAO Food Price Index, which has fallen by one-third from last June's peak (FAO/GIEWS, 2009)

By contrast, for oilseed products and sugar, production setbacks in major producing countries together with expanding consumption are stirring up prices on world markets. And the heave in soybean quotations in recent weeks, on the back of shrinking world reserves, is emerging as a cause for concern given its strong bearing on food and feed prices. On the other hand, expansions in fish, meat and milk production have coincided with faltering demands, in the wake of slowing or contracting economies and recurring animal diseases. Prices have tumbled, seriously eroding the profitability of the sectors (FAO/GIEWS, 2009).

The impact of sudden and sharp corrections to high prices of last year in several markets will have major repercussions for many producers. That markets can swiftly swing from shortages into surpluses, especially when trade is thin, is being illustrated by recent developments in the dairy economy, which, following sharp recovery in outputs has seen prices plummet. The return to the use of export subsidies, following three years of extensive use of export restrictions bears evidence of such extremes (FAO/GIEWS, 2009). Table 4 shows world cereal production from 2007 and table 5 shows world cereal facts;

Table 4: World cereal production[1] (million tonnes)

	2007	2008 estimate	2009 forecast	Change: 2009 over 2008 (%)
Asia	955.7	968.7	980.2	1.2
Far East	852.3	885.0	884.0	-0.1
Near East in Asia	69.6	55.0	65.6	19.3
CIS in Asia	33.7	28.7	30.5	6.3
Africa	132.9	148.4	156.8	5.7
North Africa	28.5	29.5	37.3	26.6
Western Africa	46.4	54.0	52.8	-2.2
Central Africa	3.2	3.3	3.3	1.4
Eastern Africa	32.6	33.8	34.7	2.7
Southern Africa	22.1	27.8	28.6	2.9
Central America & Caribbean	39.2	41.8	40.4	-3.3
South America	131.8	134.8	116.4	-13.6
North America	461.1	457.0	431.9	-5.5
Europe	389.7	501.8	448.7	-10.6
EU	260.1	314.6	286.8	-8.8
CIS in Europe	115.1	169.3	143.9	-15.0
Oceania	25.4	34.4	35.3	2.5
World	2 134.5	2 285.5	2 208.5	-3.4
Developing countries	1 206.9	1 240.0	1 239.9	0.0
Developed countries	927.5	1 045.5	968.6	-7.4
- wheat	610.9	683.8	655.2	-4.2
- coarse grains	1 082.5	1 142.7	1 093.1	-4.3
- rice (milled)	441.0	459.1	460.2	0.2

[1]Includes rice in milled terms.

Note: Totals computed from unrounded data.

Source: FAO (2009)

Table 5: Basic facts of the world cereal situation (million tonnes)

	2007/08	***2008/09***	***2009/10***	***Change: 2009/10 over 2008/09 (%)***
PRODUCTION [1]				
Wheat	610.9	683.8	655.2	-4.2
Coarse grains	1 082.5	1 142.7	1 093.1	-4.3
Rice (milled)	441.0	459.1	460.2	0.2
All cereals	2 134.5	2 285.5	2 208.5	-3.4
Developing countries	1 206.9	1 240.1	1 239.9	0.0
Developed countries	927.5	1 045.5	968.6	-7.4
TRADE [2]				
Wheat	112.8	128.6	114.0	-11.3
Coarse grains	129.5	111.9	112.0	0.0
Rice	30.0	31.0	30.6	-1.4
All cereals	272.3	271.5	256.6	-5.5
Developing countries	84.4	68.8	64.7	-6.1
Developed countries	187.9	202.7	191.9	-5.3

[1]Data refer to calendar year of the first year shown.
[2]For wheat and coarse grains, trade refers to exports based on July/June marketing season. For rice, trade refers to exports based on the calendar year of the second year shown.
[3]Data are based on an aggregate of carryovers level at the end of national crop years and, therefore, do not represent world stock levels at any point in time.
[4]The major wheat and coarse grain exporters are Argentina, Australia, Canada, the EU and the United States. The major rice exporters are India, Pakistan, Thailand, the United States and Viet Nam.

FAO (2009)

2.2 World Food Consumption Trends (Commodity Crop Consumption per Region)

Despite the persistence of food insecurity, food consumption has been rising in many developing countries, and with it has come higher rates of overweight and obesity. Income disparity within and among developing countries explains how there can be obesity in the midst of under nutrition. Rising incomes, urbanisation, global integration, and more supermarkets have contributed to increased consumption of convenient; high-calorie foods among the higher income population obesity-related diseases have become more widespread in developing countries (Rosen and Shapouri (IFPRI), 2008)

The first decade of this century has seen rapid and sustained economic growth and increased urbanisation in a number of developing countries, most remarkably in large emerging economies such as China and India. These two countries alone account for more than 40 percent of the world's population. As the purchasing power of hundreds of millions of people has increased, so has their overall demand for food. This new wealth has also led to changes in diet, especially to greater consumption of meat and dairy products, which are heavily dependent on cereal inputs (Frazao et al, 2008). However, the recent high commodity prices do not appear to have originated in these emerging markets. Cereal imports by China and India have declined from an average of about 14 million tonnes in the early 1980s to roughly 6 million tonnes in the past three years, suggesting that changes in consumption patterns have largely been met through domestic production. While continued strong economic development in China and India may increasingly affect food prices, this has not yet been an exceptional factor(Undernourishment report, 2008).

IFPRI (2008) highlights that many countries have adjusted their trade and consumption policies in response to higher international prices. A sizeable number of countries have changed trade or consumption policies with a view to mitigating the impact of higher prices on consumers. Trade policies are among the most-used measures, with some countries reducing import tariffs on cereals and some imposing export restrictions. Of the latter, some countries have placed quantitative restrictions or outright bans on exports. Consumption policies have included reducing food taxes in some countries or providing consumption subsidies in some. An additional eight countries have adopted price controls. Of these measures, export bans and price controls are the most disruptive to markets and are likely to suppress incentives to producers to increase production. Table 6 shows global and regional per capita food consumption.

Table 6: Global and regional per capita food consumption (kcal per Capita per Day)

Region	**1964 - 1966**	**1974 - 1976**	**1984 - 1986**	**1997 - 1999**	**2015**	**2030**
World	2358	2435(3.3)	2655(9.0)	2803(5.6)	2940(4.9)	3050(3.7)
Developing countries	2054	2152(4.8)	2450(13.8)	2681(9.4)	2850(6.3)	2980(4.6)
Near East and North Africa	2290	2591(13.1)	2953(14.0)	3006(1.8)	3090(2.8)	3170(2.6)
Sub-Saharan Africa	2058	2079(1.0)	2057(-1.1)	2195(6.7)	2360(7.5)	2540(7.6)
Latin America and the Caribbean	2393	2546(6.4)	2689(5.6)	2824(5.0)	2980(5.5)	3140(5.4)
East Asia	1957	2105(7.6)	2559(21.6)	2921(14.1)	3060(4.8)	3190(4.2)
South Asia	2017	1986(-1.5)	2205(11.0)	2403(9.0)	2700(12.4)	2900(7.4)
Industrialized countries	2947	3065(4.0)	3206(4.6)	3380(5.4)	3440(1.8)	3500(1.7)
Transition countries	3222	3385(5.1)	3379(-0.2)	2906(-14.0)	3060(5.3)	3180(3.9)

Source: FAO (2009)

2.3 Who is Hungry, and Where?

Almost all of the worlds undernourished live in developing countries. The FAO (2008) quoted in the world undernourishment report notes that higher food prices have triggered an increase in hunger worldwide. Provisional FAO estimates show that the number of chronically hungry people in 2007 increased by 75 million over and above FAO's estimate of 848 million undernourished in 2003–05, with much of the increase attributed to high food prices. This brought the number of undernourished worldwide to 923 million in 2007. Given the continued and drastic price rises in staple cereals and oil crops well into the first quarter of 2008, the number of people suffering from chronic hunger is likely to have increased further. At 923 million people, the number of undernourished in 2007 was more than 80 million higher than in 1990–92, the base period for the World Food Summit (WFS) hunger reduction target.

This makes the task of bringing the number of undernourished to 420 million by 2015 more difficult, especially in an environment of high food prices and uncertain global economic prospects (Undernourishment report, 2008). At the regional level, the largest increases in the number of undernourished people in 2007 occurred in Asia and the Pacific and in sub-Saharan Africa, the two regions that together accounted for 750 million (89 percent) of the hungry people in the world in 2003–05. FAO estimates that rising prices have plunged an additional 41 million people in Asia and the Pacific and 24 million in

sub-Saharan Africa into hunger. Together, Africa and Asia account for more than three-quarters of the developing world's low-income food-deficit countries (LIFDCs).

Africa is also home to 15 of the 16 countries where the prevalence of hunger already exceeded 35 percent, making them particularly vulnerable to higher food prices. While the numbers affected are smaller, Latin America and the Caribbean and the Near East and North Africa regions have also experienced increases in hunger as a result of rising food prices (a sharp more than a decade of steady progress toward the WFS goal). Overall, the rising prevalence of hunger and the estimated increase of 75 million undernourished people reversal for Latin America after worldwide in 2007 validate concerns about a global food security crisis following high food prices, at least in the short term(FAO, 2009). Table 7 shows countries in food crisis and those at high risk;

Table 7: Countries at high risk and in food crisis

In Food Crisis	*At High Risk*
Central African Republic	Cameroon
Democratic Republic of the Congo	Comoros
Côte d'Ivoire	Djibouti
Eritrea	Gambia
Ethiopia	Madagascar
Guinea-Bissau	Mozambique
Haiti	Nicaragua
Kenya	Niger
Lesotho	Occupied Palestinian Territory
Liberia	Rwanda
Sierra Leone	Senegal
Somalia	Solomon Islands
Swaziland	Togo
Tajikistan	United Republic of Tanzania
Timor-Leste	Yemen
Zimbabwe	Zambia

Source: IFPRI (2007)

In Africa, 50% of the food insecure are farm households whilst 20% are the urban poor. Thirty percent are the rural landless. Figure 3 shows the proportions of the food insecure in Africa whilst tables 8 to 10 show basic world undernourishment facts (percentages, incidence among countries and per capita consumption over time)

Table 8: Developing countries with a given percentage of undernourishment[1]

	Population (million)			kcal/capita/day			% of population			Million people		
	1997-99	2015	2030	1997-99	2015	2030	1997-99	2015	2030	1997-99	2015	2030
Under 5%	349	1 158	5 129	3 187	3 130	3 150	2	3	3	8	37	178
5-10%	1 989	2 162	524	2 999	3 066	2 758	8	6	7	167	134	38
10-25%	1 632	1 939	948	2 434	2 644	2 411	21	13	16	349	250	155
Over 25%	586	544	239	1 988	2 085	2 149	43	35	30	251	190	72
Total	4 555	5 804	6 840	2 681	2 850	2 980	17	11	6	776	611	443

[1] Different countries form each group in the different years.

Table 9: Incidence of undernourishment in developing countries

	% population				*Million People*			
	1990-92	1997-99	2015	2030	1990-92	1997-99	2015	2030
Developing countries	20	17	11	6	815	776	610	443
Sub-Saharan Africa	35	34	23	15	168	194	205	183
Idem, excl. Nigeria	40	40	28	18	156	186	197	178
Near East and North Africa	8	9	7	5	25	32	37	34
Latin America and Caribbean	13	11	6	4	59	54	40	25
South Asia	26	24	12	6	289	303	195	119
East Asia	16	11	6	4	275	193	135	82

Table 10: Population living in countries with given per capita food consumption

Kcal/capita/day	*Population (million)*					
	1964-66	1974-76	1984-86	1997-99	2015	2030
Under 2200	1 893[1]	2 281[1]	558	571	462	196
2200-2500	288	307	1 290[2]	1 487[2]	541	837
2500-2700	154	141	1 337[3]	222	351	352
2700-3000	302	256	306	1 134	2 397[2]	2 451[2]
Over 3000	688	1 069	1 318	2 464[3]	3 425[3]	4 392[3]
World total	3 325	4 053	4 810	5 878	7 176	8 229

[1] Includes India and China

[2] Includes India

[3] Includes China

3.0 DRIVERS FOR CONTEMPORARY FOOD INSECURITY

Be they policy measures, investment decisions or emergency interventions, appropriate actions to address the human and economic impacts of soaring food prices require a thorough understanding of the underlying driving forces. These driving forces are many and complex, and they include both supply-side and demand-side factors. Long-term structural trends underlying growth in demand for food have coincided with short-term cyclical or temporary factors adversely affecting food supply, thus resulting in a situation where growth in demand for food commodities continues to outstrip growth in their supply. Many authors (USAID, 2008, CIC, 2007, OCHA, 2008, IFPRI, 2007, IRIN, 2007, IMF, 2008, among others) have written on the drivers for the current developments in food security. These are analysed in the subsequent sections.

3.1 Increase in Oil Prices

Until mid-2008, the increase in energy prices had been very rapid and steep, with one major commodity price index (the Reuters-CRB Energy Index) more than tripling since 2003. Petroleum and food prices are highly correlated. The rapid rise in petroleum prices exerted upward pressure on food prices as fertilizer prices nearly tripled and transport costs doubled in 2006–08. High fertilizer prices have direct adverse effects on the cost of production and fertilizer use by producers, especially small-scale farmers (OCHA, 2008, Undernourishment Report, 2008, CIC, 2007).

3.2 Demand for Higher-input Food

The first decade of this century has seen rapid and sustained economic growth and increased urbanization in a number of developing countries, most remarkably in large emerging economies such as China and India. As shown in previous sections, these two countries account for a significant percentage of the world's population. Improvements in purchasing power in these countries has not only lead to increased demand for food , but increased demand for higher input foods which puts pressure on cereals as major food security crops.

3.3 Decreasing Levels of Food Stocks versus Accelerating Demand Growth

In 2006-2007, a year's worth of wheat was lost to drought in Australia, and cold weather caused grain crops to fail in Europe and the United States. Extreme weather events in 2005–07, including drought and floods, affected major cereal-producing countries. World cereal production fell by 3.6 percent in 2005 and 6.9 percent in 2006 before recovering in 2007. Two successive years of lower crop yields in a context of already low stock levels resulted in a worrisome supply situation in world markets. Growing concern over the potential effect of climate change on future availabilities of food supplies aggravated these fears (Undernourishment report, 2008, USDA, 2009). On another scenario export restrictions by major grain producers – imposed in order to secure domestic supply – have further exacerbated rising prices, leading to the conclusion that big countries like the USA were now exporting food inflation (OCHA, 2008, CIC, 2007).

On the other hand, historically, demand growth averaged around 1.5 % per year; now 2.0% and others estimate 2.6% within a decade (CIC, 2007). World Bank estimates food

production will have to rise nearly 50% and meat by 85%, from 2000 to 2030. World food consumption has been greater than world food supply for the past 5 years (IFPRI, 2006). The world's population is expected to increase by 50 per cent between 2000 and 2050, with the developing countries home to almost all of that growth. However, analyses indicate that there is likely to be sufficient overall food production at the global level to meet expected increases in effective demand FAO (2006).

3.4 Climate Change and Environmental Degradation

Extreme weather events – drought, floods, and cold snaps – are affecting local harvests and food availability. Global demand for water has tripled in the last 50 years, and high rates of soil loss to erosion and desertification could diminish the capacity to produce enough food (OCHA, 2008).

3.5 Growing use of Bio-fuels

The emerging bio fuel market is a significant source of demand for some agricultural commodities, such as sugar, maize, cassava, oilseeds and palm oil. The stronger demand for these commodities caused a surge in their prices in world markets, which in turn has led to higher food prices (CIC, 2007, IMF, 2008, OCHA, 2008). While bio fuel production and consumption is supported by government policies in a number of countries, rapid increases in crude oil prices have further contributed to growing demand for agricultural commodities for bio fuel feedstock. Bio fuel production will utilize an estimated 100 million tonnes of cereals (4.7 percent of global cereal production) in 2007–08(Undernourishment report, 2008).

Significant potential exists for additional crop production in Southern Africa based on land availability. However, growing crops for bio-fuels feedstock will only be realised if there is concerted effort from key stakeholders to address the food shortages in the region. New analysis from Frost and Sullivan (http://www.chemicals.frost.com), opportunities for bio-fuel feedstock production in Southern Africa), finds that the market is still in its development stage (Undernourishment Report, 2008). Expansion of the agricultural sector to include crop production for bio-fuels has been hampered by the absence of coherent bio-fuel policies, a lack of resources dedicated to the agricultural sector, declining agricultural production and climate change.

Southern African countries including Botswana, Mozambique, Namibia, South Africa and Zimbabwe have sizeable tracts of arable land available. Most of the crops that can be used as feedstock sources are already grown in the region, but the expansion of the current agricultural production to include crops for bio-fuels would require significant investments.

Southern Africa's rapidly declining crop production has left millions facing starvation, with rural populations being the most affected. Although governments favour the establishment of a strong bio-fuels industry, they lack the financial resources to incorporate feedstock production into an already strained agricultural sector (Undernourishment Report, 2008).

3.6 Inelastic Food-production Market

A short-term issue is that food supply is quite inelastic – in other words, supply reacts slowly to increases in demand. IFPRI estimates that aggregate agricultural supply increases by about 1-2 per cent for each 10 per cent increase in price - and by even less when processes are so volatile.

3.7 Population Growth

It is estimated that by 2050 there will be billions more mouths to feed, exacerbating the demand for food (from 6.1 billion people in 2000 to an estimated 9.2 billion in 2050). (OCHA, 2008). Population growth is therefore a long term structural driver for food demand growth.

3.8 Stock Market Trends

The recent turmoil in traditional asset markets has had an impact on food prices, as new types of investors have become involved in derivates markets based on agricultural commodities in the hope of achieving better returns than those available on traditional assets. Global trading activity in futures and options combined has more than doubled in the last five years (OCHA, 2008, Undernourishment report, 2008). In the first nine months of 2007, it grew by 30 percent over the previous year. This high level of speculative activity in agricultural commodity markets has led some analysts to indicate increased speculation as a significant factor in soaring food prices. However, it is not clear whether speculation is driving prices higher or whether this behaviour is the result of prices that are rising in any case. Either way, large inflows of funds could partly account for the persistence of high food prices and their increased volatility. Further research is needed. The role of financial investors in influencing food prices and whether there is a need for appropriate regulations to limit the impact of speculative bubbles on food prices are increasingly issues of concern (Under nourishment report, 2008).

Box 1 is an extract from IMF (2008) explaining the contemporary food security situation.

Box 1: An extract from IMF explaining the contemporary food security situation

Q. Why is this happening?

A. Prices have been propelled by a mix of permanent and temporary factors:

Strong food demand from emerging economies, reflecting stronger per capita income growth, accounts for much of the increase in consumption. Although demand growth has been high for some time now, the recent sustained period of high global growth contributed to depleting global inventories, particularly of grains.

Rising bio-fuel production adds to the demand for corn and rapeseeds oil, in particular, spilling over to other foods through demand and crop substitution effects. Almost half the increase in consumption of major food crops in 2007 was related to bio-fuels, mostly because of corn-based ethanol production in the US; and the new bio-fuel mandates in the US and the EU that favour domestic production will continue to put pressure on prices.

At the same time, supply adjustment to higher prices has remained slow, notably for oil,

and inventory levels in many markets have declined to the lowest levels in years.

The policy responses in some countries are exacerbating the problem: (i) Some major exporting countries have introduced export taxes, export bans, or other restrictions on exports of agricultural products. (ii) Some importing countries are not allowing full pass-through of international prices into domestic prices (less than half a sample of 43 developing and emerging market countries allowed for full pass through in 2007).

Drought conditions in major wheat-producing countries (e.g., Australia and Ukraine), higher input costs (animal feed, energy, and fertilizer), and restrictive trade policies in major net exporters of key food staples such as rice have also contributed.

Financial factors: the depreciating US$ increases purchasing power of commodity users outside of the dollar area; falling policy interest rates in some major currencies reduce inventory holding costs and induce shifts from money market instruments to higher-yielding assets such as commodity-indexed funds.

Q. What are the implications?

A. To date, most developing countries have been able to absorb the balance of payments impact. Higher export earnings or inflows of capital and transfers helped finance the higher commodity imports.

The overall effect of the commodity price hike on the terms of trade has varied widely across countries. In about half the countries of sub-Saharan Africa, the negative impact has been offset by rising food and fuel export prices.

Higher food prices have been passed through to domestic markets in most countries, but the responses to fuel price increases have varied (the pass-through for oil-exporters averaged slightly over half of that for oil importers).

Concerns centre on possible second-round effects on inflation and the poor:

Headline inflation is up in many countries. This is a particular concern in developing countries where food expenditure shares exceed expenditure shares in other goods by a large margin. Food price increases accounted for almost 70 percent of 2007 headline inflation in emerging economies. Looking ahead, the impact on inflation of food price increases will persist through 2008 even without further price increases.

External balances of net commodity importers have deteriorated. The first round effect on 2007 current account balances exceeded 1 percent of GDP in some developing countries. With most of the increase in prices of grains and oil in the 2nd half of 2007, external balances in some LICs may deteriorate significantly in 2008.

The social implications of rising food prices can be severe for the urban poor. Some countries in Africa have recently had food price–related riots. In Burkina Faso, there have been demonstrations in two cities. In Cameroon, political unrest spilled over into protests over food and fuel prices. Niger has also suffered food-price-related riots, while in Indonesia there have been protests over soybean shortages.

At the same time, external balances of net commodity exporters have improved. The

challenge for them is to maintain macroeconomic stability while dealing with rising foreign exchange inflows.

Source; IMF(2008)

3.9 Poverty as a Central issue (in Africa and South Asia?)

Poverty is the principal cause of hunger. The causes of poverty include poor people's lack of resources, an extremely unequal income distribution in the world and within specific countries, conflict, and hunger itself. According to World Hunger Facts(2009) as of 2008 (2004 statistics), the World Bank has estimated that there were an estimated 982 million poor people in developing countries who live on $1 a day or less (World Bank, Understanding Poverty, Chen, 2004). This compares to the FAO estimate of 850 million undernourished people. Extreme poverty remains an alarming problem in the world's developing regions, despite the advances made in the 1990s till now, which reduced "dollar a day" poverty from (an estimated) 1.23 billion people to 982 million in 2004, a reduction of 20 percent over the period. Progress in poverty reduction has been concentrated in Asia, and especially, East Asia, with the major improvement occurring in China. In sub-Saharan Africa, the number of people in extreme poverty has increased (World Hunger Facts, 2009).

4.0 TOWARDS SUSTAINABLE SOLUTIONS TO THE WORLD FOOD SECURITY CHALLENGE

4.1 Role of Country Governments in ensuring Food Security (Budget and Support)- Investment in Agriculture

Growth in agriculture and in associated rural non-farm employment can have a broad impact in reducing poverty in rural areas, where seven out of ten of the world's poor live (FAO, 2009). Governments therefore need to establish the basics that are roads, irrigation systems, research, extension and land reform. This would be followed by kick starting the markets achieved through local and seasonal finance as well as input and outputs markets. The last phase would be withdrawal characterised by effective private sector markets (Kirsten and Vink,2005).

As shown in preceding sections many of the world's poor and hungry are smallholder farmers in developing countries. Yet they have the potential not only to meet their own needs but to boost food security and catalyse broader economic growth. To unleash this potential and reduce the number of hungry people in the world, governments, supported by the international community, need to protect core investments in agriculture so that smallholder farmers have access not only to seeds and fertilisers but to tailored technologies, infrastructure, rural finance, and markets (IFAD, 2009).

4.2 Climate Change as a Long Time Driver

Climate change will have impacts on soil quality, water resources, temperature regime, and growing season duration on net primary productivity of different biomes. It will also affect soil carbon dynamics and cause changes in carbon dioxide and ecological environments on agronomic yields and food production in different regions of the world. This will change the terrain of world food demand and supply in the 21st century.

Schmidhuber and Tubiello (2007) note that the impacts of climate change are significant, with a wide projected range (between 5 million and 170 million additional people at risk of hunger by 2080) strongly depending on assumed socio-economic development. The impacts of climate change on food security can be seen on food availability, supplies, access, utilisation and food prices as explained below (Schmidhuber and Tubiello, 2007);

Impacts on Food Production and Availability

Climate change affects agriculture and food production in complex ways. It affects food production directly through changes in agro-ecological conditions and indirectly by affecting growth and distribution of incomes, and thus demand for agricultural produce. Changes in temperature and precipitation associated with continued emissions of greenhouse gases will bring changes in land suitability and crop yields.

Impacts on the Stability of Food Supplies

Global and regional weather conditions are also expected to become more variable than at present, with increases in the frequency and severity of extreme events such as cyclones, floods, hailstorms, and droughts. By bringing greater fluctuations in crop yields and local food supplies and higher risks of landslides and erosion damage, they can adversely affect the stability of food supplies and thus food security.

Impacts of Climate Change on Food Utilisation

Climate change will also affect the ability of individuals to use food effectively by altering the conditions for food safety and changing the disease pressure from vector, water, and food-borne diseases.

Impacts of Climate Change on Access to Food

Access to food refers to the ability of individuals, communities, and countries to purchase sufficient quantities and qualities of food. Over the last 30 years, falling real prices for food and rising real incomes have led to substantial improvements in access to food in many developing countries. Increased purchasing power has allowed a growing number of people to purchase not only more food but also more nutritious food with more protein, micronutrients, and vitamins. By coupling agro-ecologic and economic models, scientists have gauged the impact of climate change on agricultural gross domestic product (GDP) and prices. The strongest impact of climate change on the economic output of agriculture is expected for sub-Saharan Africa, which means that the poorest and already most food-insecure region is also expected to suffer the largest contraction of agricultural incomes.

Impacts on Food Prices

Some projected development paths describe a world of robust economic growth and rapidly shrinking importance of agriculture in the long run and thus a continuation of a trend that has been underway for decades in many developing regions. This will thus be a world where income growth will allow the largest part of the world's population to address possible local production shortfalls through imports and, at the same time, find ways to cope with safety and stability issues of food supplies. Therefore where income levels are low and shares of food expenditures are high, higher prices for food may still create or exacerbate a possible food security problem. The basic messages on the effects of climate change on food prices are that; first, on average, prices for food are expected to rise

moderately in line with moderate increases of temperature (until 2050); some studies even foresee a mild decline in real prices until 2050. Second, after 2050 and with further increases in temperatures, prices are expected to increase more substantially. In some studies and for some commodities (rice and sugar) prices are forecast to increase by as much as 80% above their reference levels without climate change. Third, price changes expected from the effects of global warming are, on average, much smaller than price changes from socioeconomic development paths.

4.3 Institutions and Governance

To ensure sustainable global food security and promote sustainable management of water, forest and other natural resources, there should be special focus on small farmers, women and families. Focus should also be placed on their access to land, water, inputs, and financial services including microfinance and market. There is a need to strengthen capacity building in particular through knowledge transfer using North-South, South-South and triangular cooperation to achieve increased agricultural production and productivity with a stimulus to pre- and post-harvest intervention, with emphasis on preservation of the natural resource base, expansion of employment and decent work opportunities(FAO, 2009).

FAO (2009) notes that in the 1960s and 1970s, support to small farmers through the provision of inputs, the purchase of their output, credit and extension services was provided by public institutions and national marketing boards. In the 1980s, in line with market liberalization policy and as part of the structural adjustment programmes, these institutions were weakened and in some cases even dismantled. Yet no effective and consistent policies or continuous operational programmes were adopted and implemented to ensure their replacement with adequate private or semi-private institutions to continue to provide the same services to small farmers. It has become clear today that small farmers need public policy and institutional support to enable them to organize themselves to collect information, improve their production and benefit from economies of scale in input access and product marketing.

Against such a background, FAO (2009), highlights that there is the need to rebuild the institutional capacity of developing countries to help smallholders to access the technologies, inputs, credit and markets they need to become more productive, as well as to enable them to organize themselves better and to market their output. These include services for research and extension, access to inputs, product marketing, rural credit and capacity building of trade organizations, in particular by training producers and administrators in the sector.

The importance for developing countries to rebuild their institutional capacity and strengthen and empower farmers' organizations is critical. Developed countries and relevant international organizations should provide them with the necessary support. These renewed institutions should include more farmers' organisations and the private sector and use modern management techniques and control systems, to avoid the inefficiency and politicization that plagued some of the old institutions.

Paarlberg (2002) argues that the problems of hunger and food insecurity urgently require a national, not global focus. Many national governments in developing countries

still do not provide essential public goods, such as civil peace, rule of law, transport infrastructure, clean water, electrical power, and public research to generate new agricultural productivity— essential ingredients in the effort to boost incomes. For tackling hunger, the weak performance of nation-states remains most critical—and in most critical need of improvement. According to Paarlberg, the governance challenge as far as food security is concerned is to persuade sovereign governments to provide the necessary public goods that would ensure access to adequate food.

Kirsten and Vink (2005) conclude that in Africa, there is the 'agricultural development paradox'; *the need for pro poor state services is high while state failure is profound*. They also post some policy related success and failure factors which are:

(i) 'Partial implementation' with the argument that poor results can be attributed to government failures to fully liberalise their agricultural sectors. This view does not however recognise the fact that there are important institutional constraints to market development in rural areas
(ii) 'Weak institutions' argument attribute failures in market liberalisation policy in delivering expected benefits to weak institutional support for market and private sector development
(iii) Lack of long term productive investments in agricultural research, extension and rural infrastructure
(iv) 'Coordination failure' which is characterised by pervasive failure of state activism and the superiority of liberalised markets. It is noted that there are dramatic successes and failures which show that there is limited success in stimulating significant broad based poverty reduction and growth processes.

4.4 The Role of International Trade(Export, Import and Food Aid)

According to IFPRI (2008), the volume of major crop exports increased by 9 percent (55 billion tonnes in wheat equivalent) from 2003–05 to 2007 and is forecast to continue growing almost as rapidly to 2010. Comparing trade patterns with production for major traded commodities highlights the role that imports and exports play in different countries. Supply disruptions in major exporting countries can have important implications for export supplies and international agricultural markets even if they have little impact on global production.

FAO (2009) reiterates that a rules-based international agricultural trading system that is open, non-distorted, non-discriminatory, equitable and fair can promote agricultural and rural development and contribute to world food security. Thai necessitates the need for a successful conclusion to the Doha round of trade negotiations. While international trade in agricultural and food products has expanded, many developing nations, in particular the least developed countries have remained at the margins of these developments. These countries face specific challenges and their supply-side constraints and trade capacity in agriculture need to be addressed effectively. Their farmers will also need to be provided with adequate incentives to increase their production and productivity and to profit from increased trade opportunities. Agriculture policy should play a critical role in providing incentives to stimulate production. However, it could have adverse impacts if it is not properly designed to avoid distorting effects to the detriment of small and poor farmers. There is need for all farmers of the world, in developing and developed countries alike, to

ensure the food security of the 1 billion hungry people and to double agricultural production by the year 2050 for a world population that is projected to reach 9.2 billion by then.

FAO (2009) notes that farmers in both developed and developing countries should have an income comparable with those earned by workers in the secondary and tertiary sectors of their respective countries to remain in rural activity. This objective should be achieved through support that causes no distortions on the international markets. Developed countries should continue to shift their support to 'decoupled' forms of support authorised under WTO provisions, while for developing countries, appropriate support measures to boost production should be designed, particularly using effective support mechanisms to facilitate access to inputs, direct payments to achieve income targets and compensatory financing in cases of natural disasters. Food and agricultural trade policies should be conducive to fostering world food security. They should not be hampered by actions taken in response to the economic climate.

FAO (2009) stresses that all countries should remove food export restrictions or extraordinary taxes, especially for food purchased for humanitarian purposes, and to consult and notify in advance before imposing any new restriction. This position however remains an issue to grapple with in world where there are GMOs which have been rejected by consumers in countries which produce them. However, the WTO Agreement on Technical Barriers to Trade (TBT) sets out the rules that should govern trading practices at the international level for all consumer type products, with a view to ensuring that regulations and product standards do not create unnecessary and unjustified obstacles to trade.

It is noted FAO (2009), however, that developing countries continue to face many stringent technical requirements for their exports. Governments should be urged to refrain from using TBT-type measures to block imports, particularly from the developing countries, and to adhere fully to the provisions of the TBT Agreement as set by the WTO. There is also the need to provide developing countries with the information, training and resources needed to comply with standards and regulations governing their exports.

In an attempt to minimise the impacts of higher food prices on vulnerable population groups within countries, a number of governments and private-sector actors have taken measures that have at times exacerbated the effects of the underlying trends on food prices in international markets. The adoption of export restrictions and bans by some countries has reduced global supply, aggravated shortages and eroded trust among trading partners. In some countries, such actions have also reduced farmers' incentives to respond to higher international prices. Speculative re-stocking or pre-stocking by large importers with relatively strong cash positions has also contributed to higher prices (FAO, 2008).

FAO (2008) notes that more liberalisation would mainly benefit developed countries. It is noted that complete liberalisation of agricultural trade could produce valuable overall welfare gains, but some groups would win while others would lose. The benefits would go mainly to consumers and taxpayers in industrial countries, where agriculture is most protected, and to developing country agricultural exporters. In contrast, urban and landless rural consumers in developing countries might end up paying higher prices for some

foodstuffs, especially cereals, milk, meat and sugar. This will pose serious threats to food security. Specific measures would be needed to help such loser groups.

Agriculture accounts for 11 per cent of the value of all world exports. A quarter of Latin America's exports are agricultural and 18 per cent of Africa's. According to the FAO (2001) the measures and strategies that would ensure that the poorest and most vulnerable countries and population groups receive an equitable share of the benefits of trade liberalisation should be aimed at:

(i) Eliminate direct and indirect export subsidies.
(ii) Rationalize and simplify access to OECD markets. Specifically, rationalise and simplify trade preferences, assist countries whose preferences have been eroded through multilateral liberalisation, and deepen existing preferences for very poor countries.
(iii) Reduce OECD tariffs and consumer taxes on processed agricultural products, with special preferences for products from developing countries.
(iv) Eliminate tariff escalation for tropical commodities, in the developing as well as the developed countries. Tariffs are rising even faster in the former than in the latter group. The purchasing power of China's or India's rapidly growing middle class could turn these countries into major importers of some tropical agricultural products over the next 30 years.
(v) Create or expand safety nets and food distribution schemes, to ensure that low-income consumers are not penalised by rises in the prices of food imports.

5.0 EMERGING ISSUES FOR AFRICAN FOOD SECURITY

5.1 Drivers for Sustained Trends in Food Security (Why Does Africa Remain Poor?)

A widely accepted objective for agricultural development in Africa is to achieve sustainable agricultural intensification (Kirsten and Vink *et al*., 2005). This would be achieved through use of advanced technologies that increase land and labour productivity. They concede that for most of the rural poor in Africa, there is significant direct and indirect dependence of the local economy on agriculture. These authors also highlight that there is a set of problems which inhibit such processes from occurring. For sustainable turn around of processes there is need to address these problems. The problems include:

(i) Absence of markets because of low purchasing power in domestic markets and poor access to global markets because of trade distortions such as rich country agricultural subsidies
(ii) Long production and sales cycles which lead to significant seasonality in labour use, cash flow, food availability, prices and risks
(iii) High returns to timely labour at peak labour demand which makes poor farmers want to hire out their labour because of poverty
(iv) Technical progress and land pressure increase farmers needs for inputs which are however purchased in uneconomic quantities therefore high transaction costs
(v) Farmers input purchases that need seasonal financing which brings the issue of how such financing may be provided given that significant shares of output are for subsistence

(vi) Land which is the basis for of agriculture with tenure arrangements affecting farmers ability to borrow , expand or exit with a lumpsum via land market transactions and also influence incentives for land improvement

Kirsten and Vink (2005) also note that in addition to these general problems, substantial numbers of poor farmers face problems unique to their circumstances which have an idiosyncratic effect. Such problems include;

(i) Human health issues(HIV/AIDS, Malaria, TB etc)
(ii) Poor animal health and care systems
(iii) Heterogeneous patterns of population density
(iv) Scarcity of water for both human consumption and for direct production in irrigation agriculture
(v) Particular role of women has not been given the attention it deserves
(vi) Large parts of Africa have been subject to successive phases of colonial exploitation and manipulation
(vii) Environmental degradation that affects soil nutrient depletion , soil erosion , destruction of water catchment areas and salination
(viii) Fragile and weak states often induced by the type of development aid dispensed by the developed ,countries
(ix) Competition with food aid whose main purpose is to get rid of rich country food surpluses produced though subsidies and whose main effect is to crowd local farmers out of markets.
(x) Limited agricultural support by national governments in Africa
(xi) Limited capacity to respond to disasters and plan for the future, depend on donations from developed world
(xii) Trade of between present day political gains versus long term development policies in Africa

5.2 The Role of Land Grabs in African Agricultural Production

A report from GRAIN (http://www.grain.org/)(2009) points out that investing in farms abroad to produce food for a tight world market is a hot way to make money in the face of rising food prices. It is noted that an avalanche of investment houses, private equity managers and hedge funds have been out purchasing farmland throughout the world. The plan is to capitalise on low land costs and high food prices wherever fertile farmland is available, such as in Ukraine, China, Russia, Nigeria, Argentina, Brazil and Kazakhstan. They are getting help from agencies like the World Bank, its International Finance Corporation and the European Bank for Reconstruction and Development, who are pressing target countries to change their laws and make stronger land ownership by foreigners possible.

The contemporary food and financial crises have triggered a new global land grab. "Food insecure" governments that rely on imports to feed their people are snapping up farms all over the world to outsource their own food production and escape high market prices. Private investors, hungry for profits in the midst of the deepening financial crisis, are eyeing overseas farms as an important new source of revenue. As a result of both trends, fertile agricultural land is being swiftly privatised and consolidated by foreign companies in some of the world's poorest and hungriest countries.

Saudi Arabia and China are two nations out buying farms, from Sudan to Cambodia, to satisfy their own food needs. In these cases, governments, sometimes through sovereign wealth funds, are negotiating rights to foreign land -- whether by purchase, concession or lease -- so that their corporations can come in and produce food to export back home. In return, they are offering oil contracts, soft loans, infrastructure projects and development funds. The food-hungry land grabbers include China, India, Japan, Malaysia, Korea, Egypt, Libya, Bahrain, Jordan, Kuwait, Qatar, Saudi Arabia and United Arab Emirates. Those giving up their land, in exchange for the oil deals or investments, include the Philippines, Mozambique, Thailand, Cambodia, Burma, Laos, Indonesia, Pakistan, Sudan, Uganda, Brazil, Paraguay, Uruguay, Ukraine, Russia, Kazakhstan and Zimbabwe.

IRIN (2009) notes that between 15 and 20 million hectares of farmland in such countries have been subject to transactions or negotiations since 2006. IFPRI estimates the value of such deals at up to $30 billion. The effects are diverse. Not only will it displace small farmers but it will likely have serious environmental consequences given that the land grabbers are leasing land, not buying it, would have no interest in long-term development of the farmland they are seeking access to. Box ‘’2’’ is an extract from the IRIN article showing some of the consequences of land grabs in Philippines and Myanmar

Box 2: Consequences of land grabs in Philippines and Myanmar

In Kamukhaan village in the Philippines, such effects have become well documented, according to the AHRC. Since a Filipino company took over 613ha in the village to build a banana plantation in 1981 – to supply US-based fruit company Dole – hundreds of villagers have suffered skin and respiratory ailments from pesticide use, the group claims. The farmers had lost their farmland, their children, their natural sources, their health and their future. Now the Philippines' food sovereignty is absent and the self-sufficiency is almost zero. In the Philippines this year, Bahrain secured 10,000ha for agro-fishery, Qatar leased 100,000ha, and an unknown company from China leased 1.24 million hectares, though the deal has been put on hold, according to an April policy briefing by IFPRI. Such deals are often done in secret, it says, stopping civil society groups from overseeing the terms and defending the rights of local farmers. In Myanmar, Chinese companies have driven farmers off their land to cultivate an oil plant, according to Welt Hunger Hilfe, a German NGO. The farmers already faced seasonal changes that threatened food security, but had their last source of food taken from them by the government, the group says.

Source:IRIN

5.3 GMOS and Food Security

In 2006 the global area under genetically modified crops was 102 million hectares (252 million acres)(Shattuck, 2009). The largest areas were devoted to cotton, soybean and rape seed. Most GM crops are growing in Argentina, Canada, China and the United States. The USA Senate’s Foreign Relations Committee (US) approved the Global Food Security Act in 2009. The legislation includes a provision sought after by aid groups that would allow food aid to be purchased — at least in part, locally. The bill aims to reform aid programs to focus on longer-term agricultural development, and restructure aid agencies to better respond to crises. While the focus on hunger is commendable, funding for agricultural

development — some $7.7 billion worth of it — under the proposed law would be directed in large part to genetically modified crop research. In contrast, the International Assessment of Agricultural Knowledge Science, and Technology for Development (IAASTD), a recent four-year study conducted by the World Bank and the Food and Organization (FAO) in consultation with more than 400 scientists and development experts, reached the opposite conclusions(Shattuck, 2009). The IAASTD found that reliance on resource-extractive industrial agriculture is unsustainable, particularly in the face of worsening climate, energy, and water crises. And it concluded that expensive, short-term technical fixes — including GM crops — don't adequately address the complex challenges of the agricultural sector and often exacerbate social and environmental harm. The IAASTD called for land reform, agro-ecological techniques (proven to enhance farmers' adaptive capacity and resilience to environmental stresses such as climate change and water scarcity), building local economies, local control of seeds, and farmer-led participatory breeding programs.

Other radical scientists argue that the Global Food Security Act isn't just about feeding the hungry — it's about advancing the interests of U.S.A agribusiness (Shattuck, 2009). The IAASTD found that agro ecological techniques, stricter regulation of multinational agribusiness, and increased democratic control of the global food system can address the root causes of hunger in a way that a biotechnology never will. The Global food security act’s focus on agricultural development is welcome but that focus must come with a commitment to put the interests of small farmers before that of industry.

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APPENDIX

Table 11: Population and GDP data projections

	Total population								
	Millions					*Annual Increments (millions)*			
	1979-81	1997-99	2015	2030	2050	1995 to 2000	2010 to 2015	2025 to 2030	2045 to 2050
World (UN)[1]	4 430	5 900	7 207	8 270	9 322	79	76	67	43
World (FBS)	4 416	5 878	7 176	8 229	9 270	78	76	66	43
Developing countries	3 245	4 573	5 827	6 869	7 935	74	74	66	45
Sub-Saharan Africa	345	574	883	1 229	1 704	15	20	24	23
Near East and North Africa	238	377	520	651	809	8	9	9	7
Latin America and Car.	357	498	624	717	799	8	7	6	3
South Asia	885	1 283	1 672	1 969	2 258	23	22	19	12
East Asia	1 420	1 840	2 128	2 303	2 365	20	16	9	-1
Industrial countries	789	892	951	979	986	5	2	1	0
Transition countries	382	413	398	381	349	0	-1	-1	-2
	Growth rates (% per year)								
	Population					Total GDP		Per capita GDP	
	1969 to 1999	1979 to 1999	1989 to 1999	1997-99 to 2015	2015 to 2030	1997-99 to 2015	2015 to 2030	1997-99 to 2015	2015 to 2030
World (FBS)	1.7	1.6	1.5	1.2	0.9	3.5	3.8	2.3	2.9
Developing countries	2.0	1.9	1.7	1.4	1.1	5.1	5.5	3.7	4.4
Sub-Saharan Africa	2.9	2.9	2.7	2.6	2.2	4.4	4.5	1.8	2.3

Near East and North Africa	2.7	2.6	2.4	1.9	1.5	3.7	3.9	1.8	2.4
Latin America and Car.	2.1	1.9	1.7	1.3	0.9	4.1	4.4	2.8	3.5
South Asia	2.2	2.1	1.9	1.6	1.1	5.5	5.4	3.9	4.3
East Asia	1.6	1.5	1.2	0.9	0.5	6.1	6.3	5.3	5.8
Industrial countries	0.7	0.7	0.7	0.4	0.2	3.0	3.0	2.6	2.8
Transition countries	0.6	0.5	0.1	-0.2	-0.3	3.7	4.0	4.0	4.3

[1] World (UN) covers all countries; World (FBS) covers all countries for which FAO Food Balance Sheet data are available.
Sources: Population: UN (2001)
GDP to 2015: World Bank (2001b)

Table 12: Changes in commodity composition of food

Table A4: Changes in commodity composition of food							
	Cereals	Roots and tubers	Sugar (raw eq.)	Pulses(dry)	Vegetable oils, oilseeds (oil eq.)	Meat(carcass weight)	Milk and dairy (fresh milk eq.)
	kg/capita/year						
World							
1979-81	160	74	23.5	6.5	8.4	29.5	77
1997-99	171	69	24.0	5.9	11.4	36.4	78
2015	171	71	25.1	5.9	13.7	41.3	83
2030	171	74	26.3	6.1	15.8	45.3	90
Industrial countries							
1979-81	139	67	36.8	2.8	15.7	78.5	202

1997-99	159	66	33.1	3.8	20.2	88.2	212
2015	158	63	32.4	4.0	21.6	95.7	217
2030	159	61	32.0	4.1	22.9	100.1	221
Transition countries							
1979-81	189	119	45.9	3.1	9.2	62.9	181
1997-99	173	104	34.0	1.2	9.3	46.2	159
2015	176	102	35.0	1.2	11.5	53.8	169
2030	173	100	36.0	1.1	14.2	60.7	179
Developing countries							
1979-81	162	70	17.6	7.8	6.5	13.7	34
1997-99	173	67	21.3	6.8	9.9	25.5	45
2015	173	71	23.2	6.6	12.6	31.6	55
2030	172	75	25.0	6.6	14.9	36.7	66
Sub-Saharan Africa							
1979-81	115	172	9.9	9.8	8.5	10.6	34
1997-99	123	194	9.5	8.8	9.2	9.4	29
2015	131	199	11.3	9.8	10.7	10.9	31
2030	141	202	13.0	10.5	12.3	13.4	34
Near East and North Africa							
1979-81	199	26	28.2	6.4	11.1	17.4	85
1997-99	209	34	27.6	6.7	12.8	21.2	72

2015	206	33	28.7	6.9	14.4	28.6	81
2030	201	33	29.9	6.9	15.7	35.0	90
Latin America and Caribbean							
1979-81	130	74	48.5	12.6	10.2	40.6	97
1997-99	132	62	48.9	11.1	12.5	53.8	110
2015	136	61	48.2	10.7	14.5	65.3	125
2030	139	61	47.9	10.6	16.3	76.6	140
South Asia							
1979-81	151	20	20.7	11.2	5.8	4.0	42
1997-99	163	22	26.7	10.9	8.4	5.3	68
2015	177	27	29.5	9.1	11.6	7.6	88
2030	183	30	32.2	7.9	14.0	11.7	107
East Asia							
1979-81	181	83	8.1	4.3	4.7	13.0	5
1997-99	199	66	12.4	2.1	9.7	37.7	10
2015	190	64	14.6	2.0	13.1	50.0	14
2030	183	61	16.6	2.1	16.3	58.5	18

THE EXCITING ROLE OF PUBLIC AGRICULTURAL RESEARCH IN AFRICA'S GREEN REVOLUTION

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Alliance for a Green Revolution in Africa

ABSTRACT
While the potential for public agricultural research institutions in Africa to play a role in an African Green Revolution has been frequently noted, the input these institutions have had on food supply and farmer productivity has often fallen short of its promise. Recently, however, through a series of innovative, new partnerships formed with the private sector, agricultural universities and national agricultural research institutes have begun to emerge from the shadows to play a more critical role in creating positive change for farmers.

In fact, Africa's universities and agriculture research institutes have long been aware of their own capabilities, but perhaps remained too protective of their results in the interest of preserving the sanctity of 'public goods'. Research publications in international journals, improved technologies for crop management and improved crop varieties all figure in the litany of achievements by researchers working with public universities and institutes. What has frequently been lacking from the equation is an effective means for sharing such technologies on a sustainable basis with large numbers of farmers in a way which would allow for meaningful feedback on needed improvements (an effective feedback loop). Farmers on the other hand, have often been deprived of access to these technologies, and indeed most remain unaware that such research is being carried out on their behalf. A number of aborted attempts by universities and public research institutes at commercializing their own results have only served to reveal the inappropriateness of these institutions at surviving long-term in an increasingly competitive commercial environment.

Recently, however, a growing number of public universities and research institutes in Africa have overcome previous misgivings about the role of the private sector in agriculture development and have formed genuine partnerships with private companies. These partnerships have been facilitated, in part by policy reforms which allow them. In part, they are also the result an emerging (and increasingly professional) generation of private, agricultural enterprises. Through such agreements, public goods remain public in ownership but are transformed into commercial, privately- managed products through their use by private enterprises. At a recent field day conducted at the Kenya Agricultural Research Institute, a series of new, high yielding maize varieties was on display, with the name of the hybrid and the name of the private seed company which entered into a licensing agreement to commercialize that hybrid prominently displayed. Several new soybean varieties developed at a university in Uganda have likewise begun to reach small-scale farmers in large quantities through licensing agreements with seed companies.

In the view of the author, this can only bode well for the public institutions involved the private, risk-taking agricultural enterprises, and farmers , who for too long have remained in the shadows of Africa's liberalised economies. Several of the KARI hybrids have already been multiplied in the hundreds of metric tons and sold to farmers, whose yields have increased as a result. The case of soybean in Uganda is a similar,

emerging, success story. It is high time Africa's public research institutions and agricultural universities shed their remaining misgivings about 'going commercial'.

1.0 INTRODUCTION

Agriculture continues to be Sub-Saharan Africa's largest area of economic activity, accounting for 40% of GDP and 60-80% of employment and yet it is the one region of the world where the food supply situation continues to worsen as the population grows. In the rest of the world food supply has been increasing faster than population for a decade or more. In Africa the food supply situation can only be described as urgent:

(i) In the past 15 years, the number of hungry people has risen by 20% to over 203 million (IFPRI, 2005).

(ii) In the past five years alone, the number of underweight children has risen by approximately 12% (IFPRI, 2005).

(iii) 16 of the 18 most undernourished countries in the world (>35% of population undernourished) are in Africa (FAO, 2005).

As it has been throughout the world, increasing the level of farmer productivity is a prerequisite for economic growth and development in most African countries. The production growth needed will have to come from improved farm policies, technologies (high quality seeds of improved crop varieties of local staples, improved fertilizer use and integrated soil fertility management technologies) and techniques, including those that address climate change. However, for such productivity gains to be achieved, strong public agricultural research institutions are needed to generate key technologies needed to improve crop production in farmers' fields and effective linkages of these public institutions to the private sector that can scale up and disseminate these technologies to the farmers. All these require well trained human capacities.

Increasing agricultural research capacity is seen as an important factor in building food security and economic stability in Africa. New and better-targeted technologies are essential to this process, and a well-developed and well-supported agricultural research system is a prerequisite not only for the design of these technologies but also for their dissemination and adoption (Beintema, 2004). Growth in agricultural research and development (R&D) investments in SSA has however, remained stagnant over the past two decades while funding has become increasingly scarce, irregular, and donor-dependent. Institutional reforms and sound S&T policies are needed to improve the efficiency and effectiveness of agricultural research in Africa. Several research success stories are worth noting in Africa. These include; Nerica rice varieties, better adapted to harsh environmental conditions, can smother weeds and are more productive, enabling farmers to achieve improved livelihoods. These varieties have spread through most of the continent. Another case to note is the improved cassava varieties that are resistant to African Cassava Mosaic Virus and resulted in a yield increase of 49 % over the average yields. The last case of a non exhaustive list to note are the biological control methods developed through research that have significantly reduced the losses caused by the cassava mealy bug and green spider mite. These successes and many others indicate

the immense potential available in public and international research scientists and institutions to solve problems of small holder farmers in Africa.

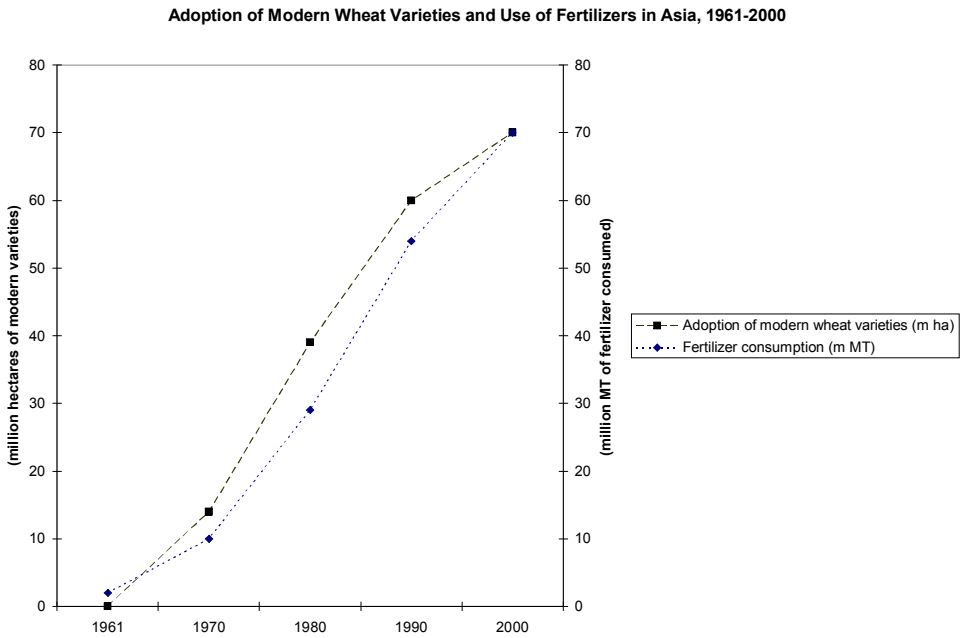
African farmers are concerned by the weak engagement of farmers and farmer organisations with research institutions in terms of setting the research for development agenda, weakness of the extension/agricultural advisory services, leading to failure of research findings reaching the farmers and failure of research to address current and emerging challenges in agricultural support and advocacy among others (GCARD Farmer Multi-stakeholder Platform, 2009).

The traditional public agricultural research institution in most African countries was to generate technologies with or without farmers inputs and hope the extension system would pick the results and disseminate them to the farmers. In most African countries the extension systems have completely collapsed and this role has in some cases been picked up by non-governmental organizations and in others by no one resulting in a lot of technologies sitting on shelves in public research institutions. The researchers have published papers and in some cases received accolades for their research but the results of the research have not reached the farmers. This paper reports the need for public research and private sector partnerships in bulking up and disseminating results of research and reports some success examples from both public universities and national agricultural research institutions.

1.1 Green Revolution

Asian farmers transformed their agriculture from being dependent upon old unimproved varieties grown with little fertilizer and constantly threatened by shortages of basic food staples into a commercial agricultural system based on modern, high-yielding varieties and fertilizer that is growing more rapidly than population through the Asian Green Revolution in the 1960's and 70's. In this green revolution, average maize yields nearly doubled between 1961 and 2000 in India, rising from 0.9 MT/ha to 1.8 MT ha; rice yields also just about doubled from 1.5 MT/ha to 2.9 MT/ha. Meanwhile wheat yields more than tripled, rising from approximately 0.8 MT/ha to 2.8 MT/ha (FAOSTAT). Initiated in wheat and rice, later development of high yielding varieties of sorghum, millet and maize likewise played an important role in raising the productivity of dryland farming areas of Asia, especially India (Streeter, 1969, Evenson and Gollin, 2003).

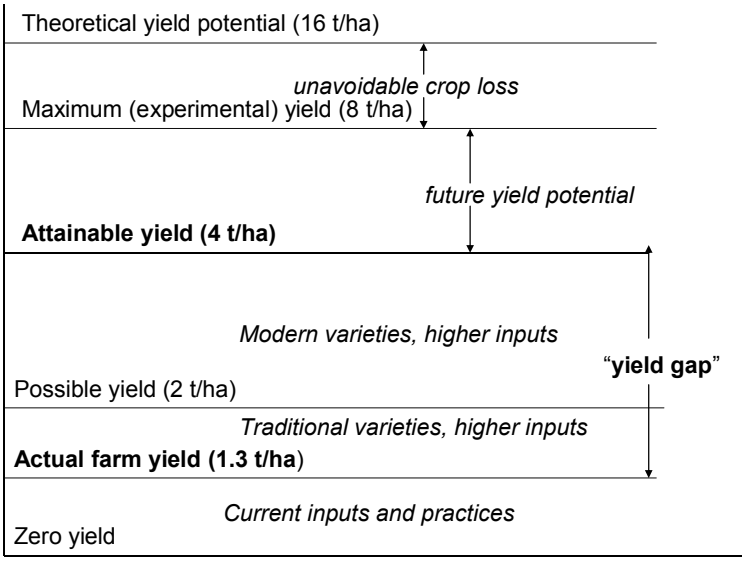
The Asian Green Revolution took from the 1960s until 2000 for suitable modern varieties to be created to cover 80% of Asia's crop land (Evenson and Golli, 2003). In the first decade a handful of wheat and rice varieties spread to over 30 % of the area, creating "breathing room" for the breeders to create varieties with greater degrees of pest resistance



in the second decade and greater local adaptability in the third decade. As in Asia, in Africa, seeds can be the point of the arrow that drives through the barrier of stagnation. The new varieties yielded more when grown with fertilizers, and use of the two inputs took off together, as illustrated (adapted from Borlaug, 2003). The Green Revolution allowed farmers to take full advantage of investments in irrigation and roads, and the creation of agricultural universities and research institutes generated indigenously educated plant agriculturalists to make the process self-sustaining (Streeter, 1969).

1.2 Africa Faces a Yield Gap and a Variety Gap

All across Africa actual yields of farmers are far below attainable yields because they grow low-yield potential varieties with poor agronomic practices, limited inputs, and because abiotic and biotic production constraints reduce the yields of those varieties. Applying higher inputs or using better farming approaches with current varieties would increase yields somewhat, as illustrated, but by a relatively small amount. Suitable modern varieties, because they are resistant to abiotic and biotic challenges and are responsive to inputs, when grown with higher inputs give a much higher yield than is attainable under farmers' conditions. Maximum yields as achieved on experiment stations or in advanced countries are still higher, and demonstrate the potential for still further gains, but under current farming condition in Africa are not attainable at this time.



Average and Attainable Maize Yields in Africa

Generating suitable varieties to overcome these yield gaps presents a greater challenge in Africa than it did in Asia because African agriculture is much more diverse and current capacity is much more limited. Africa has many different important food crops, different production conditions and great diversity of climate and soil. It has many small countries with different policies and institutions, most of which have limited government budgets for agriculture. Any new variety is adapted to a relatively small region, whereas in Asia, some Green Revolution-style rice or wheat varieties targeted to irrigated farmland were adopted on hundreds of thousands of hectares in many countries. Developing suitable technologies for Africa will be challenged by six major factors discussed below using the plant breeding and seed systems sector examples.

Many Staple Food Crops

Africa's food base is made up of at least eight staple crops, each of which is the leading contributors of caloric intake in one or more countries, whereas Asia has only two - wheat and rice. In the Sahel countries, sorghum and/or millet are the key contributors. In coastal zones of West Africa, cassava, yam, and banana form the food base. In Southern Africa, maize is the predominant crop, except in the semi-arid zones where sorghum and millet again play critical roles. In East Africa, maize is the leading contributor of dietary calories, except in the highland zones of Uganda, Rwanda, and Burundi, where highland, starchy bananas predominate. In the Horn of Africa, teff and sorghum are the two main crops. Maize is the leading crop in terms of per capita production in six countries. Cassava is the leader in 16 countries. Rice is the leader in two. Sorghum is the leader in five.

Diverse Production Environments
The diversity of African cropping systems makes it very difficult to characterize broad cropping patterns in large sub-regions of the continent. Africa also has very limited irrigation (only 5.2 million hectares in 2002, whereas Asia had 87 million hectares in 1961), and it's upland ecologies are highly varied, which results in significant differences with regard to local pests, diseases, rainfall patterns, and soil properties.

Diversity of Required Traits
Greater environmental diversity translates directly into a need for greater crop genetic diversity and management systems. The very low level of use of fertilizers, irrigation, and other purchased inputs means that African crops are subjected to high levels of stress and that more must be accomplished through genetics. Breeding successful varieties in Africa often requires setting up screening facilities which reveal and isolate key stress-resistance genes and then testing candidate varieties under local farming conditions, where farmers themselves can assist with selections. Finally, crop traits that are important to the way the harvest is processed, stored, and eaten in African villages must be included as well.

Limited Human Capacity
The absence of well-trained African scientists meant that most of the breeding had to be performed by expatriate scientists, often working from a limited number of distant locations. Breeding operations have been relatively limited in geographic extent and cannot address many of the important production zones in Africa. For example, CIMMYT data for maize shows 210 public and 290 full-time maize scientists at work in Latin America, 150 private and 505 public maize scientists at work in all of Asia, and only 45 private and 109 maize scientists in Africa. In density, Africa has about one third the maize scientists per million hectares of maize and between one third and one ninth the density of improved maize varieties as Latin America and Asia (CIMMYT,).

Constrained Breeding Facilities
The breeders in place in African national agricultural research programs have exceedingly limited support. Like most public sector workers their salaries are very low and they have essentially no operating funds to purchase fertilizer or pay laborers. In addition, agricultural experiment stations are usually outside urban areas and are frequently without water and electricity service for many hours every week, telephone service is erratic, and virtually none have internet access. The few that have operating vehicles find them expensive to maintain and when vehicles are operating the shortage of operating funds mean that they can purchase very little fuel making it impossible to operate participatory breeding programs with farmers.

Capacity to Leverage Varietal Improvements
The depressed state of African transportation infrastructure development, energy and water infrastructure, governance and institutions, and financial systems is a significant barrier to agricultural development. Ensuring adoption of improved varieties will require complementary investments in farmer training, seed enterprise development, strengthened input and output markets, improved market information systems, and knowledge and technologies to improve soil fertility and manage water catchments and water use.

The great diversity and current limits on capacity imply that a greatly increased plant improvement effort is necessary if Africa is to get the new varieties it needs to mount a Green Revolution.

2.0 CURRENT CROP IMPROVEMENT EFFORTS ARE CENTERED IN NATIONAL INSTITUTES AND THE CGIAR

Most of Africa's plant breeding capacity is in public sector national agricultural research institutes. While plant breeding in the industrialized regions of the world (and South Africa) has largely shifted from the public to the private sector, in the rest of Africa virtually all plant breeding is still conducted within the public sector, for a number of reasons: (1) seed markets, like most other markets, are poorly developed, have limited information flow, undeveloped grades and standards, and are part of a business environment in which contracts are hard to enforce; (2) the many different African food crops and constraints mean the market for any single variety is too small to repay the research investment a private company would have to make to develop well-adapted varieties; (3) intellectual property protection is limited so companies are reluctant to make investments in self-reproducing plants; (4) emerging, small seed companies lack the financial resources to hire their own breeders and support their operations during the long R&D phase.

Most national agricultural research institutes are overseen by the Ministry of Agriculture. Even small African countries have their own national agricultural research institute, although in some countries these institutes primarily test varieties produced elsewhere and carry out little or no independent plant breeding. Because these public institutes are spread throughout the continent and have the mandate of their governments to carry out plant breeding, they are a great resource for addressing the continent's agro-ecological complexity. However, as indicated earlier, they are vastly under-financed and in most countries are expected to generate varieties of all the staple crops grown in each country. Clearly these institutes are struggling. About 20 African universities teach plant breeding but few of them have much research capacity or funding.

The international agricultural research centers that fall under the ambit of the Consultative Group on International Agricultural Research (CGIAR) are another significant plant breeding resource for Africa. Each of the CGIAR research institutes are independent and separately managed although they are funded by the donor members of the CGIAR, a loose organisation of more than 40 donor agencies and foundations with a Secretariat administered by the World Bank. Seven have significant plant breeding activities in Africa (Table 2). The International Institute of Tropical Agriculture (IITA) and the West African Rice Development Association (WARDA) are headquartered in Africa; the International Maize and Wheat Improvement Center (CIMMYT), the Center of Tropical Agriculture (CIAT) and the International Center for Research in the Semi-Arid Tropics (ICRISAT) has permanent offices and breeding programs in Africa. Two other CGIAR centers, the International Rice Research Institute (IRRI), the International Two other CGIAR centers, the International Rice Research Institute (IRRI), the International Potato Center (CIP) have limited crop genetic improvement activity in Africa.

The CGIAR institutes represent a great resource for improving Africa's crops, as they house extensive collections of germplasm, both from Africa and other regions. They

are relatively well-funded and are mandated by their supporters to carry out germplasm improvement activities and provide breeding lines to national programs. They also carry out "pre-breeding" activities that address some of the more challenging constraints. However, they are constrained by the Science Council which advises the donors of the CGIAR to produce only "international public goods" and hence are not supposed to produce finished varieties; their primary aim is the development of source germplasm and research techniques. Without strong national programs, the work of the CGIAR centers has limited impact; conversely, without the CGIAR or some similar place from which to obtain "source germplasm" small national programs have limited impact.

Table 1: CGIAR centrer in Africa and their focus crops

Centre	*Focus Crops*	*Locations*
CIAT	Beans, cassava, rice, forages	Kampala, Lilongwe
CIMMYT	Maize, wheat	Harare, Nairobi, Addis Ababa
CIP	Sweet potato, potato	Nairobi, Maputo
ICRISAT	Sorghum, millet, pigeon pea, peanut, chick pea	Bamako, Bulawayo, Nairobi, Niamey
IITA	Cassava, cowpea, maize, yam, banana, plantain	Cotonue, Ibadan (HQ), Douala, Kampala, Lilongwe, Nairobi
IRRI	Rice	Cotonue
WARDA	Rice	Cotonue (HQ), Dar es Salam

Table 2: Barriers to the adoption of new agricultural products and practices by poor farmers

Barriers to Adoption: Context	*Barriers to Adoption: Technical*
Price collapse at harvest and lack of markets.	Technologists do not understand system complexity and farmer choice.
Lack of demand drivers for increased outputs.	Relative price of the new technology.
Social, political, or gender barriers to access.	Comparative advantage of new technology.
Physical distance from markets and other adopters.	Local biophysical suitability.
Declining soil fertility.	Compatibility with existing systems and practices
Lack of extension training.	Technology complexity and ease-of-use.
Lack of labor.	Trial-ability – are results visible and obvious
Access to credit and finance. Lack of or cost of complementary inputs.	Ignorance or misconceptions of technology and its benefits.
	Lack of physical availability or appropriate timing.

Source: IFPRI literature survey

3.0 THE ROLE OF THE PRIVATE SECTOR IN PUBLIC AGRICULTURAL RESEARCH IN AFRICA

The private sector can play a critical role of bulking up and disseminating technologies that the farmers can use a function that public agricultural research systems cannot accomplish as they lack capital and the ability to take risks. Innovative systems of disseminating research results are needed. Innovation is the application of knowledge to bring about technological, organisational, institutional and political change. The key elements of a good innovation systems research are research priority setting, involving other actors in the decision making process, developing and implementing demand-led research programs, and bringing relevant issues to the attention of policy makers. Researchers working in isolation of other actors have been a major cause of disappointments (Jones, 2009). Examples of successful public research scientists' partnerships with private seed companies' research are described briefly below.

The researchers discussed below have worked with farmers and other stakeholders to ensure uptake and further utilization of generated technologies.

3.1 Makerere University

Dr Phinehas Tukamuhabwa, a plant breeder and lecturer at Makerere University has a big soybean breeding program supported by AGRA entitled "**Deployment of Maksoy 1N and Namosy 4M soybean varieties and development of rust resistant soybean genotypes for improved household food security and income in Uganda".** The objectives of this project were to advance seed multiplication and dissemination of Maksoy 1N and Namsoy 4M soybean varieties and to develop superior soybean varieties that are resistant to soybean rust. Soybean research activities have been conducted in all major soybean growing regions in Uganda. Dr Tukamuhabwa has several soybean lines in intermediate trials and others in national performance trials. He has also released a variety called Maksoy 2N which is high yielding, rust resistant and has good quality seed (large round cream coloured seed). Breeder seed production (4tons of each) of the Namsoy 4M, Maksoy 1N and Maksoy 2N has been produced and distributed to NASECO a private seed company in Uganda and Leldet Seed a seed company in Kenya for bulking up and sale to smallholder farmers . Dr Tukamubwa in collaboration with the millennium villages is promoting soybean through farmer field schools

3.2 University of Nairobi

Professor Paul Kimani is a lecturer at the University of Nairobi and a bean breeder. He and a few other scientists from the College of Agriculture have developed several hybrids of climbing beans and bush beans with partners that include CIAT and Kenya Agricultural Research Institute. The climbing beans have taken up rapidly in Rwanda. The College of Agriculture of the University of Nairobi has also been able to link up with a private seed company in Kenya for bulking up and marketing of these varieties all over Kenya and within the region.

3.3 Kenya Agricultural Research Institute (KARI)

Dr Jane Ininda was a plant breeder with the KARI for about 24 years and was able to release 33 varieties in 10 years from grants from Rockefeller Foundation and other sources. These hybrids were bred for resistance to maize streak disease, turcicum leaf blight, high yield, flint grain and early maturity and are adapted to the mid altitude areas of Kenya.

She managed to get non-exclusive licenses to about 2 private seed companies for her varieties resulting in these varieties available in most parts of Kenya.

3.4 Institut d'Economie Rurale (IER), Mali

Dr Aboubacar Toure is a sorghum breeder who worked for IER for about 27 years. He has released over 20 varieties that have been disseminated and popularized through the National Seed Systems as Mali until recently did not have many private seed companies. The new seed companies in Mali are also bulking some of these hybrids for sale. He was the breeder of the most prolific variety to date in Mali called Sewa.

3.5 Research and Specialist Services (R&SS), Chiredzi, Zimbabwe

Dr Isaiah Mharapara an agronomist with R &SS in Zimbabwe and some partners from other government ministries and non-governmental organizations developed technologies for sustainably cultivating wetlands with a range of crops including rice, maize, beans, vegetables and fodder that impacted thousands of farmers in the Lowveld areas of Zimbabwe that was always vulnerable to droughts and food shortages. The researchers developed the technologies with farmers on farm and on-station together with extension personnel. The regional Initiative for the Development of Equity in African Agriculture (IDEAA) then popularized these technologies to reach more farmers. IDEAAs core business was to transform agriculture service delivery mechanisms of institutions to be more responsive to the needs of smallholder farmers.

4.0 FORMATION OF PARTNERSHIPS OF ACTORS, TO IMPROVE SMALLHOLDER FARMER PRODUCTIVITY

An example of this is Agri-ProFocus which focuses on farmer entrepreneurship. Agri-ProFocus is a partnership of Dutch donor agencies, credit institutions, companies, training and knowledge institutions, with the goal to promote farmer entrepreneurship in developing countries. The Partnership has 26 members and collaborates closely with the Directorate General for Development Cooperation (DGIS) of the Ministry of Foreign Affairs and with the Ministry of Agriculture, Nature and Food Quality (LNV).

Agri-ProFocus believes that Agricultural producer organizations in developing countries are key to economic development and poverty reduction. Promoting farmer entrepreneurship through cooperation, exchange and learning is the goal of its partnership. The focus is on seven African countries, farmer entrepreneurship, demand-driven trajectories worldwide and four themes: value chains, financial services and sustainable food production, with gender as a cross-cutting theme. Its mission is to provide coherent and demand-driven support to enhance the capacity of producer organizations in developing farmer entrepreneurship within the context of poverty reduction. The focus is on promoting farmer entrepreneurship, action-oriented country programs, learning and innovation at the level of members and producer organizations, intensification of member commitment and stronger private sector involvement.

4.1 Agricultural Research Trust Farm Case

The Agricultural Research Trust Farm was started by the Commercial Farmers Union in Zimbabwe to tap into both public and private sector research results. It showcased good public and private sector research results and the farmers would visit it on several field days a season and learn the technologies they could adopt from scientists and then adopt them. It was used to show for example the performance of new varieties from the government research and that of imported varieties by seed companies. Agro-chemical companies would also do demonstration plots to show the efficacy of some of their products. Although this is for a commercial farmer sector the lesson from here is that the farmers sought a way to learn the research results as soon as possible and the public and private sector researchers got a way to create a demand for the technologies they generated and give the farmers the choice of technology packages they can use. Smallholder farmer organisations can be facilitated to form such organisations where they demand research results and thereby increase their productivity.

In conclusion, the key to effective production of research results and their utilisation by the farmers and agro-industries is to involve the farmers in the inception and at various other stages of the research and the private sector and other players to scale-up and disseminate key technologies to the end-users. The Centre for Tropical Agriculture (CTA) African Caribbean and Pacific Islands (ACP) Science and Technology Advisory Council has just this past week come up with 5 key technological challenges ACP agriculture will face over the next 5-10 years and these are listed below:

(i) Coping with the effects of climate change.
(ii) Developing and utilising biotechnology and nanotechnology.
(iii) Establishing information and Communication systems for agricultural research and development.
(iv) Developing green agricultural innovations and to resolve issues of competing land use, and,
(v) Trading in regional and global markets.

They also selected the five disciplines below as those that were most important for the transformation of ACP agriculture.

(i) Biotechnology and Plant breeding
(ii) ICT's
(iii) Natural resource management (including Bioversity)
(iv) Post-harvest technologies
(v) Soil Sciences

SUB-THEME 2:
AGRICULTURE AND SUSTAINABILITY

SUSTAINABILITY IN AGRICULTURE: EMERGENT CHALLENGES AND RECENT PROGRESS

Dennis Garitty

ABSTRACT

Great progress has been made in global agricultural production during the past half century, but these have not ensured food security. The ability of global agriculture to sustain current productivity levels has been called into question by the acceleration of climate change and the degradation of overstretched ecosystems services upon which agriculture depends. The International Assessment of Agricultural Knowledge, Science and Technology for Development (IAASTD), emphasises the interconnectedness of agriculture's various roles and functions, and its consequent multifunctionality. The report notes the fundamental failure of development policies being the reliance on the draw-down of natural capital. Agriculture is at a crossroads and in need of fundamental redirection away from food production towards multifunctional agriculture. This paradigm shift places farmers' livelihoods in a central position. One innovative approach envisions the creation of Evergreen Agriculture, denoting the comprehensive integration of perennial vegetation into annual cereal crop farming systems, creating a green cover on the land throughout the year. One such proto-type involves the use of *Faidherbia albida*, a tree indigenous throughout the African continent. This leguminous tree fixes atmospheric nitrogen, producing nutrient-rich foliage and pods that are highly valued as organic fertilizer and livestock fodder. What makes it *Faidherbia* unique is that it sheds its leaves during the early rainy season, re-growing them only in the dry season. This makes the plant highly compatible as an intercrop with fairly dense populations of food crops. Annual crops in the vicinity of *Faidherbia* trees tend to exhibit much improved performance and yield. *Faidherbia* has been long been integrated in small-scale agriculture in some parts of Africa, with reports of *Faidherbia* agroforests being expanded to cover millions of hectares in Niger and other parts of West Africa through farmer-managed natural regeneration. This provides a basis for conceiving how food crops in the future can be produced on a broad scale under the canopies of *Faidherbia* and/or other mixed agroforests.

CAPACITY DEVELOPMENT FOR AGRICULTURAL TRANSFORMATION: MAKING POSTGRADUATE LEVEL TRAINING RELEVANT TO AFRICA'S AGRICULTURAL AND RURAL SECTOR DEVELOPMENT

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ABSTRACT
While modest success has been realized in agricultural development in Africa, food insecurity and challenges brought about by global changes continue to impact greatly on human health, energy and environment. As Africa endeavours to achieve the first of the eight Millennium Development Goals (MDGs), that is, reducing the number of poor and hungry people by one-half by the year 2015, these challenges have affected the drive towards the MDGs. Success of African agriculture and rural development will certainly come from good governance, strong rural policy, new research institutions and dedication to relevant training. This demands knowledge-based agricultural capacity development and focused science-based policies and institutions. This paper present new approaches to postgraduate level training in agriculture and related sciences that are deemed to have lasting impressions on the drive to make African Universities relevant to current and future agricultural and rural development needs of the region. It highlights existing cases of regional postgraduate programmes and argues for quality and policy relevance of training programmes in the context of sustainability as universities lead the science – policy interface and action research for farmer technology generation and support. The paper poses a number of institutional and individual capacity development questions and outlines an outlook-based approach to address the issues.
Key words: Agriculture, Africa, capacity development, agricultural innovation systems, universities, postgraduate training, higher education

1.0 INTRODUCTION

In sub-Saharan Africa (SSA), as elsewhere, universities and other agricultural tertiary education institutions have made significant contribution to the development of agriculture. It is however widely agreed that they have been slow to respond effectively to changing socio-economic development needs (Chakeredza *et al.,* 2008). The realignment of universities to national, regional and global development agenda demands a paradigm shift in the mode of training, especially at postgraduate level where high calibre expertise needs to be groomed to guide policy, relevant research and general development visioning for the region. Cost-effective training for agriculture professionals at this level remains desirable but still unachievable for many individual universities in SSA (Eicher, 2006) which are increasingly needing to compete within an increasingly internationalized higher education system and rapidly expanding knowledge base and changing technology. This will require changes in a wide range of agriculture knowledge, science and technology capacity development for innovation and using new types of public, private and university partnerships that foster an exchange of information, knowledge, and global experience (IAASTD, 2008 a & b) and resource mobilisation. This must be done in the context that over the last 20 years or so, African universities have almost been overwhelmed by increasing damands/challenges: emerging issues and societal needs, dwindling financial support by governments, increasing demands for university education and increasing sensitivity of stakeholders to quality and relevance of university training.

Sustaining socio-economic growth in SSA in the backdrop of recent economic challenges for nations dependent upon agriculture demands a dynamic human capital: flexible, innovative, passionate and able to adapt technologies to local realities. Relevant human capital can play a key role in the management of the much needed agricultural development processes. It can also maximise allocative efficiency of scarce capital, technological absorption, and global networking while maintaining local relevance. Agricultural development is a function of productivity gains from efficient resource allocation, technological change, innovation, and institutional development. High quality human capital to man SSA agriculture affects all four of these. Educated and skilled persons are responsible for advances in agricultural knowledge, new start-ups, building the institutional capabilities of the market economy, and for agricultural and rural innovation. As SSA agricultural technology needs and those of modern technologies is ever getting more skill intensive while challenges/risks multiply, the demand for higher level human capital is rising. A 2008 survey, captured in the report, *Evaluation of Tertiary Level Agricultural Institutions in the African Humid Tropic Region*, conducted by the African Network for Agriculture, Agro forestry and Natural Resources education (ANAFE) in conjunction with Technical Centre for Agricultural and Rural Co-operation (CTA), concludes that radical changes are needed to be made to curricula at agricultural institutions of higher learning in Africa and calls on universities to lobby for funds to support facilities and improve practical teaching and learning. Similarly, cases studies of five universities in eastern and southern Africa (Batte & Wanzala, 2009) recommended urgent steps for strengthening university staff capacities and skills, and development of student peer-learning groups.

This is reinforced by the findings of a recent RUFORUM sponsored study into the demand for agricultural graduates in southern and eastern Africa which showed a

remarkable consensus across the countries studied, and amongst the three main groups of interviewees (employers, graduates, and faculty):

Quality of Training and Under Investment in Facilities

The need for a major change in mindset (amongst both graduates and faculty) and substantial improvement in skills (practical experience, communication and report writing, up to date knowledge) dominated the discussions with employers and graduates alike. There was widespread recognition that curricula were outdated and students had poor access to up to date literature and research. The pressure on teaching facilities was seriously compromising quality as enrolments continued to rise without concurrent investment in infrastructure[1]. This last was further exacerbated by the introduction of 'parallel programmes' where self funded students are encouraged to enrol. Parallel programmes help the immediate funding of university operations but has led to increased overcrowding, poor teaching, and inadequate supervision.

Limited Student Opportunities in Building Analytical Skills

There were some surprising problems. The overcrowding and lack of investment has led inevitably to few (if any) 'hands on' student practicals. But there was widespread comment from graduates and students that opportunities for interaction amongst students themselves, in the form of group discussions, tutorials, and seminar presentations, were inadequate. This resulted, in no small part, to the lack of critical and analytical skills that are so widely recognised.

The Governance of Agricultural Universities Needs Updating

Current governance mechanisms are poorly suited to serving dispersed and poor rural communities, and interaction with stakeholders is poor. Thus there is poor 'ownership' of the universities by their stakeholders. As a consequence, faculties of agriculture are still not sufficiently integrated into the national and regional innovation systems.

National Agricultural Development Plans Underplay Skills Needs

The RUFORUM study reviewed university programmes in the context of national plans for the development of the agricultural sector. It was evident that, while there were ambitious plans for major increases in agricultural productivity, employment, and profitability, consideration of the human resources necessary to implement these plans was typically based on unrealistic and highly optimistic assumptions. As public sector support to agriculture has become more diversified, employment opportunities have shifted from public agencies to civil society and the private sector. But investment in human capital development overall has been constrained by public sector hiring freezes, eliminating an important avenue through which young graduates gain experience in the sector. The private sector has largely focused on attracting the more experienced and competent public employees that meet its mandate. Civil society has also poached heavily from the best of

1 Bunda University College of Agriculture in Malawi, for example, has had very little new infrastructure (in terms of classrooms, laboratories, and student accommodation since the college was first established in the late 1960s. The subsequent rise in student numbers places an impossible strain on infrastructure. Yet, despite this, the college has one of the outstanding library facilities in the region.

public sector agriculturalists, albeit often at a more junior and less experienced level. Many graduates of agriculture join other industries, seeing better opportunities there. The outcome is a large (and expanding) deficit of young people gaining experience in the sector – a recruitment 'black hole' for the not very distant future when the current generation of experienced African agriculturalists reach retirement.

Higher education is essential to development (Bloom *et al.,* 2006) especially in the knowledge economy but the resources allocated to agricultural higher education have been declining (World Bank Report 2008). In Africa, higher education has played and will continue to play a critical role in development efforts. Figure 1 illustrates this link. The current challenge HEIs face due to the inadequacy of funding combined with an enrolment explosion will continue to impinge on the capacity of most African universities to provide for effective and quality research, learning and outreach. At postgraduate levels, the agricultural tertiary institutions are at a crossroads and are constantly seeking to redefine their roles in response to global challenges and trends and the needs of local communities. While there remains a very essential role for a small caliber of highly qualified researchers, there is an increasing demand for more practical graduate programmes, in line with the MBA or residency period in medicine. After an extended period of neglect of the role of agriculture in development, the consensus of opinion regarding the importance of a vibrant agricultural sector is shifting - as evidenced, for example, by the 2008 World Bank 'World Development Report' being based on agriculture. This "engine of growth" concept, however, is predicated on achieving increased internally generated efficiencies in the use of the primary resources for agriculture (land, labour and capital) and, thereby, releasing some of these resources for use in both productive sectors elsewhere in the economy, and for increased social investments such as in health and education.

Efficiency is not simple to achieve. It not only requires the right public policy and private sector initiatives, but relies heavily on the availability, quality, and orientation ("mindset") of intellectual capital (accelerator of growth and development) within the agricultural sector. This intellectual capital includes farmers, educators, private entrepreneurs, and public servants. Thus agricultural education is an integral and essential part of a development strategy based on economic growth and poverty reduction. Innovative approaches including regionalization for resource mobilisation, academic course provisions, quality improvement, institutional governance, and human resource management can address some of the challenges. At the policy level, there is evidence of support for this change in emphasis. The 2003 Jinja Consensus called for the creation of a new African agricultural university to build a different cadre of agricultural graduates who will go on to become entrepreneurs and wealth-creators rather than cogs in the wheels of existing public agricultural education, research, and extension organisations. University education would be grounded in student-centred learning styles in which instructors would facilitate rather than direct the learning process. Graduates would be armed not only with market-oriented skills, but also with a new standard of morals, ethics, and awareness. A new vision, most recently expressed in the World Bank's *2008 World Development Report: Agriculture for Development* sees African agriculture on the tipping point of considerable increased productivity. So there is potentially a receptive environment for modernizing initiatives within the sphere of African agricultural education and training.

The Regional Universities Forum for Capacity Building in Agriculture (RUFORUM), a consortium of 25 universities in eastern, central and southern Africa, recognizes that for change to take advantage of the global goodwill requires more than altering and updating curricula; rather it requires that universities explicitly seek to integrate their programmes into the national and regional agricultural innovation systems. Specifically, RUFORUM is positioning its network to engage and contribute to the Comprehensive African Agricultural Development Programme (CAADP), the framework for revitalizing African agriculture and Africa's economic recovery. Thus RUFORUM is partnering with a number of organizations and Universities to champion a new approach to postgraduate training—to provide the required institutional capacity to build the required skilled human resource for driving the CAADP agenda. Strategic training programmes have been designed to respond to CAADP. This is because Tertiary Agricultural Education is key to the development of human and scientific capita. It also plays a vital role in building the capacity of organisations and individuals to transmit and adapt new applications of existing information, new products and processes, and new organisational cultures and behaviours (Spielman *et al.*, 2008). Strengthening the innovative capabilities of such institutions to offer quality and relevant postgraduate training through building innovation networks and linkages is thus critical.

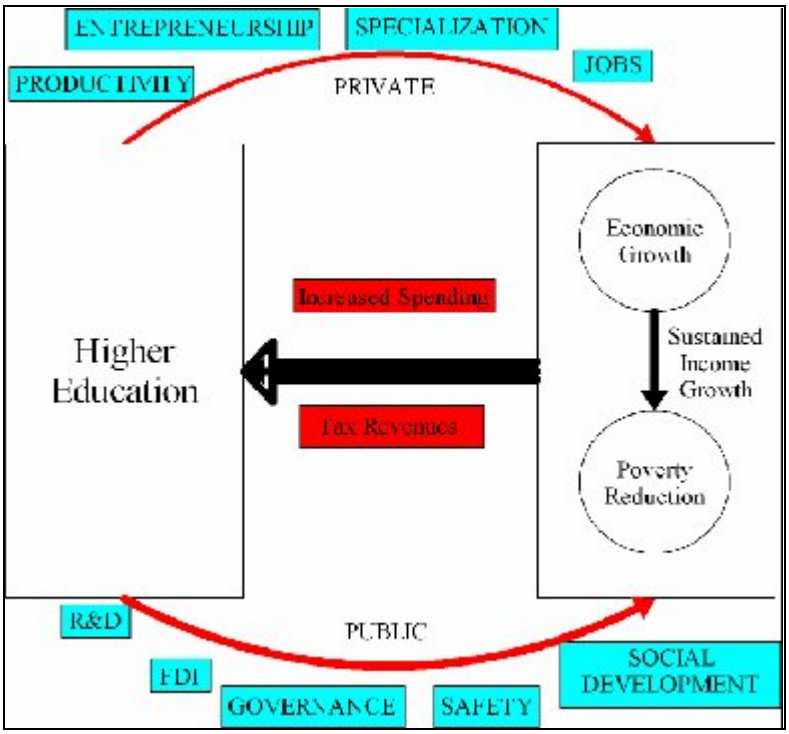

Figure 1: Higher education and development: A logical link

(Source: Bloom, D., Canning, D., and Chan, K. (2006). Higher Education and Economic Development in Africa. Human Development Sector, Africa Region, World Bank)

Furthermore, education is a process. Intellectual capital needs continual renewal – it is eroded by exogenous factors which may intervene to negate the benefits of education

(conflict and corruption are particularly pernicious in this regard). The loss of intellectual capital is an important agenda item for the African universities as highlighted during the July 2009 G8+5 Conference in South Africa. Unless linked effectively to international science, intellectual capital can become outdated. And, finally, intellectual capital is lost as individuals age and pass away.

The empirical evidence for a substantial investment in building and sustaining intellectual capital is encouraging. Asian data show that increases in the output of engineering and natural science degrees have a strong relationship to GDP per capita. A similar positive economic response to increased tertiary education in agriculture (which includes both natural sciences and some engineering) could likewise occur in Africa. Evenson (2004), quoted in IBRD (2007), argues that higher education programmes in agriculture that create skills relating to science and technology "have a public externality value much higher than the private value of these skills in labour markets." On this basis, he believes there is a strong justification for the creation of graduate programmes in innovation fields of study in Africa. But he emphasizes the need (which is given addition urgency by the scarcity of resources – financial, personnel, and infrastructure) for quality as well as quantity.

Very few postgraduate programmes in SSA Universities have changed significantly enough to address the new African Agriculture demands as they continue to struggle with inadequate resources (physical infrastructure, equipment, and communications facilities; limited human resources for teaching and research, both in terms of quantity and quality; poor incentives for teaching and research staff; limited or volatile funding from a small pool of resources; and other resource constraints) (Bloom *et al.,* 2008; Clark, 2006; Inter-Academy Council, 2004; Kroma, 2003). Many reforms to address these constraints have been largely structural and undertaken either in response to government demands for larger numbers of trained professionals, or driven by the availability of short-term and often volatile donor funding. Bloom *et al.* (2008) asserts that such reforms have not been successfully adapted to the specific context of SSA, implemented in ways that produce long-lasting organisational change, or generated positive impacts on agricultural development, poverty reduction, and economic growth. In the end such reforms have not yielded relevant postgraduate level training programmes that are responsive and innovatively attuned to the changing socio-political, economic, scientific, and agro-ecological milieu in SSA.

This paper thus argues for a new vision for preparing professionals in the Eastern, Central and Southern Africa (ECSA) region capable of leading change through postgraduate training. While RUFORUM coordinates this new scheme, universities are playing key roles in the regional orientation of this training. Critical to success of Agricultural tertiary education and training (AET) in the region is the development of internationally competitive postgraduate training programmes and cells, that identify priority gap areas to increase agricultural productivity and strengthen rural value chains, and identify best practices in agricultural education that can be improved and scaled up through regional training approaches. In subsequent sections of this paper, we highlight cases from RUFORUM's regional postgraduate programmes to propose a vision and an

agenda for progressive action towards the production of agricultural graduates who will be relevant to the current socio-economic milieu in ECSA and the greater SSA.

2.0 PROFILING THE RIGHT POSTGRADUATE

Chakeredza *et al.* (2008) note that the prime movers for sustainable agricultural production include: availability of improved technologies, human capital, sustainable growth of biological and natural resource capital, improvement in performance of supporting institutions and favourable economic policy environment. Central to making these components operational is the production of suitable graduates, who are:

(i) Technologically competent and relevant.
(ii) Equipped with the necessary "soft skills" and business skills, and,
(iii) Able to work with local and especially rural communities.

The 2009 GCHERA conference poses pertinent questions to agricultural tertiary institutions:

(i) Are they effectively selecting incoming students with a true vocation for agriculture?
(ii) Are agricultural faculties committed to the sustainability of the natural resource base and the health of the planet?
(iii) Is this reflected in their curricula and research?;
(iv) Are the faculties, responding to market needs?;
(V) Does the training prepare students for disaster preparedness, risk management and conflict resolutions?;
(vi) Is the training in response to changes in the global trade agreements and regulations?; (vii)Do graduates have the knowledge and skills required for promoting sustainable rural development, enabling them to respond to the diverse needs of producers, rural communities, agricultural industries and businesses?;
(viii) Are graduates able to transform their scientific knowledge into relevant innovations, which will reverse the deterioration of the environment and the continued impoverishment of rural communities?
(viii) Are the graduates prepared to become leaders and innovators when they leave the university?

Emerging from the 2007 GCHERA conference in Costa Rica was the need for a new profile of graduates who:

(i) Have strong entrepreneurial skills and spirit, and are capable of initiating new job opportunities.
(ii) Are guided by positive values and high ethical standards; are committed to a new vision of agricultural production compatible with the natural environment and the conservation of biodiversity.
(iii) Have a solid grounding in the scientific and technical principles that underlie practice as well as the practical experience critical to developing confidence coupled with a generalist preparation that will enable them to develop holistic solutions to the problems that they will encounter in their careers.

(iv) Are innovators with the confidence to be creative, adaptable and responsive to real needs.
(v) Are life-long learners capable of taking advantage of relevant information as it is generated and to take advantage of new information technologies
(vi) Possess strong leadership, interpersonal and team-building skills and demonstrate strong communication skills, including effective use of international business languages and information technology.

In line with recommendations by many experts on HEI (Diao *et al*., 2006; Johnson and Hazell, 2002; Rosegrant *et al*., 2005; Sherrard, 2003), RUFORUM is reorienting and transforming postgraduate training at the regional level by encouraging member universities to reform the student recruitment process, the plan of study, the organisation of the programme, the nature and content of curricular and engage in multi-dimensional approaches to integrated capacity development. This is against a myriad of development challenges as highlighted below.

After decades of steady decline, since 2006 world prices for staple grains such as rice and maize have increased steadily (see the following box). Shortages have been severe in sub-Saharan Africa (SSA), where agricultural productivity has been trending downwards for several decades. The farmer has so many demands on her very limited resources of cash and labour that she needs to know, as far as it is possible, that any investment she makes in her farming enterprises will repay the labour or cash adequately and reliably. If she has access to sufficient productive land, she may grow enough to feed herself and her family - providing her health is good and the weather favourable. But the start of the rains brings diarrhea and malaria. Often, illness of herself or her children will result in her planting her crop late. With a poor rainy season her crop may fail. Too often she will be unable to produce enough food for her family's needs and will seek work or food elsewhere – often planting, weeding or fertilising a neighbour's crop – which means that her own is left unplanted, unweeded and unfertilised until later in the season. Late planting and poor weeding mean a poor harvest and once again she finds herself without food before the next crop comes in. This is the downward spiral that creates much of Africa's poverty (Kumwenda *et al*., 1996). Add in the devastating AIDS pandemic (which in no small part is both driven and exacerbated by poverty – see Conroy *et al*, 2006), and farm households can find themselves enmeshed in a poverty trap with no evident escape.

This is the challenge that the universities have to take up – they are developing the skills and competencies in today's youth that can bring about change. The task is so daunting that only the best will do. It is a fact that agriculture is not perceived to be an attractive career proposition (Maduke, 2002). Opinions such as 'the clever do not go into agriculture as they can make more money elsewhere', 'girls are not interested in studying agriculture', 'people do not opt for agriculture because entrance requirements are too low' all stem from a widespread perception that a career in agriculture is unattractive. Improving the image of agriculture will not only increase the quality and quantity of university applicants but also bring benefits to the whole sector and to the economy overall. Universities have a central role in leading and facilitating this change.

3.0 NEW APPROACHES AT RUFORUM

The recent concerns with the quality of agricultural training at postgraduate level in Africa is compounded by observations that agricultural universities are under-funded, suffering from poor quality and in urgent need of curriculum reforms. Universities world- wide are noted for their slowness to address their agreed-upon reforms. In addition to the internal reforms of universities, a new set of problems has emerged under the ''new'' African agriculture that is dominated by climate change, biofuels, rising global food prices and food insecurity. Without doubt, institutional innovations and public-private sector partnerships are needed to generate human capital and institutional reforms to drive agriculture-based socio-economic development of the nations in SSA. This obviously requires changes in a wide range of ways of doing business through innovative approaches and new graduate programmes on top of adopting regional and networking approach as used by RUFORUM. RUFORUM hopes to achieve this by using a multi-faceted approach.

First, the network is working with universities and consortia of universities in ECSA prepare a landscape analysis of the magnitude and country-specific challenges and tertiary education demands to address the issues surrounding the changing face of New Agriculture and Food Systems in SSA. Secondly, the network jointly with member universities and other stakeholders in higher education lays out the types of postgraduate training programmes that are needed at both MSc and PhD levels. Thirdly is enhancing adoption of emerging technologies such as ICT training modules about the New Agriculture that are needed to train innovative extension workers, policy makers, researchers, academicians and other professionals to work in the private and civic society sectors. Special attention is paid to the adoption capacity development approaches that would foster functional and leadership competencies of the graduates. The approach largely encompasses bottom up approaches to curriculum development in a bid to engaging the universities in Africa to respond to the New Agriculture and to increase their emphasis on graduate training within Africa because of the rising cost of overseas graduate education. A key aspect of the approach is joint resource mobilisation, joint training and cross-learning among the universities in the region and with other networks such as Agri-Natura.

For the postgraduate level training, RUFORUM is working with the member universities to foster more engagement with stakeholders, and have established National Forums as an interactive platform for obtaining feedback with key stakeholders and generating demand agenda for university services. RUFORUM uses these fora to facilitate field attachment of students and for building experiential learning teams of university lecturers, students and other stakeholders. RUFORUM hopes in this process to produce more entrepreneurial graduates, but also faculty and graduates more responsive to especially rural communities. RUFORUM has identified three priority areas for the postgraduate programmes:

(a) Focus on increasing agricultural productivity while enhancing natural resource sustainability. Examples include the Regional PhD Programme in Plant Breeding and Biotechnology with focus on African neglected crops, PhD in Soil and Water Management and PhD in Dryland Resource Management. These programmes place great emphasis on responding to emerging environmental challenges, such as climatic change and variability, and prepare students to work in multi-stakeholder platforms. A major thrust in the training

is to instill not only technical but also social and professional skills. Thus, the Plant Breeding PhD students work in National or CGIAR Plant Breeding Programme, undertake internship in seed companies (and also spend time in community based seed systems) and also take courses in Programme Management and Personal Mastery/Soft Skills. Students and lecturers are drawn from the different RUFORUM universities and beyond.

b) Enhancing research quality and information management and sharing: the FARA 2006 study established that in most African NARS there were no research methods specialists to guide research. At the same time, there were concerns that the current training in Statistics and Biometrics does not address well agricultural research issues and take into account emerging frontiers such as tracking development challenges and participatory approaches. Because this is also a weak area in most universities in the region, RUFORUM, in partnership with the University of Reading and Technical Centre for Agricultural and Rural Cooperation (CTA), is running a regional MSc Programme in Research Methods that draws lecturers from several universities and students from across Africa. Emphasis is on practical orientation of the training, making mathematics and statistics related to practical issues. Two main innovative features are that it is a professional training and it links methods to the context of research. The quality and reach of this initiative is further enhanced through linkage to research systems in the region, and utilizing a pool of trained experts to train across the region.

Belatedly, the Association for Strengthening Agricultural Research in eastern and central Africa (ASARECA) through a wide stakeholder consultation identified a regional need to build capacity in Agricultural Information and Communication Management. RUFORUM has been mandated to build capacity in this area. We have initiated a phased approach, involving MSc, diploma and short duration training at regional nodes. The first intake of about 30 MSc students are being trained in Kenya (University of Nairobi and Egerton University), with planned intake for Haramaya University in Ethiopia and Sokoine University of Agriculture in Tanzania in 2010, and at Makerere University in Uganda in 2011.

c) Building capacity for policy analysis, through a Regional PhD Programme in Agricultural Resource Economics at the University of Malawi. The students undertake internships at national and regional agencies such as Ministries of Finance, National Planning Authorities and NEPAD Secretariat.

The isolated country level reforms have been complemented variously by recent regional initiatives through the Forum for Agricultural Research in Africa's (FARA's) Building African Scientific and Institutional Capacity (BASIC) network to improve teaching methods and content in the region's Agricultural Education and Training systems (BASIC, 2006; FARA, 2007; Von Kaufmann and Temu, 2003) and RUFORUM's networking approach to capacity building for training, research, and collaborative programs. The drive has been to build a new cadre of dynamic agricultural graduates armed not only with market-orientated skills, but also with a new standard of morals, ethics, and awareness. To go beyond mere structural reforms, such programmes must consider putting in place innovative, competitive and responsive agricultural postgraduate training and research systems to effectively contribute to the realignment of visions and mandates in universities and networks. This requires maintaining a long-term,

multigenerational training system, resource mobilization system, incentives that attract and retain trained professionals, cost-effective training modalities (regional training models and sandwich programs with foreign universities) and the use of interdisciplinary learning and research centres; production enterprises such as science parks and start-up ventures; diversification and decentralization of funding mechanisms; and new partnerships (Clark (2006). As a Network, RUFORUM is engaging African universities to take advantage of ICTS to strengthen research, teaching and learning. The RUFORUM initial thrust is to ensure that by 2013, all its regional programmes have courses on-line and use OERs to reach a wider student population. In terms of graduates, RUFORUM initiated a programme in 2007 to train at least 800 MScs and 150 PhDs by 2013: these numbers are still too low compared to the capacity gap needs in the ECSA region.

4.0 ADDRESSING GENDER CONCERNS

Women comprise a small minority of agricultural students, and are inadequately represented at all levels of the agricultural industries (except as active farmers where they are over 50% of the workforce). There is considerable pent up demand for female agriculturalists to play a full role in the future development of the industry as customs and traditions often mean that women farmers are less likely to communicate adequately with male agricultural staff than with female. Consequently, all employers are seeking to increase the numbers of female graduates they employ as they are seen as vital to addressing the fundamental constraints of agricultural systems (especially, but not confined to, those in the smallholder sub-sector). Furthermore, the absence of women in the training system means that many potential excellent graduates are failing to enter the industry.

While gender issues are widely accepted and many agricultural specialists are fully attuned to gender sensitivity, an understanding of how to mainstream gender issues and, importantly, to engage fully women at all levels of agricultural development is less evident. The data show there are important obstacles to increasing the numbers of women agricultural graduates. Probably the most important one is the poor teaching of science to girls in school. Girls are not encouraged to study science subjects and, for those that do, the standard of training is often inadequate. For the school female 'high fliers' in science, careers in the heath sector look more attractive and remunerative than those in agriculture (and recall that information on agricultural careers at school is typically poor in any event). For those with more modest school leaving qualifications, the favoured options are often the 'caring' disciplines such as food science, midwifery, nursing, or home economics. Very often these skills are acquired at diploma level and, if the women go on to further studies, it will not be in agriculture. But this does mean that there are a useful number of female diploma holders in science related subjects who could, with attractive programmes, be attracted to take further qualifications in agriculture.

Enlightened and focused programmes, such as those introduced by Sokoine University of Agriculture in Tanzania, can substantially increase female enrolments in agricultural education. Broadening access will go some way to providing career opportunities for women (who are often disadvantaged in education) to enter university level education.

RUFORUM is committed to working with its member universities to address gender disparities in the region. Women play an essential role in agriculture in Africa and women need to be more prominent in agricultural leadership and in universities. In addition agricultural research and curricula need to take into account the gender perspective, especially when designing development technologies and strategies which will need to be implemented predominantly by women. As a network, currently only 18% of our grantees are females while female postgraduate students constitute only 24%. Our grant system is being revamped to ensure greater gender sensitivity in research and training, and incentive scheme is being developed to increase recruitment of female postgraduate students.

5.0 RUFORUM INNOVATION THRUST

RUFORUM is promoting both structural and systemic changes to postgraduate level training in response to changing socio-political, economic, scientific, and agro-ecological conditions in the region. An innovation system perspective is being adopted requiring that postgraduate training programmes need to:

(i) Accommodate different types of individuals and institutions;
(ii) Provide alternative menus of learning opportunities for students and lecturers to accommodate diverse capabilities;
(iii) Make sufficient reference to the needs of actors and organisations that have their own innovative capabilities developed over time and from context-specific factors;
(iv) Understand the nature and dynamics of organizational cultures
(v) Catalyse significant change in the cultures and behaviors that characterize participating universities;
(vi) Be embedded in networks, partnerships, and other interactions that link a wide range of stakeholders in a dynamic agricultural innovation system; and
(vii) Address the fundamental economic constraint underlying innovation including the scarcity of resources with which to Innovate and implement the training programmes

RUFORUM's regional postgraduate programmes focus on strengthening individual and collective capabilities to innovate; changing organisational cultures and behaviors; or building innovation networks and linkages. The network prioritizes the creation of more dynamic, responsive and competitive MSc and PhD programmes that harness new and emerging tools and approaches. These are not meant to replace on-going institution based training and research programmes but to complement parallel reforms occurring in SSA agricultural training, research and extension systems. The development, implementation and monitoring of these programmes are conducted through consultative processes. This results in coordination and creative engagement with universities and other relevant actors in postgraduate agricultural training and research organisations. Table 1 and Table 2 present some of the options and data targets of student numbers.

Table 1: Options and approaches to integration of reforms in regional MSc and PhD Programmes

Option	*Approach to Integration in Regional MSc and PhD Programmes*
Realign visions and mandates	Avoiding replication of foreign training programmes but realigning visions and mandates driven not by predictable, top-down priority-setting exercises, but by consultative processes that rely on inputs from user communities, the small holder farmers, private agribusinesses, rural producer associations, research organisations, extension services, non-governmental organisations and other sources of demand for post graduate level training in agriculture. Such consultative processes are backed by labour market and graduate tracer studies to gauge demand for particular skills; and routine priority-setting exercises.
Developing the human capital base by enhancing innovative capabilities	Integration of Personal Mastery and Soft Skills, and Leadership and management enhancement in the training programmes and inclusion. Integration of new interventions designed to further develop the innovative capabilities of the graduate geared towards specific needs of different actors in the agricultural innovation systems of the region rather than on traditional benchmarks set by standards of public service or academia. Diversifying away from well-structured degree programs centred solely on traditional disciplines, and moving into in-building a wider variety of programs, ranging from short, applied courses to short-term professional training into long-term multidisciplinary degrees programs. Design of regional PhD and MSc programmes that are less encyclopedic and more strategically attuned to the different needs of social and productive actors. Integration of topical courses such as agribusiness, project management, social research approaches, social organisation; leadership, conflict management, and human resource management; and information and communications technologies (ICT).
Change management and inducing change in organizational cultures, behaviors and practices	Institutionalisation of the regional postgraduate programmes requires concerted and coordinated efforts to induce change in organizational cultures, behaviors, and practices are a longer-term undertaking. RUFORUM engages actors to this end including policymakers, university management, other professionals and many other actors in the course development and implementation processes. Efforts to this end include capacity enhancement for leadership and management, quality assurance and a monitoring and evaluation system for postgraduate training. The programmes are actively adopting a long-term outlook as the reform practices

	and cultures of both formal and non formal agricultural training do happen overnight. This allows for learning and adaptation to the specific
Enhancing quality of graduate programmes and research	While most universities in Africa have elaborate quality checks with respect to undergraduate training, this is largely lacking for graduate studies. There are thus, no periodic reviews of the graduate programmes by external evaluators. With support from an EU-EDULINK project, RUFORUM is working in partnership with the Inter-University Council of East Africa, Higher Education Quality Assurance Mechanism in Southern Africa and Association of African Universities to develop a harmonized quality assurance system for postgraduate training and research in eastern, central and southern Africa Universities. This includes developing a credit transfer system in the area of agricultural tertiary education.

Table 2: Targets for RUFORUM regional postgraduate programmes

Category of Postgraduate Students	Targets for 2013	Trained before 2004 (under FORUM)	Trained during 2004 – 2009 Period (under RUFORUM)
PhD	150	8	6
Female	50	1	2
Male	100	7	4
% Female	30	12	30
MSc	800	250	300
Female	300	50	72
Male	500	200	228
% Female	38	20	24

None of the RUFORUM member universities has the stable capacity to individually run the PhD and some MSc programmes (such as research methods) alone. RUFORUM therefore works to pool resources and capacities from the region and beyond. The coordination of the programmes epitomises their regional structure (Figure 2) and their rollout is staggered for strategic reasons: (1) to facilitate lessons learning by dove-tailing for improvement of subsequent programmes; (2) to build and nurture regional and international partnerships that are critical to the quality and success of the programmes; and (3) to avoid over stretching the limited resources at RUFORUM Secretariat and member universities and among partners in the region and beyond.

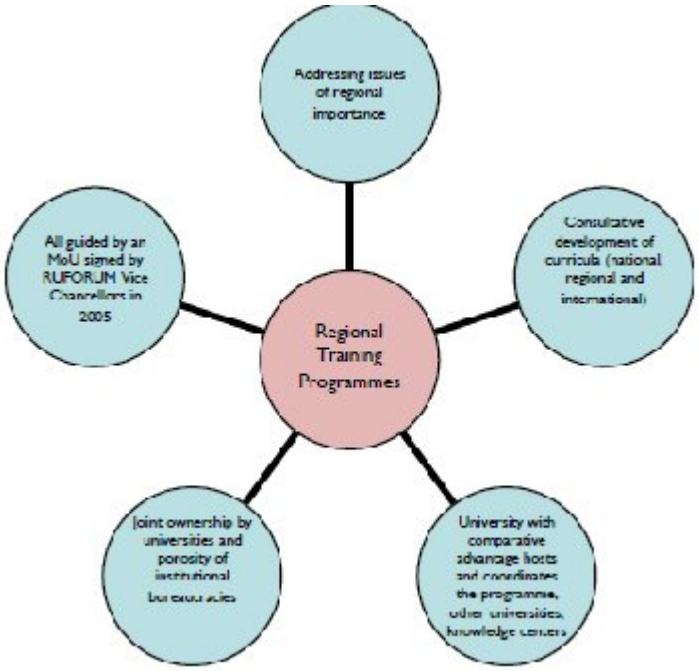

Figure 2: Regional nature of RUFORUM postgraduate programmes

RUFORUM recognises the urgency to build Africa's next generation of agricultural scientists as a "replacement stock" for the aging and retiring professionals. RUFORUM is currently coordination the implementation of the following regional PhD and MSc programmes hosted in various universities in the region: Dryland Resource Management at the University of Nairobi,

These regional programmes are meant to contribute to redress challenges facing agricultural tertiary education in SSA, some of which include, according to Wallace (2007):

(i) Incoherent policy framework for agricultural education.
(ii) Weak or non-existent linkages among the various training institutions involved; both across the divide between formal and non-formal modes of education and between the various stakeholders in a rural knowledge system, including training, research and extension providers, as well as end users at household and community levels.
(iii) Lack of labour market studies either for professional and vocational training, or of training needs assessment among rural households. (The identification of new target audiences, and the training needs of women in particular were also generally overlooked).
(iv) The management of training organisations often lacked capacity, especially for strategic planning, pre-appraisal, monitoring/evaluation and for entrepreneurial thrust;

(v) Ability to recruit and retain staff with the skills, aptitudes and commitment for all the activities required for effective rural training (including teaching, research, outreach and networking);
(vi) Institutions often lacked a sufficient 'critical mass' of change-oriented staff to ensure successful innovation;
(vii) Rigid teaching curricula that often fail to adapt to changing priorities in the external environment (e.g., sustainability, conservation, gender issues), or to deliver job-related and transferable skills.

6.0 CONCLUSION

After decades of neglect of higher education in Africa, there is today the realisation of the urgency to rebuild higher education institutions (HEIs) in the continent, to provide the required skilled human capital to support innovations and direct the continents development agenda. African universities and their networks such as Association of African Universities and RUFORUM, must quickly engage in this process to develop more sustainable and development oriented research, training, outreach and advocacy programmes. They together with their partners in and outside Africa must continue to lobby for political commitment to this cause. Otherwise Africa will remain outside the world knowledge base economy, and the continent will continue to be a consumer rather than a generator of innovations.

As recommended in the 2007 GCHERA conference, African universities must quickly re-engineer themselves to deliver the quality and type of graduates required to build innovation capacity in the continent. The challenge is not only for universities, but also to consumers of university products to become more actively engaged in university processes, provide policy direction for reforms and engagement, and foster field opportunities for student internships. The universities on their part must be strategic, identifying areas of comparative advantage. Resources will continue to be limited and scattered, requiring that African universities strengthen networking to ensure economies of scale and scope, and where necessary run regional programmes to address strategic gap areas. Strategic partnership with other networks such as Agri-NATURA (European Network of Agricultural Universities and research) and NUSLGIC (Association of USA Land Grant Universities) will be important for enhancing quality and mobilizing resources.

Among several demands, African universities must quickly re-build Africa's human capital base, and ensure research and up-take pathways lead to increased entrepreneurial capacity within an overarching agricultural innovation system framework. Innovative models of capacity building are needed that link especially postgraduate training and research to increasing productivity of small-scale farmers and agri-business. For RUFORUM, the approach is to mobilise existing capacities to train within Africa, but with linkage to other knowledge centres within and outside Africa. RUFORUM has identified key investment areas that relate to increasing small-scale productivity, enhancing the natural resource base and resilience of small–scale farming communities, and builds capacity for policy formulation and implementation. We have established Networks of Specialisation to marshal existing capacity to produce quality graduates and research products, in line with CAADP and sub-regional and national priority needs.

In addition to other reforms, African universities must develop themselves beyond being national universities: education is now part of globalisation. Students will go to the best universities, which through ICTs, they may access within their homes. Thus there is urgency to reform for development relevance, while ensuring that these universities remain internationally competitive.

Amidst the challenges listed above, African universities have supported development process in the continent. With increased and sustained support from African governments and their development partners, AU_NEPAD, RECS such as COMESA and strategic leadership from AAU and FARA, African universities can be strengthened to support more effectively development process in the continent. A key component of this will be postgraduate training in strategic areas, because no country in the world has developed without a strong human capital base.

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AGRICULTURAL INNOVATION AND PROSPERITY IN AFRICA: CHALLENGES AND OPPORTUNITIES FOR HIGHER EDUCATION AND RESEARCH

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ABSTRACT
It is often stated that sub-Saharan Africa continues to suffer from food insecurity because it was bypassed by the "Green Revolution".[2] It is therefore concluded from such statements that an African Green Revolution is needed to help enhance Africa's food security. While some elements of the Green Revolution are essential for addressing Africa's agricultural challenges, food security is not a function of agricultural production alone.[3] "Food security" is a term that covers critical attributes of food such as sufficiency, reliability, quality, safety, timeliness and other aspects of food necessary for healthy and thriving populations. It is therefore intricately linked to economic health.[4] This paper outlines the critical linkages between food security, agricultural development and economic growth and explains why Africa has lagged behind other countries agriculture. It argues that improving Africa's agricultural performance will require deliberate policy efforts to bring higher technical education, especially in universities, to the service of agriculture and the economy.

The current global economic crisis and the rising food prices are forcing the international community to review their outlook for human welfare and prosperity. Much of the current concern on how to foster development and prosperity in developing countries reflects the consequences of recent neglect of sustainable agriculture and infrastructure as drivers of development. Sustainable agriculture has through the ages served as the driving force behind national development. In fact, it has been a historical practice to use returns from investment in sustainable agriculture to stimulate industrial development. Restoring it to its right place in the development process will require world leaders to take a number of bold steps.

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2. The term "Africa" is used herein to mean "Sub-Saharan Africa".
3. This is clearly articulated in InterAcademy Council. 2004. *Realizing the Promise and Potential of African Agriculture*. InterAcademy Council, Amsterdam.
4. These connections were graphically captured by UK Prime Minister Gordon Brown: "When I visited Africa earlier this year, I saw not only the potential and promise of economic and social growth in Africa but also mothers paid only £5 a week begging for free education for their children, supporters of AIDS orphans asking only that they have free healthcare, and men and women everywhere with a yearning that their growing political and constitutional rights now be matched by economic and social opportunities. We know that despite increased aid, trade and debt relief, coupled with improvements in economic growth and governance in Africa, those opportunities will not be realised unless and until the foundations of economic growth–sustained investment, innovation, education, skills, science and technology–are in place and built on over the long term," Brown, G. "Foreword," in Juma, C. 2005. *Going for Growth: Science, Technology and Innovation in Africa*, Smith Institute, London, p. 5.

Science and innovation have always been the key forces behind agricultural growth in particular and economic transformation in general. More specifically, the ability to add value to agricultural produce via the application of scientific knowledge to entrepreneurial activities stands out as one of the most important lessons of economic history. Reshaping sustainable agriculture as a dynamic, innovative and rewarding sector in developing countries will require world leaders to launch new initiatives that include the following strategic elements:

Bold leadership driven by heads of state in developing countries, supported by those of developed and emerging economies, is needed to recognise the real value of sustainable agriculture in the economy of developing countries. High level leadership is essential for establishing national visions for sustainable agriculture and rural development, championing of specific missions for lifting productivity and nutritional levels with quantifiable targets, and the engagement of cross-sectoral ministries in what is a multi sector process.

Sustainable agriculture needs to be recognised as a knowledge-intensive productive sector that is mainly carried out in the informal private economy. The agricultural innovation system has to link the public and private sectors, create close interactions between government, academia, business and civil society. Reforms will need to be introduced in knowledge-based institutions to integrate research, university teaching, farmers' extension and professional training, and bringing them into direct involvement with the production and commercialization of products.

Policies have to urgently address affordable access to communication services for people to use in their everyday lives, as well as broadband Internet connectivity for centers of learning such as Universities and technical colleges. This is vital to access knowledge and which also triggers local innovations, boosting rural development beyond sustainable agriculture. It is an investment with high returns. Improving rural productivity also requires significant investments in basic infrastructure including facilities such as transportation, rural energy, and irrigation. There will be little progress without such foundational investments.

Creating entrepreneurship and facilitating private sector development has to be highest on the agenda to promote the autonomy and support needed to translate opportunity into prosperity. This has to be seen as an investment in itself, with carefully tailored incentives and risk-sharing approaches supported by government.

1.0 INTRODUCTION

Science and technology has historically been implicated as a major source of ecological degradation. This paper explores the role rapid technological innovation in fostering the sustainability transition, with specific emphasis on sustainable agriculture.[5] The paper will use illustrations from advances in information technology, biotechnology and nanotechnology. It builds on recent advances in knowledge on the origin and evolution of technological systems.[6]

Agricultural productivity, entrepreneurship, and value addition have the potential to be drivers of poverty reduction in rural-based economies. In many poor countries, however, farmers, small and medium sized enterprises, and research centres do not interact in ways that accelerate the move beyond low value added subsistence sustainable agriculture. Strengthening rural innovation systems, developing effective clusters that can add value to unprocessed raw materials, and promoting value chains across such diverse sectors as horticulture, food processing and packaging, food storage and transportation, food safety, and distribution systems and exports are all central to moving beyond subsistence sustainable agriculture, generating growth, and moving towards prosperity.

Developed and emerging economies can do much more to identify and support policies and programs that can assist developing countries to break out of poverty by taking a comprehensive approach to agricultural development. This requires rethinking the agenda in terms of innovation systems to foster interactions among government, industry, academia and civil society - all of whom are critical actors.

The paper is guided by the view that innovation is the engine of social and economic development, in both developed and developing countries. There is a particular need to get innovation onto the development agenda, into the development process, and to promote co-operation between developed and developing countries to achieve this.

2.0 SEEDING NEW GROWTH

We are entering a new age where our knowledge of global productive systems requires us to think and act in a more holistic way. Dealing with the challenges of sustainability demands greater imagination, creativity, and innovation than we thought was necessary. Once again humanity is challenged to bring its best talents to the task of renewing sustainable agriculture as a foundation for regional economic development, particularly in Africa. The prospects of building a modern sustainable agriculture that is knowledge-intensive and rewarding are real.[7] The current global economic crisis, rising food prices, and the general uncertainty over global ecological degradation generate new opportunities

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and imperatives to create a more adaptable sustainable agriculture in developing countries that is both more productive and more sustainable.

The good news is that the global community has over the centuries amassed considerable knowledge and experience in the field of agricultural development. We live in an age of technological abundance. Scientific and technical knowledge now accumulates at an astounding rate. In addition, our capacity to collect, store, and transmit knowledge has considerably expanded through the use of new technologies. As a result, many of the practices that had previously been a part of traditional knowledge can now be harnessed and put to the service of agricultural development. Moreover, local knowledge can now be applied globally because of advances in information and communications technologies.

The world is now one, both technologically and ecologically. We can now think globally and act globally in every locality. But to do this requires that our political leaders muster the courage needed to put sustainable agriculture in developing countries at the centre of our efforts to renew growth and promote prosperity. They must abandon the view that sustainable agriculture is a transient phase on the linear road to the post-industrial age. A focus on sustainable agriculture as the foundation for new prosperity is not a return to the past, but a new step forward in our socio-economic evolution. The demands of the new sustainable agriculture require executive leadership to align the wide range of actors needed to achieve specific economic and societal goals.

In other words, modern sustainable agriculture in developing countries can no longer thrive without the express guidance and direction of heads of state or government from both developing countries and developed or emerging economies. The success of ministries of sustainable agriculture will depend largely on the extent to which they can secure the executive support needed to implement long-term efforts to put sustainable agriculture at the centre of economic renewal and development. Ministers of sustainable agriculture around the world must take bold measures to advance their cause as a joined-up, cross-economy effort. They must harness the political urgency of the food and sustainable agriculture agenda and the political force of their sovereign leaders, working for coherent policies and action in the national, regional and global arenas.

However, it is not just ministers of sustainable agriculture who need to take bold action. Successful sustainable agriculture means that developing countries need to develop agricultural universities to train farmers, improve the quality of agricultural research and harness it to solving local problems, develop roads, ports, and fiber optic infrastructure to support rural development and access to markets, and promote entrepreneurship and a spirit of innovation. Each of these activities typically falls under the domain of a different ministry. Coordinating all of these activities requires vision and leadership on the part of developing country leaders and the developed or emerging economies who work with them. As things are now, tangible support this holistic approach is not always evident.

Food security in Africa has worsened since the early 1970s. Food availability has failed to keep up with the growing population, as reflected in the rise of the absolute number of undernourished people. Between 1990-92 and 2001-03, the number of undernourished people in Africa rose from 169 million to 206 million. Of the 39 countries for which data are available, only 15 reported reductions in the number undernourished

people.[8]. The situation is projected to worsen if current policies continue. These trends could be reversed through a variety of measures addressing rural development in general and agriculture in particular .[9] This can be done through measures such as "investments in education, HIV/AIDS prevention and treatment, water-harvesting technologies and agricultural extension, female schooling, and clean water access."[10]

Agriculture is central to African economies, making up 30-50% of national income, employing nearly 60% of the population and generating about 40% in foreign exchange earnings. But policymakers often treat agriculture as a separate sector with little regard to its relationship with the rest of the economy.[11] A more realistic view is to treat economies as integrated "systems of innovation" where new actors and institutions constantly are being created, changed, and adapted to suit the dynamics of scientific and technological creation. Government, the private sector, institutions of higher learning such as universities, and civil society organisations are important parts of a larger system of knowledge and interactions that allows diverse actors to come together to pursue broad common goals, including agricultural innovation.

In many African countries, the state still plays a key role in directing productive activities. But the private sector is increasingly becoming an important player in adapting existing knowledge and applying it to new areas. This in turn is changing the role of the government, making it largely a facilitator of economic change. Democratic change and elections have helped to bring to power new leaders who are pressing for change across the continent. They are often at odds with their own bureaucracies that are still steeped in old practices.

Africa's food security can only be guaranteed through long-term economic growth; not by emergency interventions alone. This shift in policy will entail placing emphasis on renewing infrastructure, building human capabilities, stimulating agribusiness development, and increasing participation in the global economy. These areas that constitute what can be called "the learning economy" should be the foundation upon which to base international development partnerships.

3.0 HARVESTING TECHNOLOGICAL OPPORTUNITIES

The most daring initiative to address hunger was the Green Revolution. This initiative enabled countries in Latin America and Asia to overcome chronic food shortages by focusing on agricultural productivity. There are two important pointers from the Green Revolution. The first was that efforts must be focused on harnessing existing scientific

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[8]. FAO 2006. *The State of Food Insecurity in the World 2006*. Food Agriculture Organisation of the United Nations, Rome, pp. 23.

[9]. Thomas, G. 2005. "Innovation, Agricultural Growth and Poverty Reduction," in Juma, C. ed. *Going for Growth: Science, Technology and Innovation in Africa*. The Smith Institute, London, pp. 74-85.

[10]. Rosegrant, M., Cline, S., Li, W. Sulser, T. and Valmonte-Santos, R. 2005. *Looking Ahead*: *Long-Term Prospects for Africa's Agricultural Development and Food Security*. International Food Policy Research Institute, Washington, DC.

[11]. Omamo, S. and Lynam, J. 2003. "Agricultural Science and Technology Policy in Africa," *Research Policy*, Vol. 32, pp. 1681–1694.

knowledge and technological opportunities to address food security. The second was the creation of a new generation of agricultural research institutions whose focus was to adapt existing varieties to new terrains. With these research institutions came a wide range of institutional innovations in property rights, dissemination of seed, access to inputs, creation of markets and the development of new businesses.

Today, the global community has more access to scientific and technical knowledge than it did in the 1960s. Advances in fields such as information and communications technology, genetics and ecology, as well as global connectivity have put powerful agricultural tools in the hands of the global community.[12] For example, farmers around the world are now using mobile telephony to exchange market information, transfer money, and organise their operations in ways that were not possible only a few years ago.

The emergence of new digital banking standards is replacing conventional currencies and transforming rural business practices. Kenya's Safaricom Ltd, for example, was among the first companies in the world to introduce a service that enables the transfer of money through a mobile phone. The M-PESA service is available to all Safaricom subscribers even if they do not have a bank account. Its advent has transformed banking and created new employment opportunities for agents. It has also simplified money transfers to rural areas that were previously excluded from financial services and made these transactions more secure and affordable.

When officials of British mobile telephony transnational Vodafone chose Kenya as the seed bed for the study of a money transfer service they were piloting; they may not have envisaged the revolution they had just kicked off. The tests, carried out among members of a peri-urban community in Thika, were hugely successful. Buoyed by its phenomenal uptake and potential, the service's promoters could not wait to implement it on a larger scale. The rest is history.

Over two years since it was commercially launched in Kenya by Safaricom as M-PESA (Swahili for mobile money) in March 2007, this pioneering money transfer service, which is recognized as a global first, has evolved into an alternative bank for people who hitherto were disenfranchised from a decidedly elitist and dear formal financial system. Nowhere has this impact been more profound that on the country's farms, which are responsible for eight out of every 10 jobs in Kenya. Such is the importance of agriculture to Kenya that over half of the country's export earnings are directly attributable to foreign exchange from coffee, tea, tobacco, cotton, sisal, pyrethrum and cashew nuts, among others.

Thanks to M-PESA, Kenyan farmer-folk now have access to a stored value account where they can keep their money and get it on demand. Unlike conventional bank accounts which most of cannot afford, all one needs to register for M-PESA service is a Safaricom mobile line and a handset, items whose current affordability make them accessible to almost all farmers. They can also receive and withdraw payment for their

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[12]. Frame, B. and Brown, J. 2008. "Developing Post-modern Technologies for Sustainability," *Ecological Economics*, Vol. 65, pp. 225-241.

produce through the service's extensive network in rural shopping centers without having to make the normally expensive trip to the nearest town with a bank branch or Nairobi.

Rural folk working in tea farms are largely un-banked. Statistics show that only 23 per cent per cent of the Kenyan population is banked thus leaving a whopping 77 per cent with no access. Most farmers are therefore severely challenged when it comes to paying their employees on time and ordering for farm inputs such as fertilizer and machinery. M-PESA has come as a godsend to farmers allowing them to send and receive money at minimal cost. It snugly meets the needs of mobile customers who do have no bank account either by choice, have no access to a bank or do not have sufficient income to run a bank account.

Almost half of all Kenyans have access to a mobile phone as compared to 2006 where the penetration was below 22 per cent. As a result of the increase in mobile phone access farmers are now able to pay his suppliers, purchase farm products and pay wages using M-PESA. M-PESA has positively changed the lives of millions of Kenyans. The statistics tell the rest of the story. In the short time it has been around, the service has attracted over 6.7 million subscribers, overtaking the six million Kenyans who have a bank account.

Similarly, advances in genetics have made new tools available to local farmers that enable them to adapt crops to local conditions, respond to environmental stresses such as drought, and reduce the use of polluting agricultural chemicals.[13] Tools such as digitization of data are transforming property rights and making it easier for farmers to access credit. The digitisation of over 20 million land records under the Bhoomi Project in India's State of Karnataka helped to improve the availability of information on land rights and land use practices, but it also created demand for the establishment of data access kiosks. It not only has lowered the costs of accessing records, but has also become a platform for further innovation. Emboldened by the success of the project, the government of India has launched the National Land Records Modernisation Programme (NLRMP) to cover the entire nation.

Similarly, geographically-referenced information is helping to provide precise information about location and transforming agricultural logistics. Many of these technologies have been developed outside the farming sector but they now can be harnessed to facilitate agricultural innovation.

The ability of the sustainable agriculture sector to harness the power of emerging technologies will depend in part on the existence of foundational infrastructure in rural areas. Infrastructure can be defined as the facilities, structures, and associated equipment and services designed to facilitate the flow of goods, services, and ideas. Poor infrastructure is a critical barrier to accelerating economic renewal and prosperity. For example, farmers cannot acquire inputs or sell their outputs without efficient transportation facilities. But more importantly, infrastructure facilities are also the centers for the diffusion of technical skills in society.

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[13]. Brookes, G. and Barfoot, P. 2009. GM Crops: Global Socio-Economic and Environmental Impacts, 1996-2007. PG Economics Ltd., London.

Infrastructure is defined as the facilities, structures and associated equipment and services that facilitate the flow of goods and services among individuals, firms and governments. Conventional infrastructure includes: public utilities, such as power, telecommunications, water supply, sanitation and sewerage, and waste disposal; public works, such as irrigation systems, schools, housing and hospitals; transport sectors, such as roads, railways, ports, waterways and airports; and research facilities, such as laboratories and related equipment.

Poor infrastructure in Africa is a critical barrier to economic growth and improvement of human welfare in general and agricultural improvement in particular.[14] In Uganda, for example, transport costs add the equivalent of an 80% tax on clothing exports. Transport costs directly contribute to food crises by hindering the shipment of food between regions. Infrastructure is also critical in investment decisions. Farmers will not plant crops if there is no way to get them to market. Agribusinesses will not invest if there is no cost-effective way of transporting crops and reaching global markets. More broadly, infrastructure is essential for the delivery of health and education services, creation of employment and dissemination of knowledge.

Telecommunications infrastructure is an area of particular concern for Africa. Investments in basic telecommunications infrastructure have allowed the rapid diffusion of information technology in recent years: exploding rates of cellular telephone and internet usage among people of all income levels. Electronic information systems, which rely on this infrastructure, now account for a substantial proportion of production and distribution activities in the secondary and tertiary sectors of the economy. But investment could be still larger, and high telecommunications costs are at present a substantial drag on economic growth. They have also hindered education, training, and the use of advances in fields such as geographical information sciences in sustainable development.

The construction and maintenance of infrastructure facilities have the potential to become "schools" where most basic technical skills that are taught in the classroom are strengthened in the form of on-the-job training. Indeed, many countries have realised this and routinely link formal technical training to the construction and maintenance of infrastructure facilities. Countries such as South Korea, Malaysia, Egypt, Ghana, and Kenya have created universities that are directly connected to the telecommunications ministries and sectors and which seek to train students in skills that are directly relevant to the telecoms sector.

The need to expand infrastructure as a foundation for sustainable agriculture and prosperity is so great that it will require concerned efforts beyond standard private sector investments. It has to be treated as a matter of urgency. Creative approaches which include the use of existing resources, including those of the military for road construction, for example, need to be used to refocus attention on expanding critical rural infrastructure.

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[14]. Studies have shown that "apart from traditional variables (income, assets, education, and direct health interventions), better access to basic infrastructure services has an important role to play in improving child-health outcomes," Fay, M., Leipziger, M., Wodon, Q. and Yepes, T. 2005. "Achieving Child-Health-Related Millennium Development Goals: The Role of Infrastructure," *World Development*, Vol. 33, No. 8, p. 1267.

4.0 LEARNING TO GROW

The rising interest in Africa's future has coincided with a new awakening of interest within international development agencies in the role of technological innovation in economic growth. But much of the discussion on Africa's development only marginally addresses the need to harness the world's existing fund of knowledge for development. Universities and other institutions of higher learning are key players in domesticating knowledge and diffusing it into the economy. But they can only accomplish that through close linkages with the private sector. This will require major adjustments in the way universities function in Africa (as well as the rest of the developing world). Many of these universities will need to be changed from being conventional sources of graduates to becoming engines of community development. In other words, they will need to become "developmental universities," working directly within the communities in which they are located.

4.1 Hobbled Minds

The main role of the original generation of African universities was to create civil servants. Unfortunately, this classical model has become the template within which new universities are created, even though social and economic needs have changed radically. The continent needs a new generation of universities that can serve as engines of both community development and social renewal.

The task ahead requires deliberate efforts by governments, academia, agribusiness and civil society to reorganize and redirect higher education and reorient it to serve all the African people. To achieve this, a qualitative change in the goals, functions and structure of the university is needed. As part of this process, fundamental reforms will be needed in curriculum design, teaching, location, selection of students and the management of universities. Laws governing higher education and universities will need to be overhauled and parliaments will need to play a bigger role in this regard. Courage and leadership will be essential because of the political nature of such reforms.

Curriculum reform is needed to create an adaptive generation of professionals. South Africa's Stellenbosch University offers a shining example of how to adjust curricula to the needs of research and development (R&D) organisations. It was the first university in the world to design and launch a advanced micro-satellite as part of its training. The aim for the program was to build competence in new technologies in the fields of remote sensing, spacecraft control, earth sciences, and to offer services (such as mailbox, speech and data relay experiments) to the community. In Uganda, Makerere University has developed new teaching approaches that allow students to solve public health problems in their communities as part of their training. Similar approaches should be adopted by students in other technical fields such as infrastructure development and maintenance.

Universities should be at the centre of using new telecommunications technologies and should serve as loci for technology diffusion. In addition, the education of the students would include designing radio programs which would prepare them for participation in the emerging creative industries. Many of these examples are the result of isolated initiatives. The challenge is to move away from relying on luck and tenacity, and to create an environment that helps to realize the developmental role of universities. This must start with government policy. Little will happen unless governments realize the strategic role

that universities can play in harnessing the world's fund of scientific and technological knowledge for development.

4.2 Slashed Budgets

International donors started to cut back on international agricultural assistance in the 1980s. In 1980 the US was a leading international advocate for agricultural development assistance, with nearly 25% of official development assistance (ODA) going to this sector. A decade later the share had fallen to about six per cent of the total. By 2003 it stood at one per cent. This drop was happening at a time when overall US foreign assistance was rising in constant dollar terms. Between 1980 and 2003 total bilateral ODA increased by 69%.

The cutting of agricultural development assistance in the US Agency for International Development (USAID) has been so thorough that the term "agriculture" is hardly used. A 63-page five-year joint strategic plan developed by the USAID in 2003 did not directly mention agriculture. The agency still has an agriculture office, but its total budget had dropped to just $27 million. The total US development assistance to agriculture from all USAID offices now stands at a mere $169 million, or 1% of the total ODA. This has significantly undercut the capacity of the US to be a serious diplomatic player in Africa where agriculture still remains a core economic activity.

Africa has lagged behind other regions of the world in agricultural development for two mean reasons. First, its institutions of higher learning hardly played their role as promoters of agricultural innovation. They focused on producing functionaries for the civil service. Second, reductions in foreign agricultural assistance undermined the local research efforts as well as international university partnership. The challenge now is to forge a new partnership between the US and Africa that will bring new financial resources to enable US universities to team up with their African counterparts.

4.3 New Beginnings

Sustainable agriculture is by definition a networked activity that involves a complex web of actors forming clusters of creativity. Agricultural innovation is a product of interactions between actors from a wide range of fields including agronomy, food processing, export development, food safety, standards, metrology, and packaging. For innovation to occur, the interactions need to be open and draw on the best available knowledge. Defining sustainable agriculture as a knowledge-based activity requires a repositioning of learning institutions such as universities and research institutes. Most importantly, critical functions such as research, teaching, extension and, commercialisation need to be much more closely integrated.

The Brazilian Agricultural Research Corporation (EMBRAPA) represents a recent institutional innovation that has played a pivotal role in transforming Brazilian sustainable agriculture. This example and lessons learnt should be considered in developing knowledge systems in developing countries. Taking a regional approach is also more likely to reflect the growing interest among developing countries in promoting integrated approaches to economic development.

But such agricultural agencies will need to forge close collaboration with local universities and research institutes charged with promoting rural development. Ministries of sustainable agriculture need to work closely with agricultural enterprises and farmers to

create a new generation of universities that combine research, teaching and commercialisation or products. Some of the existing research institutes could be transformed into such universities along the lines of the emerging telecoms universities. These institutions should in turn open their doors to farmers through "open classrooms".

America's land-grant colleges have been pioneers in fostering agricultural growth by combining research, education and extension services. This model is being reinvented around the world to address analogous challenges. One of the most pioneering examples in curriculum reform is EARTH University in Costa Rica, created through a $100 million endowment provided by the US Agency for International Development and Kellogg Foundation. Its curriculum is designed to match the realities of agribusiness. The university dedicates itself to producing a new generation of agents of change who focus on creating enterprises rather than seeking jobs.

EARTH University emerged in a context that mirrors today's Africa: economic stagnation, high unemployment, ecological decay, armed conflict. Inspired by the need for new attitudes and paradigms, EARTH University was created in 1990 as a non-profit, private, international university dedicated to sustainable agricultural education in the tropics. It was launched as a joint effort between the private and public sectors in the US and Costa Rica. The WK Kellogg Foundation provided the original grant for a feasibility study at the request by a group of Costa Rican visionaries.

Based on the study, USAID provided the initial funding for the institution. The original mission of the university was to train leaders with ethical values to contribute to the sustainable development of the humid tropics and to build a prosperous and just society. Through its academic, research and outreach programs, the university offer innovative solutions for improving the quality of life of the inhabitants of the humid tropics.

Located in the Atlantic lowlands of Costa Rica, EARTH University admits about 110 students a year and has a total student population of about 400 from 24 countries (mainly in Latin America and the Caribbean) and faculty from 22 countries. Through its endowment, the university provides all students with 50% of the cost of tuition, room and board. In addition, the university provides scholarships to promising young people of limited resources from remote and marginalised regions. Nearly 80% of the students receive full or partial scholarship support. All students live on campus for four intensive years.

EARTH University has developed an innovative, learner-centered and experiential academic program. Its educational process stresses the development of attitudes necessary for graduates to become effective agents of change. They learn to lead, identify with the community, care for the environment and be entrepreneurial. They are committed to life-long learning. There are four activities in particular within the curriculum that embodies EARTH University's experiential approach to learning.

4.4 Learning from Work Experience and Community Service

The first is the Work Experience activity, which is taken by all first, second, and third year students and continues in the fourth year as the Professional Experience course. In the first and second years, students work in crop, animal and forestry production modules on

EARTH University's 3,300-hectare farm. In the first year, the work is largely a routine activity and the experience centers on the acquisition of basic skills, work habits and general knowledge and familiarity with production. In the second year, the focus changes to management strategies for these same activities.

Work Experience is later replaced with Professional Experience. In this course students identify work sites or activities on campus, which correspond with their career goals. The student is responsible for contacting the supervisors of the campus operations, requesting an interview, and soliciting "employment". Upon agreement, they develop a joint work plan which the student implements, dedicating a minimum of ten hours per week to the "job".

The second activity is an extension of the Work Experience course. Here third-year students work on an individual basis with small, local producers on their farms. They also come together in small groups under the Community Outreach program that is integral to the learning system. Community outreach is used to develop critical professional skills in students, while at the same time helping to improve the quality of life in nearby rural communities.

The third year internship program exemplifies the emphasis on experiential learning. The 15-week internship is required for all students in the third trimester of their third year of study. It is an opportunity for them to put into practice all they have learned during their first three years of study. For many of them it is also a chance to make connections that may lead to employment after graduation. The international character of the institution allows many students the opportunity to follow their interests, even when they lead to internship destinations other than in their home country.

4.5 Sharpening Entrepreneurial Skills

The fourth activity is the Entrepreneurial Projects Program. EARTH University's program promotes the participation of its graduates in the private sector as a critical means by which the institution can achieve its mission of contributing to the sustainable development of the tropics. The development of small and medium-sized enterprises (SMEs) is a powerful way to create new employment and improve income distribution in rural communities. For this reason, the university stresses the development of an entrepreneurial spirit and skills. Courses in business administration and economics combined with practical experience prepare the students to engage in business ventures upon graduation.

This course provides students the opportunity to develop a business venture from beginning to end during their first three years at EARTH University. Small groups of 4-6 students from different countries decide on a relevant business activity. They conduct feasibility studies (including financial, social and environmental criteria), borrow money from the university and implement the venture. This includes marketing and selling the final product. After repaying their loan, with interest, the group shares the profits.

This entrepreneurial focus has permeated all aspects of the university's operations and prepared students to become job creators and agents of change rather than job seekers. About 17% of its 1,100 graduates run their own businesses. The university manages its own profitable agribusiness, which has resulted in strong relationships with the private sector. When the university acquired its campus, it decided to continue operating the

commercial banana farm located on the property. Upon taking over the farm, the university implemented a series of measures designed to promote more environmentally-sound and socially-responsible production approaches.

4.6 Global Outreach

EARTH University has internationalised its operations. It signed an agreement with US-based Whole Foods Market as the sole distributor of bananas in their stores. The university sells bananas and other agricultural products to the US market. This helps to generate new income for the university and for small farmers while providing an invaluable educational opportunity for the students and faculty. In addition to internships, students have access to venture capital upon graduation. The university uses part of the income to fund sustainable and organic banana and pineapple production research.

The university has US supporters who raise additional funds through a private foundation. In June 2004 the family of the former Costa Rican President Daniel Oduber donated the La Flor farm to the university to be used to develop techniques to improve the quality of life in the Guanacaste area and the dry tropics of Latin America. EARTH University hopes to achieve its mission at La Flor by establishing world-class research and training that promotes entrepreneurship and contributes to the sustainable development of the tropics. As part of this effort, La Flor will host a Technological Center, a Green Conference Center, an Exhibition Center and a housing complex with the aim of contributing directly to the economic transformation of the region and Costa Rica.

Over the years the university has worked closely with African institutions and leaders to share its experiences. Following nearly seven years of study through workshops, discussions, training courses and site visits African participants agreed to the importance of reforms in their own university systems, especially through the creation of new universities along the lines of the EARTH model. This was undertaken through a series of workshops on Sustainability, Education and the Management of Change in the Tropics (SEMICT) funded by the WK Kellogg Foundation and the Norwegian Agency for Development Cooperation (NORAD). The lessons learned during the process provide fertile ground upon which new institutional ideas could grow.

The case of EARTH University is one of many examples around the world involving major collaborative efforts between the US and developing countries to bring scientific and technical knowledge to improve welfare through institutional innovations. Such experiences, and those of US land-grant universities, offer a rich fund of knowledge than should be harnessed for Africa's agricultural development and economic growth.

Elements of this approach already exist in some African universities. For example, Kenya's Jomo Kenyatta University of Agriculture and Technology - built with the support of Japan International Cooperation Agency (JICA) - works closely with farming communities. Furthermore, variants of the new model are in operation at the African Rural University for Women in Uganda and the University of Development Studies in Ghana.

These models show how to focus agricultural training as a way to improve practical farming activities. Ministries of sustainable agriculture and farming enterprises in developing countries should be encouraged to create entrepreneurial universities, polytechnics and high schools that address agricultural challenges. Such colleges could

link up with counterparts in developed or emerging economies as well as institutions providing venture capital and start to serve as incubators of rural enterprises. Establishing such colleges will require reforming the curriculum, improving pedagogy, and granting greater management autonomy. They should be guided by the curiosity, creativity, and risk-taking inclination of farmers.

5.0 SPROUTING NEW BUSINESSES

Economic change entails the transformation of knowledge into goods and services through business enterprises. In this respect, creating links between knowledge and business development is the most important challenge facing agricultural renewal in developing countries.

The development of small and medium-sized enterprises (SMEs) has been an integral part of the development of all industrialized economies. This holds true in Africa. Building these enterprises requires development of pools of capital for investment, of local operational, repair and maintenance expertise, and of a regulatory environment that allows small business to flourish. Africa must review its incentive structures to promote these objectives.[15]

A range of government policy structures is suitable for creating and sustaining enterprises – from taxation regimes and market-based instruments to consumption policies and changes in the national system of innovation. Policy-makers also need to ensure that educational systems provide adequate technical training. They need to support agribusiness and technology incubators, export processing zones and production networks as well as sharpening the associated skills through agribusiness education. The US can help in all these avenues.

Banks and financial institutions also play key roles in fostering technological innovation and supporting investment in homegrown domestic businesses. Unfortunately, their record in promoting technological innovation in Africa has been poor. Capital markets have played a critical role in creating SMEs in other developed countries. Venture capitalists not only bring money to the table; they also help groom small and medium-sized start-ups into successful enterprises. Venture capital in Africa, however, barely exists outside of South Africa and needs to be introduced and nurtured.

One critical starting point is "knowledge prospecting" which involves identifying existing technologies and using them to create new businesses. The Chile Foundation, for example, stands out as an example of a "knowledge prospecting" agency that has played an inspirational role in economic diversification in Chile. Many regions of the developing world have so far been too isolated to benefit from the global stock of technical knowledge. Countries in these regions, particularly Africa, need to make a concerted effort to mobilize the Diaspora, which can serve as a link to existing know-how, establish links to global markets, train local workers to perform new tasks, and organize the production process to produce and market more knowledge intensive, higher value added agricultural products.

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[15]. Pragnell, M. 2006. "Agriculture, business and development', *International Journal of Technology and Globalisation*, Vol. 2, Nos. 3/4, pp. 289–299.

Advances in communications technologies and the advent of lower-cost high-speed Internet will also reduce this isolation dramatically. The laying of new fibre optic cables along the coasts of Africa and, potentially, the use of lower-latency satellite technology can significantly reduce the price of international connectivity and will enable African universities and research institutions to play new roles in rural development. The further development of Internet Exchange Points (IXPs) in those African countries where they do not exisit also has an important role to play. IXPs enable Internet traffic to be exchanged locally, rather than transversing networks located outside the continent, improving the experience of users and lowering the cost to provide service.

Much is already known on how to support business development. The available policy tools include direct financing via matching grants, taxation policies, government or public procurement policies, and rewards to recognize creativity and innovation.

For example, China's mission-oriented "Spark Programme", created to popularize modern technology in rural areas, had spread to more than 90 percent of the country's counties by 2005. The programme helped to improve the capability of young rural people by upgrading their technological skills, creating a nationwide network for distance learning and encouraging rural enterprises to become internationally competitive. The programme was sponsored by the Minister of Science and Technology.

But none of these measures will succeed in the absence of consistent and long-term policy guidance on the one hand, and autonomy of action on the part of farmers and entrepreneurs, on the other hand. The latter is particularly critical because a large part of economic growth entails experimentation and learning. None of these can take place unless farmers and associated entrepreneurs have sufficient freedom to act. In other words, development has to be viewed as an expression of human potentialities and not a product of external interventions.

As the emergence of a vertically integrated silk industry in Rwanda suggests, one motivated foreign entrepreneur and investor supported by the President can improve the financial well-being of hundreds, if not thousands of subsistence farmers without displacing them from rural areas to urban slums.

Raj Rajendran, a textile engineer and entrepreneur, was sent to Rwanda in 1999 to close down a cotton textile factory that was rendered unviable by the events during the civil war. However, he soon realised that Rwanda's volcanic soil and climatic conditions were similar to those of southern India where sericulture was a major industry. Raj also had an occasion to meet President Paul Kagame, who gave his blessing to the silk production. Raj therefore planted mulberry cuttings brought from India and received co-operation from a Korean expert from the Food and Agriculture Organisation who brought silk worm eggs from Korea. After experimentation, the worms grew into quality cocoons by eating the Rwandan mulberry leaves. Furthermore, they discovered that while cocoon production can only have 2-5 cycles in Asia, those in Rwanda could have 8–10 cycles a year due to the fertile soil and abundant rainfall.

Around that time (2003–04), the Ministry of Defense was searching for alternative employment for demobilized soldiers. Raj therefore proposed to provide employment for the ex-soldiers in sericulture. The Ministry of Defense considered this proposal and

informed the President about its viability. The President immediately tasked the Ministries of Agriculture and Defense to expand sericulture in the country by including it as a priority in Rwanda's Vision 2020.

Raj converted an old refrigerator into an incubator to hatch silk worm eggs, imported second-hand machinery from India, and started reeling Rwanda's first silk yarn. He sent Rwandans to India for training and engaged local engineers to design and produce handlooms at local vocational centers. The Ministries of Agriculture and Defense jointly promoted sericulture farms and supported training and formation of co-operatives involving the local population. As a result, the produced silk materials, tested in Bangalore and Lyon, were rated as high quality. Indian experts were then hired to train locals for product development such as ties, scarves and traditional Rwandan attires using vegetable dyes.

The silk products are now ready to be exported to the African region and possibly to the US and Canada, with their own brand name 'Silk Hills', proudly emblazoned with a 'Made in Rwanda' label. Raj's company has also become the largest private employer in Rwanda. He is working towards creating approximately 150 000 jobs in the silk industry in parallel with the Rwandan governments' program of 10 000 hectares of mulberry cultivation. Raj was also able to revive the production of cotton-based textiles using cotton grown in the region, enabling his company to supply products such as bags to Macys and Starbucks. The company has also supplied promotional products for the Obama campaign and the inauguration ceremony. Raj is now working on banana stem and pineapple leaf-based textiles to make use of the abundant resources that are being wasted in Rwanda and elsewhere. As a result of these innovative ideas and support from leaders and government, Raj's company expects revenues to eventually reach the order of USD 250 million per year through exports in the next 5 years, making the company's slogan "Weaving Dreams into Prosperity" become a reality in Rwanda.

This example also illustrates that entrepreneurs are more likely to excel if they feel that they are trusted and are given the autonomy or ownership needed to experiment and take risks. Ownership and risk taking are in fact two elements that need to be emphasised much more in the support by developed and emerging economies.

6.0 PLOUGHING NEW GROUND

6.1 Entrepreneurial Leadership in Developing Countries

It is not enough for governments simply to reduce the cost of doing business. Fostering agricultural renewal will require governments to function as active facilitators of technological learning. Government actions will need to reflect the entrepreneurial character of the farming community; they too will need to be entrepreneurial.[16] Moreover, addressing the challenge will require governments to adopt a mission-oriented approach where they set key targets and provide support to farmers to meet quantifiable targets that the farmers can assimilate to. A mission-oriented approach will require greater reliance on executive coordination of diverse departmental activities.

[16]. von Tunzelmann, N. 2003. "Historical Coevolution of Governance and Technology in the Industrial Revolutions," *Structural Change and Economic Dynamics*, Vol. 14, No. 4, pp. 365-384.

Fostering economic renewal and prosperity in developing countries will entail adjustments in the structure and functions of government. More fundamentally, issues related to agricultural innovation must be addressed in an integrated way at the highest possible levels in government. There is therefore a need to strengthen the capacity of presidential offices to integrate science, technology, and innovation in all sustainable agriculture-related aspects of government. Moreover, such offices will also need to play a greater role in fostering interactions between government, business, academia, and civil society. This task requires champions.

One of the key aspects of executive direction is the extent to which leaders are informed about the role of science and innovation in agricultural development. Systematic advice on science and innovation must be included routinely in policy-making.[17] Such advisory activities must have access to credible scientific or technical information drawing from a diversity of sources including scientific and engineering academies. In fact, the magnitude of the challenge for regions like Africa is so great that a case could be made for new academies dedicated to agricultural science, technology and innovation.

Science and technology diplomacy has become a critical aspect of international relations. Ministries of foreign affairs in developing countries have a responsibility to promote international technology cooperation and forge strategic alliances on issues related to sustainable agriculture. To effectively carry out this task, foreign ministries need to strengthen their internal capability in science and innovation.

6.2 New Roles For Developed and Emerging Economies

We have examples which show that, with the appropriate policy space, developing countries can provide creative leadership on critical challenges. For example, Malawi's dramatic achievements in food security can largely be attributed to bold executive actions. Developed and emerging economies should therefore identify and work closely with leaders of these developing countries who demonstrate such leadership. This leadership and the associated institutional innovations may be more important than large financial flows. Indeed, these are essential companions for effective scaling up of financial assistance.

Developed and emerging economies are major repositories of scientific knowledge and lessons of relevance to developing countries. Their most important contributions might lie in their ability to help create new institutional arrangements that support application of existing scientific and technological knowledge in promoting sustainable agriculture in developing countries. They would need to do so as part of new and bold institutional innovations aimed at restoring the standing of sustainable agriculture as a leading driver of economic transformation and prosperity.

Along with support in terms of developing infrastructure and the supply of communications technology, the capacities of developed and emerging economies in serving as honest brokers in linking technical knowledge to funding sources has also become one of the most urgent roles they can play in developing countries. Such brokerage must be done at a scale that can make a difference. In particular, international

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[17]. Science and Technology Committee. 2006. *Scientific Advice, Risk and Evidence Based Policy Making*. House of Commons, The Stationery Office, London.

cooperation can help create agricultural innovation systems in developing countries by supporting local efforts to: improve the quality and relevance of agricultural research; establish new agricultural universities; focus the work of agricultural universities and national and international research institutes on problems that are relevant to the needs of farmers, food processors, and value added exporters; and promote rural entrepreneurship and innovation.[18]

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The meeting was guided by the view that innovation is the engine of social and economic development, in both developed and developing countries. There is a particular need to get innovation onto the development agenda, into the development process, and to promote co-operation between developed and developing countries to achieve this. The outputs of the meeting were contributed to the Horizontal Project on Food, Sustainable agriculture, and Development as well as to the OECD Strategy on Innovation and later submitted to the OECD Meeting of the Council at Ministerial level in 2009.

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SUB-THEME 3: AGRICULTURE AND HEALTH

THE ROLE OF AGRO PRACTICES SUCH AS BREEDING, PRODUCTION, PROCESSING AND MARKETING OF NEUTRACEUTICALS

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ABSTRACT
Lately in Japan, the supply of most of crude drugs depends on the imports from China. However, from the standpoint of securing resources and risk diversification in the long term perspective, the resumption of domestic production has been attracting much attention. Recently, a local government and a pharmaceutical company presented their own policies on promotion and revival of the domestic production of medicinal plants. However, in Japan facing with the problem of aging society with a falling birthrate, the farming population is dwindling and the seeds and seedlings as well as the techniques for growing medicinal plants in formerly established production areas have mostly disappeared.

Since the uses of these crops are deeply associated with pharmaceutical products and human health, the safety and the quality of products need to be treated as the priority issues. On the other hand, from the viewpoint of business management, the production cost needs to be reduced to a low level. Consequently, what is at stake is to produce safe medicinal plants of high quality at a low cost. The efforts of research and development in this sector have to address such issues as the facilitation of acquisition of seeds and seedlings, the training of manpower, the development of mechanisation and labor saving technologies suited for large-scale cultivation. Furthermore, it is needed to develop the cultivars suitable for medicinal purposes as well as the methods of processing to produce products with high quality which are safe.

Our centre is committed to carry out the research on production, evaluation of product quality, and collection and preservation of resources of medicinal plants in Japan. We also offer, in response to the requests from local governments, the services of supplying seeds and seedling and of provision of technical assistance. Moreover, we carry out research programs in collaboration with pharmaceutical companies in order to develop labour saving techniques for large-scale mechanised cultivation aiming at cost reduction. The present report shall examine the relevant issues of the sector and the roles of agricultural sciences, through the presentation of research programs implemented by the Hokkaido Division of the Center, concerning the technologies for producing medicinal plants.

1.0 PROBLEMS NEEDING SOLUTION FOR SECURING 'SAFETY' AND 'QUALITY'

Regarding medicinal plants used for preparation of medicines and health supplements, taking account of the particularity of their use, the most important problems concern their "safety" and "quality" in the sources of seeds and seedlings, cultural methods, processing methods and distribution processes. In order to secure the "safety" and the "quality", it is needed that the government or a certain public institution concerned of each country enacts a necessary law and formulates the criteria to determine safety and quality. The expected role of institutions of higher education including universities and that of research institutions are the generation of basic information to define the aforementioned criteria on safety and quality as well as the development of methods for assessing safety and quality.

Regarding the criteria of quality of medicinal plants and the methods to assess it, the World Health Organisation (WHO) has already published the guidelines [1-6]. They present the procedures for certifying the safety and the quality of medicinal plants and products derived from them and specify the rules that producers and business operators have to adhere to.

In Japan, regarding the crude drugs used for deriving pharmaceutical products, the standard of quality and the procedures to assess it are defined rigorously by the Japanese Pharmacopoeia[7]. Concerning the cultivation of medicinal plants, our Centre is taking the initiative in publishing the guidelines for cultural practices and for methods of processing products [8].

2.0 PRODUCTION OF MEDICINAL PLANTS AND PROBLEMS NEEDING SOLUTION

Although medicinal plants used to be cultivated widely all over the country in Japan, currently Japan depends on the imports from foreign countries including China for most part of supply of raw materials of crude drugs. Lately in China the population of those who engage in agriculture in rural areas is on the decrease due to the remarkable economic development, and there is a fear that the reduction of resources is taking place as a result of development of natural lands. Those who are associated with market in Japan forecast that the procurement of low-priced crude drugs of high quality will become difficult in the future. Under such social circumstances, Japanese pharmaceutical manufacturers have proposed the policy to acquire again a part of their requirements of raw materials of crude drugs from domestically grown products, and some local governments are trying to revive the production areas.

Key factors in the development of production of medicinal plants in Japan are: provision of seeds and seedlings to growing areas; dissemination of production techniques; creation of human resources of leaders and technical experts. Furthermore, in response to the reduction and the aging of agricultural workers, it is needed to develop cost effective technologies which assure the production of safe products of high quality. The following sections present some cases of efforts made in such context.

2.1 Development of Production Techniques for Mechanisation and Labor-saving

In the commercial production of herbal medicines, the greatest problems to be dealt with are the reliable supply of raw materials and the reduction of their cost in cultivation processes. These problems call for solutions by collectivising the production areas to enlarge the scale as well as by improving the efficiency of farming management through adoption of mechanized and laborsaving techniques in the farming processes as a whole.

An example of the achievements is as follows. The root of Mongolian milk vetch [*Astragalus mongolicus*, name of crude drug, *Ogi*, *Huang qi* (Astragalus root)] is used as a crude drug. The shape of root is straight with a diameter of 0.7 to 2 cm and a length of 30 to 100 cm. In the cultivation of *A. mongolicus*, the challenge is how to harvest efficiently the long slender root without damaging it.

In Japan a vegetable plant, great burdock, *Arctium lappa*, the edible root of which very much resembles that of *A. mongolicus*, is cultivated all over the country. For harvesting the vegetable crop, a specialised implement mounted on a tractor and called burdock harvester has been developed and is being used by most of growers of great burdock.

We have tried the burdock harvester for digging the roots of Mongolian milk vetch and demonstrated that they can be harvested continuously without the need for modifying the machine. We concluded that the machine can be utilised satisfactorily by growers themselves. Furthermore, we have studied the possibility of mechanisation of sowing operation and demonstrated that it is conveniently mechanised by applying the machine for sowing wheat and soybean, if the shape of plates for feeding seeds is improved to conform to milk vetch seeds.

As a consequence of the success of trials for mechanising seeding and harvesting operations, currently the commercial production of the crop has been started.

2.2 Development of Processing Techniques for Securing Safety and Quality

As an example of research efforts for improving safety and quality, I would like to present the study on methods for processing Green Dragons [*Pinellia ternate*, name of crude drug, *hange*, *Ban xia* (Pinellia Tuber)]. Dried tubers (0.2 to 2 cm in diameter) of *Pinellia ternate* are used as a crude drug. In the Japanese market, buyers prefer to acquire the merchandise in which processed tubers have white surface and powdery appearance. Incidentally, when the tubers are dried by a heated air drier, tuber surfaces turn to brownish tinge, and the products consequently losing commercial value. The principal production areas of *Ban xia* (Pinella tuber) are in China where the fumigation with sulfur (sulphuring) is reportedly practiced in order to give white appearance to the tuber.

The fumigation by sulfur of food and pharmaceutical products is restricted in Japan, because residual sulfuric substances may cause harmful effect on human health.

Therefore, we have studied the method to dry Pinella tubers in a safe and reliable manner and devised a process which excludes the uses of chemicals and special machines[9)]. The method enables the drying of Pinella tuber while preserving white color through the regulation of temperature and humidity of aeration, with an advantage that the process is able to be expanded to that of an industrial scale by applying multi-purpose equipment used by manufacturing industries.

3.0 IMPROVEMENT OF VARIETIES SUITED FOR MEDICINAL USES

Our centre has developed one variety of Job's tears (*Coix lacryma-jobi* var. *ma-yuen*) and two varieties of peony (*Paeonia lactiflora*). In the breeding of medicinal plants and neutraceuticals, objectives include, in addition to traits such as higher yield and resistance to diseases which are the objectives in breeding of ordinary crops, also the content of marker compound or the advantages in operations of cultural management and harvesting. The following sections present the cases of the 3 varieties developed by our Center.

3.1 Breeding of An Ultra-early Variety of Job's Tears

"*Kitano-hato*", a variety of Job's tears, is an ultra-early strain of this crop species. This variety was registered according to UPOV protocols in 2005 in Korea (Registration No. Job's tears 5), and in 2007 in Japan (Plant Variety Protection Registration No. 15003, Japan). In 2008, commercial production was started in Hokkaido, Japan, and 3 parties, our Center, private enterprises, and growers, have been cooperating in the development of production areas.

Job's tears variety "*Kitano-hato*" is an ultra-early one which makes it possible to harvest seeds even in cold region. In the cold region of Hokkaido, existing varieties have not allowed the harvest of seeds, because snow begins to fall before flowering and ripening take place. In the case of "*Kitano-hato*", it flowers in late July and the seeds mature in October before snow begins to fall.

In many cases, Job's tears is cultivated in temperate regions where the needs for controlling diseases and insect pests have been presenting substantial constraints. In the case of cultivation of Job's tears "*Kitano-hato*" in the cold region of Hokkaido, to the contrary, the cool climate there is favorable for lowering the incidence of diseases and insect pests, enabling the cultivation with reduced or no application of agricultural chemicals, the farming practice preferred by Japanese consumers. Moreover in Hokkaido, the large-scale mechanized farming of food crops such as rice and wheat is very much developed, and such a type of mechanization technology is equally applicable to the cultivation of Job's tears. Consequently, the combination of varietal characteristics of Job's tears "*Kitano-hato*", the cool summer climate in Hokkado, and the type of agriculture prevailing there has made it possible to grow Job's tears of high quality at a low cost in Japan.

3.2 Breeding of Medicinal Peony Varieties of High Yielding Traits

The peony variety, "*Kita-saisho*", registered in 1996 in Japan according to UPOV protocols (Plant Variety Protection Registration No. 5005, Japan), is one which yields a large quantity of root used for medicine, having been developed by using the content of marker compound as a criterion of selection.

Existing peony varieties have been developed mainly for the ornamental quality of flowers. While the root of peony is used for medicinal purposes, existing varieties are vulnerable to the occurrence of diseases such as rusts during the summer, which causes the withering of aerial parts, and has constituted the constraint factor limiting root yield.

Peony variety "*Kita-saisho*" shows few signs of withering during the summer and yields a large quantity of root. Moreover, it has the characteristic of a high content of marker compound, paeoniflorin, specified in the Japanese pharmacopoeia and used as a

selection criterion in the breeding process. The variety tends to show reddish tinge in the cross section of roots processed as a crude drug. Since Japanese market rather prefers white products, currently this variety is not grown so widely.

3.3 New Peony Variety with a Particular Flowering Trait

The peony variety, "*Benishizuka*", of which the procedures for plant variety protection registration are in progress, is a variety that is slightly inferior to "Kita-saisho" in respect of root yield, but has overcome the defect of reddening of root cross section. Furthermore, the peony "Benisizuka" is a variety which exhibits a particular flowering trait. The rate of flowering is extremely low and plants of the variety flower only at a rate of 5 % of the entire population at flowering time. This trait presents a disadvantage as an ornamental plant. However, in cultivation of peony as a medicinal plant, an operation has to be carried out to eliminate flowers (flower picking), in order to fatten the roots. Consequently, flower picking operation otherwise required for peony grown for medicines is not necessary in the case of cultivation of "*Benishizuka*", offering a great advantage of realising labor saving in cultural management.

4.0 CONCLUSION

The necessary conditions imposed on medicinal plants and crops as raw materials for pharmaceutical products and neutraceuticals, are that the products with a high level of safety and quality have to be produced at a low cost. We believe that the role to be played by agronomic research and the orientation of policy in this sector can be summarised as follows:

(i) Compared to the cases of general agricultural crops, the establishment of cultural techniques and the development of suitable cultivars are not well advanced in the medicinal plants used as crude materials for processing medicines or as those for preparing neutraceuticals. Consequently, it is needed to carry out research and technology development focusing on productivity enhancement.

(ii) Since these medicinal plants are closely associated with medical treatments and human health, it is needed for a public institution to establish the guidelines for cultural practices and processing methods for their production, and to standardise the criteria for assessing product quality.

(iii) Very few technical experts and scientists are engaged in the production in this sector. However, there exists practically no university or research institution which is devoted to the training of qualified professionals. Since the sector requires the occupation with a wide range of knowledge and skills in agronomy, botany and pharmacy, the creation of human resources would contribute to its development,

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IMPACT OF GLOBALISATION ON INFECTIOUS PATHOLOGY: NEW CHALLENGES

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1.0 INTRODUCTION

Currently, the situation of diseases caused by infection has changed notably: every year the number of ill animals increases, large centers of stationary undesirable conditions are constantly forming and changes are happening in the way infections show symptoms and are being carried, the importance of associative diseases raises, new tax appear, adaptive features of pathogens are transforming, more often there are exposed new infectious diseases of humans and animals, etc.

Infectious diseases have always been basically a natural calamity for people and along with fear caused interest and aspiration to find out the causes of these phenomena.

As time progressed, diagnostic and precautionary products were invented and significant results in fighting these diseases were achieved. The experience gained and positive outcomes of pox eradication on global scale, successful poliomyelitis elimination in most regions of the world signified the possibility of curing dangerous diseases. The idea of solving the problem of elimination of disease exciters in nature and disease eradication came up.

However, in conditions of globalisation, according to the WHO data, already in 1996 infectious diseases were the leading cause of deaths of humans and animals.

There were noticed newly appeared or seldom registered infectious diseases of people and animals, and their wide spreading over many countries of the world. Some of the appeared diseases such as aids in people, RRSS in swine, hydrophobia for bats in Australia, Paramix virus diseases (Neepa swine virus, Hendra virus in horses) are new diseases, other such as tuberculosis and auesk disease which are more actively targeting developed countries, although it was thought that they remain controlled.

Moreover, the population increase led to the need of providing animal husbandry products since 1950's in world practice and intensive development of industrial animal husbandry. All this caused a raise of animal populations, the closeness of livestock in maintaining conditions, intensification cycle of production and as a result – the change of status of animal health and also that of features and spectrum of disease exciters.

Globalisation of stock-raising caused the appearing of new pathogenic properties of ESSE-pathogenic microorganisms which cause an infectious disease at high concentration of animals.

The most dramatic emerging infection of the beginning of the twentieth century was the influenza pandemic (1918 - 1919) that took lives of few millions of people. The possibility of such pandemic at the beginning of the twenty-first century is still disturbing as we do not fully understand what happened then or can it occur again.

Moreover, some diseases continue to spread at a high rate (brucellosis, tuberculosis), others (foot-and-mouth disease) reappear and cause severe damages. There are arising such diseases that were almost not registered in the recent past (parainfluenza-3, rinotracheidosis, rota- and corona virus infection of calf, poliocerosis, chlamidiosis, microplasmosis, etc.) Such diseases as infectious anaemia of horses have practically stopped to show even without applying specific precautions and diagnostics.

In conditions of globalisation it is necessary to understand peculiarities of spreading traditional infection diseases in new conditions, appearing and spreading new infection diseases of animals on the population level (population of exciters effect animal populations (and/or people) in conditions of suddenly changed due to human activities environment.

The display of epidemic process need to be analysed from the perspective "agent – host - environmental" in which every component brings in its content. In contemporary conditions of globalisation in episodic process the exciter plays the key role due to its permanent changeability, broad spreading, complicated control and forecasting. Therefore, viruses are constantly changing – point mutations (quazivid peculiarities – almost all RNA viruses), recombination, reassortation, adaptation, constant evolution.

Synergism of exciters in poly microbe diseases leads to the formation of complexes, whilst the role of separate species may vary up to insignificant. This way in the formation of PMWS – the syndrome of multi-system exhaustion after weaning the prior role belongs to sugar virus of the 2nd type (SVS 2). However as a mono infection it is disposed only in 2% of symptom displays and more than 80% - multi-infection.

The second factor that is promoting disease occurring and spreading is the immune body status. The health condition of a person and productive animals may be controlled by people but this factor is impossible to be tracked and evaluated in wild nature. More and more often situations are worsened by the appearing of the second immunodeficiency and immunosuppressive conditions, which enhance the spreading of diseases.

The third factor is environment: climate, type of managing ones household, stresses, animal migration, type of preservation (ventilation, sanitation), environmental conditions (temperature, humidity and so on), and feeding (protein, macro- and microelements, vitamins). Natural and climate conditions define the world division of not only natural-center infections but also other infection diseases. In particular, out of 8 milliard hectares of potential agricultural lands more than half are not used regarding zoonose spreading (malaria, trypanosomosis, onchocercosis, and so on).

Zoographical factors (global division of animals or global zoography) are obtaining defined geographical compliance, especially for productive animals. High zoographical closeness is noticed in china regarding swine and poultry (more then a half of world population), Australia – sheep, and Latin America – cattle.

Similar conditions allow pathogens to adapt in populations of vulnerable animals, evolutionate, cover natural habitats of domestic and wild animals and create emerging situations (in Asia, high closeness and the degree of contacts of water flawing birds, swine

and people provide conditions for regular emerging of highly episodic varieties of viruses of flu). The change of climatic and ecological terms (change of climate, global warming, changes in ecology, expansion of animal populations) constantly creates pre-conditions for the display of episodic processes.

A not less action is rendered by the terms of globalisation: trade, tourism, traveling, transport, biomedicine (vaccines), industrial agricultural systems, land-reclamation, deforesting, etc.

Conceptually, disease emerging is a result of dynamic co-operations between quickly evolving infectious agents, environmental changes and owner's condition, which provide such agents with friendly to them new ecological niches (Friend, 2006).

Infectious diseases of people, domestic and wild animals are interconnected with two general descriptions: firstly, they are in the process of permanent change, increasing in the amount of incidents, extending the circle of owners, natural habitat of spreading or changing virulence, patotype or other properties of the exciter. Secondly, these changes are almost always conditioned by anthropogenic impact on environment (destroying forests, urbanization), by a change in the structure of owners' population (closeness rises) or conduction (extensive use of medications, intensification of production, international trade) (Gilbert *et al*, 2000).

For explaining all possible forms of displaying episodic process, Last (1988) suggested to use an iceberg principle – universal principle in obedience to which «obvious is always only a small part of actual». In an episode-logistic context it means that infectious disease as clinically expressed extreme degree of infection is always only part of the last one, and along with a manifest infection appropriately coexist its hidden forms in different frequently prevailing correlations.

The iceberg system is fair practically for all emerging infections. So, chlamidiosis shows up clinically in 7-10 % (death 1-2 %) of cases and more than 90 % of cases it is a sub-clinical flow that is the most dangerous as constantly there is infecting of healthy animals, which for many animals transforms into lifelong carrying of chlamidiosis (to 20 % female cats).

In modern conditions, pathogens are able to adapt themselves to the owner in existing terms and preserve their biological properties (infection activity, invasion, ability for reproduction (antibiotics resistance), etc., that result in appearance of the hidden forms of the illness.

This fact is observed for piglings which are a susceptive (an extraordinary target in a way) object, that increases virulence of exciter and allows to form steady undesirable state on all swine livestock.

A visible example of overcoming species' barrier between dogs and lions is a plague of carnivorous, causing death of the bigger part of African lions in 1994 in Tanzania and emerging situation of death of seals from the dogs plague in the lake Baikal in 1989 (Osterhaus, 1991)

Application of antibiotics, which was originally considered as a rescue from a row of infectious diseases resulted in appearance of antibiotics resistant races of microbes which without causing signs of illness circulate on the livestock, resulting in screening of illness.

Thus, in the conditions of globalisation exposure of episodic process in a subclinical form can frequently take place that hampers not only diagnostics but also allows pathogens to persist on the susceptible livestock, and at certain terms to result in the appearance of disease.

Nowadays there are 1415 pathogens that cause people's diseases, 616 in domestic and agricultural animals and 374 at domestic carnivorous. Multi-household pathogens are especially wide-spread among people (61.6 %) and even more among pathogens of domestic animals (agricultural animals – 77.3%, carnivorous – 90%) (Cleaveland, 2001).

Thus, pathogens can circulate between different types of owners and present a potential threat to the health of people. It is supposed that the probability of contact between people, wild and domestic animals is growing which will result in the origin of diseases.

Development of infections, bound by circulation and persistency in the organism of a few exciters is more and more frequently pointed out.

There are registered cases of the simultaneous impacting organisms of pigs of VCPS and VRRSS or VCPS and exciters of salmonelosis, forming of syndromes and complexes (PMWS and the complex of respiratory illnesses of piglings - PRDC). There is a supposition that in etiology PRDC can participate up to 7 viral pathogens and up to 8 bacterial pathogens.

Moreover, basic diseases (classical plague of swine, CPS), foot-and-mouth disease, etc) which were a big deal in the past, were almost eradicated, however in many countries the sporadic flashes of such diseases can appear, if the their causing pathogens are brought in the populations of domestic animals from wild (CPS in the Netherlands).

Currently, there is wide distribution of complexes of respiratory diseases of pigs which by are characterised by the reproduction of a number of exciters (RRSS, svc 2, etc). All this signifies permanent changeability of pathogens, forming of new illnesses and complexes and their expansion between domestic and wild animals and humans [18, 19].

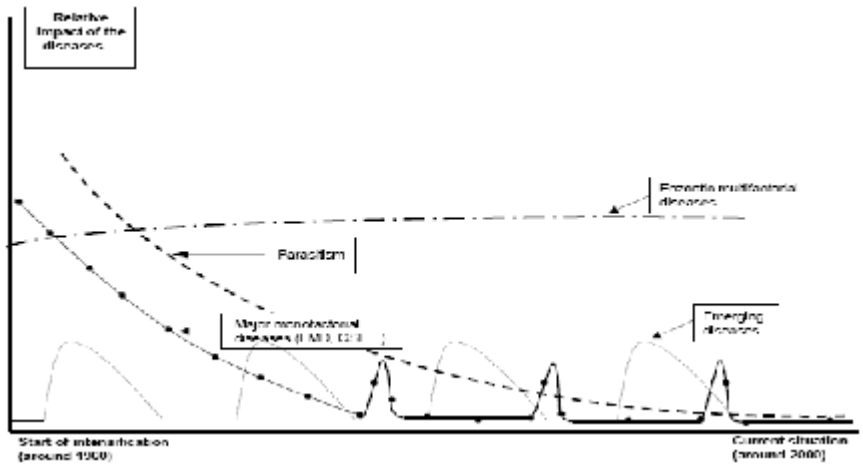

Figure 1: The exposure of emerging and reemerging infectious diseases of animals from 1960 to 2000 (Madec, 2003)

In figure 1 (Madec, 2003) is presented the chart of exposing infectious diseases over 40 years, which shows the permanent circulating of exciters of multifactor infections from the moment of globalization of stock-raising, decline of the role of monofactor diseases (except for the row of flashes) and fluctering structure of emerging infections.

To the problem of the modern ongoing of infectious diseases should be directed questions of immunosuppression and immunodeficits, the role of which in the diseases of polimicrobic etiology is yet to be estimated, including cases with the viral infections.

2.0 CONCLUSION

Globalisation caused the change of the type of distribution of animal species, creation of new conditions of environment and establishment of interspecific relations, allowing and contributing infringements changeability of exciters of traditional diseases and appearance of new illnesses.

The structure of diseases has changed, thus along with classic and factor there is marked forming of emerging/reemerging illnesses. Features of co-adaptation in the system (agent-host-environment) in modern terms often result in persistence of exciters and sub-clinical form of the display of illnesses.

Co-evolution of micro and macro organisms resulted in appearance at the population level of polimicrobic diseases/complexes of diseases which have substantial influence on animals and people.

The mentioned questions are only the apex of an iceberg of all those processes, which arise up between infectious pathogens and owners, in contemporary terms.

The all above-stated requires a careful study, understanding, estimation and use for the search of decision by screening, serial monitoring, prognoses, estimation of risks taking into account all constituents.

SUB-THEME 4: AGRICULTURAL CHALLENGES AND GRADUATE PROFILE

TERTIARY AGRICULTURAL TRAINING IN THE 21ST CENTURY: CHALLENGES, NEEDS AND OPPORTUNITIES

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ABSTRACT
In sub-Saharan Africa (SSA), agriculture is the major source of food, income and employment and is considered as the backbone of the economy. However despite the tremendous technological developments in the world, African agriculture has remained small scale, low input, rain-fed and low-tech. Major transformations are needed for agriculture to take its place in driving development. Human capital remains the most important factor for transforming Africa's agriculture. Higher education is increasingly recognized as a critical aspect of the development process, especially with the growing awareness of the role of science, technology and innovation in economic renewal. Critical needs for tertiary agricultural education (TAE) in Africa include upgrading teaching and learning programmes and processes, improving access to locally relevant education materials, breaking down the institutional and programmatic separation of universities and national Agricultural research institutions, systematically upgrading knowledge and skills of researchers and educators, and creating attractive career opportunities for women and youth through agribusiness skills development. The challenge today is for TAE institutions to link their programmes more effectively to community and industrial development and also to global issues like climate change, food security, nutrition and health, and poverty reduction. This would justify the continued investment in TAE. The food and financial crisis is a challenge to Africa's agriculture, but also an opportunity since it has enhanced the interest of national, regional and international policymakers and donors to support more investment in agricultural productivity. This will in turn favor the elaboration of well designed and contextualized tertiary agricultural education which can provide scientific expertise, technical innovations and training in strategic areas of education for rural people, industry and policy makers. Strategic partnerships will need to be established between African and non African training institutions to share experiences on best practices and to scale out innovative capacity strengthening initiatives.

Key words: Tertiary agricultural education, training needs, challenges, opportunities

1.0 INTRODUCTION

Africa's development is in many ways synonymous with the development of its agriculture and related sectors. Agriculture remains the foundation of sub-Saharan Africa (SSA)'s economic activity accounting for 40% of GDP, 15 % of exports and 60-80 % of employment (Diao *et al.,* 2006). About 70% of the African population lives in rural areas and agriculture is a major source of food, employment and income. In SSA, agriculture also contributed a third to economic growth in 1990 – 2005 (World Bank, 2007). However, the agricultural sector is underperforming and 80 % of all Africans are living on a daily income of less than US$ 2 while nearly half struggle to survive on US$ 1 a day or less. As a result, one in every 3 people is malnourished due to lack of access to sufficient food. Increasing the level of farmer productivity is a prerequisite for economic growth and development in African countries. The production growth needed will have to come from improved farm policies, technologies (high quality seeds of improved crop varieties of local staples, improved fertilizer use and integrated soil fertility management technologies) and techniques, including those that address climate change since agricultural land is not increasing. Increasing crop yields has consistently been shown to reduce hunger and increase income among inhabitants of rural areas, where Africa's food shortages are most pronounced. However, for such productivity gains to be achieved, strong agricultural education and training systems are necessary for providing the human resources to drive the change. Under- and post-graduate training to provide high-level scientists and researchers is an essential part of human capacity improvement in Africa (Lindley *et. al*., 1996). The World Bank's Africa Action Plan, clearly points to tertiary education as one of the key drivers of growth to generate the knowledge and skills necessary for sustained growth in SSA. Skills and knowledge economy are built at the tertiary education level. Improving tertiary education systems must therefore be high in SSA's development agenda. Plant breeders, seed scientists, agronomists, soil scientists, food technologists and policy analysts are needed to be in governments, public and private research centers and agribusinesses to develop, review and disseminate generated technologies.

To meet the challenges of agricultural productivity and food security facing Africa today and in the 21st century, Africa must be willing to invest in its human capital for development. There are 70 researchers per million people in Africa compared to North America with 2640 and Japan with 4380 (IFPRI, 2006). The number of agricultural researchers declined by half in SSA in the last 20 years due to poor or no funding of tertiary agricultural education. More than half of the current researchers are due to retire in the next 5 years. Only one in four of the African researchers hold a PhD compared with nearly two thirds in India (RUFORUM, 2007). As a result most governments and university research systems in Africa are producing only a trickle of new technologies that can be used by farmers (Eicher, 2006). To compound this problem, enrolment rates for higher education in Africa are the lowest in the world with gross enrolment at only 5 % compared to 19 % of the population for East Asia (Chicago Council on Global Affairs, 2008). Most donor-funded training programs have relied on awarding African students fellowships to developed-country universities, leaving African universities out of the equation. This has meant no real research and teaching infrastructure improvements in most African universities resulting in obsolete and non-functional equipment. From the early 1990's even these opportunities for overseas study were significantly reduced due to donor focus away from agriculture. This then means that African Universities must

ultimately be responsible for training and replenishing human capital in their respective nations.

Education and training is a strategic priority if we are to achieve food security, eradicate malnutrition and poverty and spur development in rural Africa. Well designed and targeted tertiary agricultural education (TAE) can provide scientific expertise, technical innovations and training in strategic areas of science and technology that can improve rural people's livelihoods, industry and policy makers. Recent research findings indicate that expanding tertiary education may promote faster technological catch-up and improve a country's ability to maximize its economic output (Bloom *et al.,* 2006). Currently SSA has close to 100 universities teaching agriculture and natural resource sciences. However, the visibility of these universities and their programmes is marred by the fact that their impact on agricultural development is unclear. Agricultural education in its current form is poorly targeted and structured to deliver on such an ambitious programme.

2.0 CHALLENGES FACING AFRICAN TERTIARY AGRICULTURAL EDUCATION

African tertiary agricultural training institutions were initially meant to simply raise human resources to meet public sector needs. This has long petered off and many graduates end up jobless because the industries which would have absorbed them are not yet developed, or if they are available, are non-functional. The graduating students are not prepared to establish their own businesses. Neither are there adequate support systems, financial or otherwise, to enable self-employment. Frequently mentioned challenges in African tertiary agricultural education include lack of national funding, brain drain due to lack of incentives, weak teaching capacity and quality and relevance of education. However, the world globalisation has internationalised higher education and put more pressure on the weaknesses that urgently need to be addressed if Africa is to achieve the MDG targets by 2015. A few are described briefly in the next section. However, they are all interlinked.

2.1 Lack of Funding

Most universities in Africa receive very little support from their national governments. This usually covers undergraduate programs with very little support for postgraduate students. The budgets for universities are usually included with general education budget that includes primary, secondary and tertiary education. MacGregor (2008) stated that although enrolments in SSA tripled from 1991 to 2005, public funding did not keep up from an average US$ 6,800 to just $ 981 in 25 years for 33 countries. The negative impacts of this radical increase in student numbers without corresponding funding support were made worse by lack of attention to quality assurance and labor market needs, governance issues and lack of accountability.

The lack of adequate funding for tertiary institutions fosters lack of autonomy to make decisions and flexibility to adapt to labour market demands resulting in graduates with weak skills who often do not meet the job market needs. This is however, part of a bigger problem of lack of understanding by the governments on the role of education and training

in reducing poverty. A World Bank report of 2006 found that only 20 countries in SSA out of 47, mention tertiary education in their national development strategies and only 3 national development strategies reviewed out of 31 indicated tertiary education as a priority for reducing poverty, 2 planned to increase funding while 6 planned to decrease funding. This lack of understanding by national governments means institutional funding is not even a national priority. The challenge for tertiary agricultural education community is to improve packaging and articulation of arguments in support of tertiary education in a manner that demonstrates impact to the economic development and well-being of citizens (Materu, 2008).

2.2 Low and Weak Human Capital

Most universities are not operating at full capacity for generating the human resources needed for development (Temu *et al.,* 2004). Existing human resource capacity in all units of the *Institute des Sciences Agronomique du Rwanda* ISAR in Rwanda are 2 PhD's, 25 MSc's and 51 BSc's (SCARDA, 2007). In Mozambique, the current agriculture trained workers are 488 compared to a target of 5484 and in Ghana current workers number 2135 compared to a target of 6535 (ITOCA, 2007). The observations reveal that the landscape of human capacity in Africa is very low but consistently variable, and requires detailed analysis of national-level needs in both the public and private sectors. This situation hinders growth and undermines the foundation for sustainable development.

African agricultural universities are short of trained faculty with 30-70 % of the required posts not filled in part because of low wages and poor working conditions. Trained faculty is in short supply also because the universities have so few graduates at MSc and PhD levels (von Kauffmann, 2006). MacGregor (2008) also stated that graduate students comprise a shrinking portion of total enrolments, reducing the next generation of tertiary level instructors and researchers. These trends make it difficult to provide relevant knowledge and core skills needed for competitiveness and growth. Insufficient attention to professional development, inadequate salaries, heavy teaching loads resulting from declining staff to student ratios, deficient personnel in management and lack of research opportunities makes staff retention and recruitment difficult.

The primary source of wealth is practical and effective application of human capital. As a source of livelihood, Africa's agriculture has invested considerably in training at various levels, from vocational to postgraduate education. However, many of the graduates do not get employed because their knowledge and skills fail to meet the requirements of the workplace. Studies commissioned by ANAFE (1999, 2005) and UNEP (2004) showed that despite the fact that TAE programmes in Africa are relatively young, many of them have moved quickly to specialize in several areas such as Entomology, Horticulture, Food Science, Home Economics, Beekeeping, among others. Graduates produced under this system are not able to relate well with one another. UNEP (2004) found that only 5 % of the universities in Africa had evolved to address the inter-disciplinary nature of agriculture and environment. The thrust to specialize has been so strong that highly specialized professionals being produced lack in the broader understanding of agricultural business within the context of natural resource management and conservation. A study by Ocholla *et al.* (2009) also indicated typical skills employers perceive fresh graduates lack to include, farmer training skills, implementation of adaptive

or on-farm demonstrations or trials, financial and project management, agricultural value chain addition skills and business start-up advisory entrepreneurial skills. A wide perception amongst employers is that agricultural graduates are weak in terms of problem analysis and solution skills. A new range of competencies such as adaptability, team work, communication skills and the motivation for continual learning have also become critical. Tertiary institutions are therefore challenged to adjust their program structures, curricula, teaching and learning methods to adapt to these new demands. Greater attention therefore has to be focused on quality.

2.3 Weak Research and Innovation

Much of the research that takes place at African universities is of an academic nature and pays little attention to the utility of results. The training curricula of the majority of African Higher Education institutions still focuses only on theory and are divorced from production and development needs. The fact that agricultural production is increasingly integrated in value chains with input/supply and marketing linkages require wider competencies in dealing not only with technical issues, but also with complex and nonlinear partners engaged in innovation, development, production and marketing (World Bank, 2006). The context of agriculture is continuously evolving. New regulations, consumer preferences, competitors, pests and diseases, climate change and human health problems such as HIV/AIDS are some of the changes that agricultural systems must face. Different sources of knowledge are needed to deal with these challenges which require networks (World Bank, 2006). TAE institutions often have a narrow and academic understanding of the practical world that shapes development policies and economic growth. In 2005, FARA commissioned an assessment of National Agricultural Research Centers in SSA to identify major areas of weaknesses and recommend corrective strategies. The study identified human and institutional capacity for designing, implementing and managing scientific research as the most important weakness.

The problem of educator isolation could be addressed through a scheme that opens up TAE institutions to a deliberate tapping of knowledge and experiences from outside the academia. Interactions between educators, students, private sector and local communities will enrich curricula content and produce more practical graduates and more relevant research.

A scoping study done by FARA (2005) also indicated that there is not enough capacity to form strong multi-institutional partnerships between NARS, universities, extension agencies, farmers' organisations, private enterprise and other groups that are essential to bring about the required change.

Africa is still faced with challenges of Internet connectivity, information availability in the right format, cost and quality and this seriously affects research quality.

2.4 Lack of Integration

Agricultural development is viewed independently from closely related resource sectors such as forestry, water management, energy and environment. Thus, agricultural practices purely geared at productivity become less sustainable due to nutrient mining leading to land degradation and desertification. Creative strategies are needed for elaborating practical mechanisms that bring TAE into closer, more productive relationships with other

closely related sectors of agriculture, natural resource management, land-use and industry. This will bring about sharing of comparative advantages of different actors and institutions to reduce transaction costs, achieve economies of scale, exploit complementarities, and realise innovation synergies. Lack of coordination between the different branches of agriculture has resulted in silos, with limited synergy or complementarities.

2.4 Inappropriate Teaching Materials

Much of SSA relies on imported scientific knowledge and technologies to fuel its development. This is in spite of Africa's enormous wealth of local knowledge in agriculture and natural resources (Temu *et al.,* 2007). The latter is locked within specific cultures, social groups, or institutions and as a result, the knowledge has failed to find access into learning systems in order for it to reinforce scientific knowledge. The integration of local knowledge into agricultural programmes remains limited or even non-existent. As a result a huge gap exists between what is being taught in agriculture and actual practices, especially by small-scale farmers.

Too much emphasis is placed on the adoption of modern technologies, some of which are inappropriate for small scale farmers. It is common to find learning materials that emphasize exotic animal and crop management systems based on outdated and/or out of reach technologies (economically), and further compounded by instructors whose capacity is limited by lack of familiarity with local circumstances and therefore cannot draw examples or case studies from the local environment. Few countries (e.g., Ethiopia, South Africa and Sudan) can boast of having strong local inputs into the agriculture and natural resources learning materials. Experience from elsewhere indicate that a change in the learning systems, in terms of relevance of content and quality of delivery influences many other areas like policy, strategies and practice. Therefore improving the quality of educators, learning resources and the whole education system (including faculty attitudes) becomes a fundamental prerequisite.

3.0 TERTIARY AGRICULTURAL EDUCATION NEEDS IN A FAST CHANGING GLOBALISED WORLD

Africa's human capacity needs in agriculture and natural resource management cannot be met by the occasional projects involving a few universities here and there. It requires comprehensive inclusive programmes that are open to all African universities that are teaching agriculture and natural resources management and which enables them to draw widely on the strengths of their counterparts in advanced universities and the African-based international, regional and national agricultural research institutions. This unfortunately is quite costly.

There is a need to appreciate TAE's potential role in promoting innovation, and growth for Africa's agriculture. Creative strategies are needed for elaborating practical mechanisms that bring TAE into closer, more productive relationships with other closely related sectors of agriculture, natural resource management and land-use. This will bring about sharing of comparative advantages of different actors and institutions to reduce transaction costs, achieve economies of scale, exploit complementarities, and realise innovation synergies. A few of these needs are highlighted briefly in the next section.

3.1 African Governments Need to Increase Funding to Tertiary Agricultural Institutions

National commitments should be made to higher education through adequate budgetary allocation. African governments should allocate more resources (at least 20 % of national budgets) to education in accordance with the letter of the African Union Plan for the Second Decade of Education in Africa, while prioritising the sub-sector (Strategic orientation for higher education in Africa, 2009). Governments need to rethink the role of tertiary education in capacity building for the attainment of Millennium Development Goals and new development visions and give it a proper place in the national and regional development strategy. This can only come about if universities have management and leadership capacity focusing on development. Governments need to review the funding frameworks for tertiary education and link funding levels to inputs and outputs. Eicher (2006) also highlighted the need to mobilise and sustain greater political support for continuous investment in agricultural education and training, design incentives that attract and retain trained professionals, explore alternative cost-effective training modalities (such as sandwich programs with foreign universities) and invest in graduate programs to strengthen agricultural education training research. There is also a need to define a competitive system to finance the research, and incite private enterprises to participate in the financing of technological innovations and research. There is a need to promote research and development and reward innovative research and development activities especially those that target development problems indigenous to Africa.

3.2 Improve Quality of Graduates Produced

Institutions need to prioritise the production of those skills and areas of research that will promote a mix of dynamic and competitive industries. Public universities can therefore consolidate and boost quantity, by reinvigorating research and solidifying graduate programs. This can be achieved by upgrading teaching and learning programs and processes.

There is a need for greater educational relevance and higher quality graduates. This can be achieved by devising or formulating strategies to tap existing pools of world class knowledge and forge effective linkages with the private sector so as to better align tertiary education outputs to present and future needs of the labor market especially in the leading sectors of growth. Research should not only be scientifically good but must as much as possible meet real needs of key growth sectors.

3.3 Training of Trainers

Creating attractive career opportunities for academics are critical through agribusiness skills development, information and communication technologies for education (ICT for ED) in order to develop and support implementation of distance learning. Ongoing training for academic professionals is required to update and expand their skills and knowledge.

There is also a need to encourage authorities to innovate in the allocation of opportunities and advantages to the teachers and researchers in the scientific and technological sectors. Universities need to adopt a human resources management approach in which labor is considered the most valued asset to be nurtured, motivated, and

supported to enhance organisational competitiveness. Review of workloads and staff audits should be done in order to ensure equal work for equal pay.

3.4 Curricular Review and Development

Institutions are struggling with curricula that are often obsolete, outdated and lack local relevance. Existing curriculum often lacks dynamism, practicality and fails to inspire and engage learners. There is a serious need for continual improvement of curricular to make it not only more robust, relevant but responsive to the agricultural needs of the economy. Private and public sector representatives to curriculum communities are needed to ensure institutions meet industry requirements and expectations. Much of SSA relies on imported scientific knowledge and technologies to fuel its development. This is in spite of Africa's enormous wealth of local knowledge in agriculture and natural resources as highlighted before.

3.5 Improve Linkages

There is a need for tertiary agriculture education in Africa to foster and establish meaningful institutional linkages with national and global information networks, reducing academic isolation and enabling the institutions to grow. The need for greater educational relevance and higher quality has been reported by Lindley *et al.* (1996). Relevance can be achieved by ensuring that institutions of higher learning play a developmental role by establishing linkages with relevant private and public agricultural agencies and farming communities. Rivera (2006) also recommended including intensifying linkage-building efforts as a key reform to improve relevance of agricultural education. Greater understanding is specifically needed of how alternative strategies and selective approaches might shift agricultural education and training into closer, more productive relationships with other actors in the agricultural sector and wider economy.

3.6 Increased Experiential and /or Practical Learning Methods

Experiential learning approaches are needed in order to ensure that newly acquired skills are applied suitably and benefit the individual as well as the institution (von Kauffmann, 2006). Practical experiences such as field trips and mentorship programs are important to attract students and allow them to experience real life situations thereby preparing them to work. Some universities in SSA have internships where the student spends a stipulated amount of time in the curricula working for an agribusiness outfit, either private or public. This activity can be monitored to ensure the students complete involvement. At post-graduate level, students can be attached to national and private research institutes to conduct their research and/or add components of on-farm research.

3.7 Improving Access to Locally Relevant Education Materials

Over 90% of all agricultural text books used are produced elsewhere and are used by academics and students usually without contextualisation. There is a need to at least produce advanced teaching materials based on local knowledge and technologies and putting into context the materials produced in developed countries. The basic principle courses can use materials produced in developed countries but all applied courses need to be developed locally for relevance.

4.0 OPPORTUNITIES

4.1 Right Policies

Africa is responding to its agricultural development challenges with a new approach articulated in the Comprehensive Africa Agricultural Development Program (CAADP) which has been endorsed by African Heads of States and governments as a framework for agricultural growth, food and national security (NEPAD, 2005). The African Heads of State meeting in Maputo in 2003 endorsed an increase in public investment in agricultural development to 10 % of their national budgets. NEPAD has identified agriculture as the engine for Africa's economic development and set out a programme for this in the CAADP which calls for an investment of US$ 251 billion between 2002 and 2015. The World Summit on Sustainable Development (WSSD) held in 2002 recognized that education is the driving force for development, and recommended to the UN General Assembly to declare 2005-2014 the "*Decade of Education for sustainable Development*". If all these agreements are followed then agricultural education would be more resourced than it currently is.

4.2 Effective Regional Networks and Renewed Interest By Donors in Agriculture

There are some effective regional agricultural education networks available such as RUFORUM and ANAFE that can roll-out curriculum review and development (Rudebjer *et al.,* 2005); teaching materials development; Post-graduate research support addressing real farmer problems; Establishing of farmer learning resource centers used for effective teaching and extension support to farmers; Training of trainers; and other success stories enabling learning together and sharing information. These need to be strengthened to deliver more on relevant education across the sub-continent.

4.3 Open Educational Resources

Open Educational Resources (OER) are teaching and learning materials that are freely available for anyone to use, reuse, adapt and share for teaching, learning and research (Bomba, 2009). OER can exist as smaller, stand-alone resources that can be mixed and combined to form larger pieces of content or as larger course modules or full courses. OER can also include simulations, labs, collections, journals, and tools. These materials are considered open if they are released under an open license such as a Creative Commons license.

The benefits of OER include; opportunity to improve content and curriculum quality due to abundance of choice, reducing the time and cost of curricula development by building on the work of others, organizational and personal development opportunities associated with participation, engage many parts of the agricultural community and bring to life the curriculum by making it more practical, relevant and inclusive. There is increased interest and engagement in the agricultural sector with RUFORUM (the Regional University for Capacity Building in Africa) and OER Africa, among others taking a leadership role. A number of US universities including Cornell, Michigan State and others are also working on these opportunities.

4.4 Large Pool of African Diaspora

African governments and agricultural education training institutions must view the Diaspora as a resource, not a loss and learn from them. This happened in China and India. There must be deliberate strategies to engage the Diaspora in education and training.

4.5 New Tools

New tools such as molecular techniques and global communications can be used to upscale technologies and review curricular. Write-shops can be used to develop relevant teaching materials by African scientists for Africa.

5.0 CONCLUSIONS

The challenges for tertiary agricultural training in sub-Saharan Africa are daunting. Africa needs to make concerted efforts that appropriate capacity is developed in our tertiary agricultural education institutions. The challenges facing tertiary agricultural education training can easily be surmounted by embracing the opportunities that are currently available. Central to the opportunities is application of effective networking. However, governments need to follow up on their commitments with effective support to tertiary agricultural education.

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THINK AGAIN - REINVENTING PERCEPTIONS OF AGRICULTURE

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ABSTRACT

The College of Agricultural Sciences at The Pennsylvania State University has a rich tradition of excellence in agricultural education and research; in 1861 we conferred the first baccalaureate degrees in agriculture by a United States university. As a land-grant university, Penn State was charged with teaching agricultural sciences and engineering to the "industrial classes," particularly to rural farming communities. Through time, enrollment in the College has remained strong, but declined in recent years. With less than two percent of the population directly engaged in food production, fewer people understand their connection to agriculture, even though they eat daily, and students found it hard to identify with professional opportunities in agriculture. In response, we engaged in a college-wide initiative to help prospective students understand the relevance of our programs and the wealth of career opportunities in the agricultural sciences. The starting point was a college-wide commitment to this strategic effort. A Communications and Marketing Group was established develop a plan that would serve as a guide to enhance college communication and marketing efforts and to engage marketing experts from across the University level at all levels. Our "Think Again" campaign emerged from this year-long process. The campaign targets 15-18 year-old students and their families. Our message conveyed the diversity and excitement of our "hands-on" educational programs and the career opportunities for students with degrees in these programs. We engaged our faculty, staff, county extension educators, current students, alumni, and industry partners in delivering this message. The net result has been outstanding - an increase in college enrollments approaching 25% over the first three years of the campaign. This campaign is a work in progress, and we continue to emphasize new angles, update our materials and strategies, and develop new and exciting curriculum to keep students engaged and prepare them for the challenges of the global food system. We set a goal that in the next ten years 50% of our students will study abroad, participate in an internship or service-learning project, or conduct research. In this way, we are bringing the curriculum alive by showing our students how what they learn in the classroom can make a difference in the lives of others. We have also made international partnerships a cornerstone of our new curriculum offerings, believing that our best research, teaching, and outreach will be done through the exchanges of knowledge gained by working, learning and growing together.

1.0 INTRODUCTION: THE LAND-GRANT HISTORY

"Upon the subject of education, not presuming to dictate any plan or system respecting it, I can only say that I view it as the most important subject which we as a people can be engaged in."

And so were the musings of former U.S. President Abraham Lincoln who signed the Morrill Land Grant Act in 1862 establishing the land-grant university system in the United States. With the stroke of a pen, President Lincoln began an educational experiment which continues to this day.

The road we started down roughly 140 years ago was a timely and effective economic development strategy for its day. The donation of lands for these institutions democratized education and transformed educational opportunities for individuals into prosperity for communities, states and the nation. Imagine a nation without any public colleges, but only private schools to teach only men to be preachers, teachers, doctors and lawyers! The Morrill Act was designed to provide practical education for the working classes focusing on agriculture and the mechanic arts. Subsequent legislation rounded out the approach by incorporating research and extension missions into the land-grant vision. Legislation in 1890 and 1994 integrated other institutions--historically black colleges and minority serving institutions--into the land grant family.

Today's land grant universities are some of the top comprehensive research universities in the world. Penn State currently has an annual enrollment of 93,000 across 20 campuses. Penn State is ranked ninth among public universities in the U.S. for the amount of federal research and development dollars ($405 million in 2008) in areas as diverse as renewable energy, materials science, cyber security, plant disease, health and medicine and the natural environment. Our college continues its tradition of excellence dating back to 1855, when we awarded the nation's first baccalaureate degree in agriculture.

2.0 CHANGING TIMES

One could make the case that the success of our country is built on the success of the land-grant university concept. An assessment of the agricultural sector in the U.S. over the past century tells the story of amazing accomplishment.

According to USDA Economic Research Service, in 1900, 41% of the United States population was engaged in farming. By 2000, however, only 1.9% of the U.S. population was engaged in farming in some capacity, and less than 1% of the population claimed farming as their principal occupation. Despite this decline in percentage of population working directly in farming, the agricultural sector in the United States has grown in terms of dollars, from $7 billion in 1930 to $73 billion in 2001.

During this time, the amount of land being farmed in the U.S. has remained relatively constant. In simplified terms, today, as a percentage of population, far fewer people work in production agriculture, growing far more food, worth far more money, feeding far more people, on the same amount of land. The changing face of agriculture has provided relatively inexpensive, healthy, and safe food for a growing nation, and world.

This is an incredible success story that did not happen by chance, but in part is the dividends paid on our investments in our land-grant system! With its focus on teaching, research, and the application of new knowledge through the extension service, the land-grant system helped an increasingly complex agricultural system met the demands of a growing nation. With the world population expected to grow to 9 billion by 2040, and with agriculture expected to not only feed, but fuel, a growing population in an environmental sustainable manner, the future of agriculture is bright, albeit challenging.

However, it could be said that agriculture's success is also its demise. With fewer people involved in production agriculture and with a relatively abundant, diverse, and easily accessible food supply came a lack of awareness of the importance and complexity of our agricultural system.

Colleges of Agricultural Sciences were not spared from this trend. Between 1994 and 2005, we saw the enrollment in our college decline by 33% and a shift in the demographics of our students. Today, only 15% of our students come from traditional agriculture backgrounds and nearly 60% are female. Our funding portfolio changed as well. Between 1977 and 1992, our college's research and extension federal funding increased at an average annual rate of 15% and 11% respectively. However, since 1992 these funds have increased by an average annual rate of less than 0.5%. A similar story is true concerning funding from the state government. Between 1980 and 2000, state government funding for research and extension more than doubled. However, since the turn of the new millennium, this funding has risen by an average annual rate of less than 0.5%, less than the rate of inflation. As a result, we are looking at new approaches for funding and broadening our portfolio by building partnerships with local governments, the private sector, clients, and donors.

Meeting the challenges of declining enrollments and public appropriations required us to rethink the way we did business − to create a new vision and a new way of showcasing ourselves to the world – and to reposition the college in the eyes of our potential students and funders as well as the public at large.

3.0 CHANGING WAYS

Our college set out to repositioning itself with prospective students as an active college with a meaningful and engaging academic lifestyle, leading to exciting and diverse career opportunities, as well as to demonstrate relevancy and impact with government and industry stakeholders.

Consensus for change was built within the college through the development of a new strategic plan in 2005. This plan was based on making efficient, creative and strategic decisions, on focusing resources – both financial and human – on the priorities of the college, and on managing expectations – appreciating that we could not be all things to all people. The centerpiece of the vision of the strategic plan was to organise our approach to all college teaching, research and extension around three interrelated systems – food and fiber systems, ecosystems, and socioeconomic systems.

From this foundation, one of the central goals articulated in the plan as a critical way for our college to attain this new vision was to increase enrollment and enhance student success. The college urgently needed to redefine agriculture for younger

generations. Agriculture was increasingly seen by students as an out-dated and narrow topic of study, and misconceptions of agriculture abounded. However, agriculture involves more than farming for production, and includes agribusiness, nutrition, engineering, sustainability, national security, and a whole host of other local, regional, national and global issues that are immediately relevant to today's youth. We took to heart the very real challenge of the need to promote to our target audiences that our college is applying sound educational principles towards addressing these vast, diverse, and also very timely issues both in our home state and across the world.

To further help us achieve our goal of increasing enrollment, curricula have been revitalized, more relevant programs have been introduced, and efforts have been made to increase student and general public literacy on agriculture. This has all been done in conjunction with stepping up efforts to recruit and retain a high-quality and diverse pool of both undergraduate and graduate students. Specifically, the college focused on reviewing current college marketing materials and developing standards, processes, and procedures to enhance, streamline, and increase the consistency of college marketing and branding efforts as well as developing aggressive recruitment and retention strategy. As a result, enrollment continues to increase, retention rates are improving, and student, employer and alumni satisfaction with the college is on the rise.

4.0 CHANGING PROCESSES

Recognising we needed to change and executing meaningful change were two different things. In an effort to implement the charge of the college strategic plan, a Communications and Marketing Study Group was formed to "update and improve college marketing materials, specifically recruitment publications and Web site, to enhance the image of the college to target audiences."

The study group, working with University Marketing, created a final report with recommendations, while concurrently providing direct oversight over the production of recruitment products in their initial planning stages including professional, high impact photography, development of imaging and positioning messages, production of a new viewbook, new major brochures, and the development of a new college Website and videos.

Significant challenges identified in the Communications and Marketing Study Group Report were:

(i) Need for consistency and quality control in college marketing materials, as across the college there was no consistency in the look and feel of communication materials and quality varied greatly. We had more than 300 different Websites in our college that were not connected or consistent.

(ii) Need for college level branding, as there was currently no authority to mandate the use of college campaign materials. Some college materials did not even have the college logo on them.

(iii) Need for some level of centralised marketing budget and financial incentives for units to utilize professional services and products.

(iv) Need for an overall marketing and communication strategy and plan.

The inclusion of communication and marketing goals in our college strategic plan, and the focused efforts in this area, resulted in creative freedom that was lacking in the past. The results were award winning products being developed at the college level. The "Think Again" campaign rolled out in an effort to reposition the college beyond production agriculture and farming, particularly with future students, but addressed broader audiences as well…to get folks to "think outside the barn" with regard to the relevance and diversity of agricultural sciences.

5.0 CHANGING STRUCTURE

With positive results, both in products and recruitment numbers, the next step was to keep the momentum going. The college made a decision to restructure the college communications unit, moving agriculture communications from the technology unit into the college relations office. The college relations office - responsible for industry, legislative, and alumni relations - had the responsibility to build mutually beneficial relationships with college stakeholders. The merger of the college communications unit into the college relations office resulted in the integration of those charged to build strategic stakeholder relationships with those charged to deliver strategic information to stakeholders. It worked.

Not only did our recruitment pieces improve, but pieces targeted at our funders, legislators, alumni, and other stakeholders improved. New print pieces, such as our AGRImpact pieces, which demonstrate college impacts and are designed to strategically position the college around emerging or critical issues, were created. Mission focused (teaching, research and extension) one-pagers, that target legislative and other funding sources, were developed to demonstrate the impact and value of college funding. Regardless of the target audience, all of our communication and marketing products now focus on the relevancy, breadth, and impact of the agricultural sciences, to continue to strategically position our college.

The newly structured college communication unit shifted focus and responsibilities through this process from a service unit to a strategic unit, providing a comprehensive vision and strategy for college communication and marketing efforts, based on the college strategic plan. To provide guidance, a Communication and Marketing Advisory Committee (a recommendation from the study group report) was created to serve in a high level advisory role for communication and marketing efforts in the college. The advisory committee also serves as a sponsor and is the connection to the resources needed to accomplish college communication goals, a critical component for success.

A leadership/creative team was established to process all college communications requests and to approach each request as a team – this enabled us to combine and focus our efforts in order to generate the greatest impact possible. This team consisted of a web director, a marketing specialist, a communications specialist, a designer, a news coordinator and a photographer. This team sparked creativity within the college in order to improve the image of the college both locally and globally. New promotional strategies were developed that were comprehensive and professionally designed, including flyers, postcards, fact sheets, folders and brochures. Every publication that our college puts out now has the same brand, with similar looks, while still promoting our college in diverse ways to reach potential prospective students.

Furthermore, other committees were established including the undergraduate recruitment committee, trade show committees and a social networking committee to ensure high level strategies for all major audiences and events.

6.0 CHANGES IN TECHNOLOGY

Unique to our new college communications structure was the full inclusion of a Web communications team into the communication unit as equal partners, not just as a technology or delivery mode. No area of communication has changed more rapidly than that of digital technology in social interaction and media. A new vocabulary--Twitter, FaceBook, Google, Delicious, StumbleUpon, Linked-In, MySpace, YouTube, Blogs--defines not just how we get information, but how we manage and respond to it. To be a 21st century institution, our college decided to learn the vocabulary of our students and embrace the technology as the most effective and up-to-date way to interact with our students, future students, and other stakeholders. Having the Web team, including technology experts, as part of the communications leadership team resulted in technology becoming part of the strategy rather than a delivery mode. The team developed strategies such as the Dean's Desk – a Web page dedicated to presenting the new dean to the world through strategic blog entries, Twitter messages, and Flickr photo galleries.

Our Web vision is to create a unified college Web presence that provides useful and rich content to our audiences while ensuring high quality-control standards. We have uniquely implemented a content management system, Plone, to allow our academic units to focus on content rather than technology. We have a developed a college-level template built with a user-centered design that provides the users with continuous upgrades, search engine optimisation, social networking technologies, Web statistics, and easy content management while providing the college with high quality and consistent branding.

7.0 NEW INVESTMENTS

Crucial to the success of the strategic plan was both the collaboration and long-term commitment from all departments in the college and from administration units across the university system. In achieving their goal, the Communications and Marketing Study Group had to work closely with the University Marketing and Advertising Team, Undergraduate Education for information on college recruitment practices, and University Publications on college-level publications and image development. Collaboration with Cooperative Extension reaped major benefits, as extension offices made it a strategic priority to share about our college's undergraduate educational opportunities. Some departmental units within our college even started to assign part-time duties to faculty, staff and graduate students to focus on and assist in "recruiting and retention" events.

The focus of new investments was placed on prioritising for maximum impact with limited resources. This was implemented by placing priority on communication pieces addressing the five priority areas defined in the college strategic plan including - 1) energy, 2) entrepreneurship, 3) food, diet and health, 4) pest prediction and response, and 5) water quality and quantity. By focusing communication resources around the defined priority areas of the college there was buy-in and awareness regarding the prioritization process for allocating communication resources.

Furthermore, a reframing process of the current extension system enabled extension offices to be more effective in promoting Penn State programs. This process was

conducted with emphasis on: 1) increasing the transfer of new knowledge into innovative solutions that address societal challenges, 2) consolidating and improving the quality and consistency of statewide programs, 3) improving flexibility and agility of service provision, and 4) developing self-empowered teams through the creation of 21 working groups statewide. This process provided a strategic structure to prioritise extension publications and communication resources as well.

8.0 CONCLUSION: WHAT LIES AHEAD

The college is now seen as a leader in communication strategies within the University and beyond. Our award winning publications, our innovative and effective Website, our strategically targeted impact pieces, and our overall quality and creativity have uniquely positioned us for the future. Involving all stakeholders was central to this process of restructuring, and without such universal involvement, the implementation of the strategic plan would not have been a success. The college has multiple stakeholders including not only the internal academic units and administration, but also a variety of external partners such as industry, government, alumni, donors and cooperative extension.

Agriculture is facing challenges like never before--the world's most complex problems are global in nature (food security, climate change and natural resource depletion, health) and are interrelated with decisions about agriculture at their core. Our mutual goal is to build ag literacy and train the next generation of young people with the tools to address these types of issues. Much like the land grant system envisioned teaching the tools of the trade of mechanised farming within the U.S. borders, perhaps we need to think about the global land-grant that works across continents and oceans to teach the tools of a new way of doing business.

SUB-THEME 5:
CLIMATE CHANGE

CLIMATE CHANGE AND FORESTS OF EASTERN EUROPE

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ABSTRACT
The global climate changes touch the forests of the Earth. Forests of Europe are an important component of global ecological system. Forests of Eastern Europe are a subject of particular interest from the point of view of their ecological potential, as until recent time they were a part of closed socialistic system of former USSR. It was ascertained, that one of the most effective way of combating global climate change is to increase percentage of forest land in the region.

By using of the original technique, experimental and literary data, ecologic potential of the forests of the region and its influence on climate changes was estimated. The main point of the technique is an integral combination of conversion ratios of phytomass components for main forest forming tree species of the studied region and forest cadastre data. Based on the abovementioned technique, amounts of phytomass and sequestered carbon in forests of nine Eastern European countries (Estonia, Latvia, Lithuania, Belarus, Ukraine, Moldova, Georgia, Armenia and Azerbaijan) were calculated. A complex index which enables estimation of efficiency of use of ecological potential of forests is density of carbon in forest ecosystems. By the end of the last century in the abovementioned countries this index was equal 4.08 $kg \cdot (m^2)^{-1}$ (Moldova) to 6.28 $kg \cdot (m^2)^{-1}$ (Lithuania).

Because of scarcity of statistical data on dynamics of forest areas, stocks and productivity in the abovementioned countries, authentical estimation of trends of carbon dynamics is problematical. Regional trends of influence of forests on climate change can be observed on an example of Ukraine.

Results of the study prove an increase of carbon content in forests of Ukraine during a period from 464,5 millions of tons (1988) to 658,9 millions of tons (2008). Average carbon density has increased correspondingly. Taking into account big afforestation potential of Ukraine (2.5-3 millions of hectares) on former agricultural lands, regional ecological potential is going to increase.

LINKING SUSTAINAGILITY AND AGROFORESTRY SCIENCE TO MULTIFUNCTIONAL POLICY ACTION

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ABSTRACT
Agroforestry as a concept has its roots in a critique of a development pathway that segregates functions in the landscape. By building on the multifunctionality of landscapes in which trees serve multiple functions in the provision of both goods and services, agroforestry research aims to enhance the understanding of tradeoffs (at patch, field and landscape scale), find ways to maximise local benefits, provide global benefits through appropriate incentives and challenge the regulatory frameworks that 'divide and rule'. As the continued 'agility' of farmers is crucial for continued adaptation to changing climate, markets and livelihood options, we are interested in 'sustainagility': properties of a system that support actors to cope with change, to be adaptive and resilient. Sustainagility complements sustainability at any scale, and contributes to 'meeting current needs without compromising the future'. Trees and diversity in landscapes contribute to sustainagility. To be effective in this area requires ability to handle 'conceptual pluralism' and be an effective communicator and often interlocutor between local ecological knowledge (LEK), the ecological knowledge and paradigms of public policy (PEK) and the ecological knowledge, models and systems analysis of science (MEK). As 'boundary agent', the agroforester has to obey the rules of the game of science with its absence of everlasting truths, trust in empiricism, reliance on trustworthy data and continued challenge to 'predictability' by maximising clarity of thought.. But she/he also has to obey rules of effectiveness as change agent: understanding, respecting and appreciating the perspectives of multiple stakeholders, optimal ambiguity as basis for political platforms and policy progress, and the relevance of 'buy in' through intellectual ownership of self-discovered ideas, rather than being taught. The pursuit of 'sustainagility science' is a challenge for African universities as training ground for 'boundary agents', as much as for those in Asia and other parts of the world.

1.0 INTRODUCTION

Agroforestry as the interface of the agricultural and forestry spheres has strong roots in an 'integrate' approach to multifunctionality. It achieves short, medium and long term goals in the provision of valued goods and services. The 'segregate' approach as alternative path to achieving multiple goals by intensive agriculture (or tree production) in one part of the landscape and areas dedicated to conservation elsewhere has minimized the interface of agriculture and natural forests in the dominant 'development' paradigm of the past century – leading to the articulation of 'integrated' systems, including agroforestry, as a counter-movement in the past decades.

The segregate or integrate choice plays out at multiple spatial scales, from farm to landscape, but also across time. The 'segregate' pathway has been associated with the 'intensification' hypothesis, expecting that more productive forms of agriculture will leave more space for conservation. In reality, however, this forms a necessary but not sufficient condition for achieving conservation goals. The shape of tradeoff curves between the multiple functions provides a guide to rational choices in the segregate-or-integrate dilemma. Locking up land for single functions may seem efficient for now, but reduces future options. The sustainagility questions focuses on the maintenance of resources for future change and includes the reversibility of choices and opportunities for cross-scale access to biological resources for future goods and services.

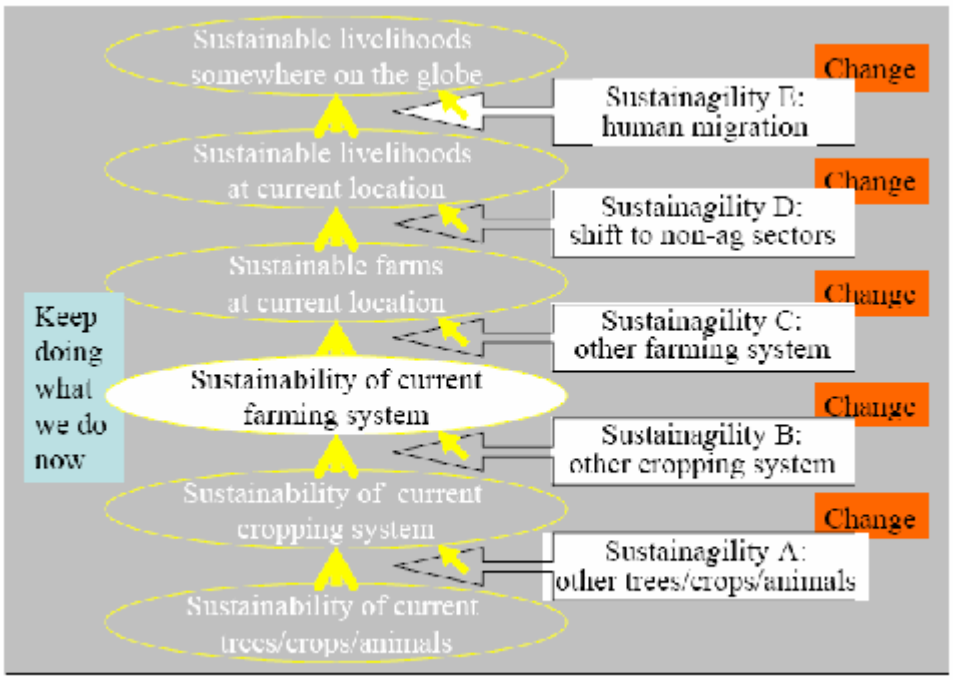
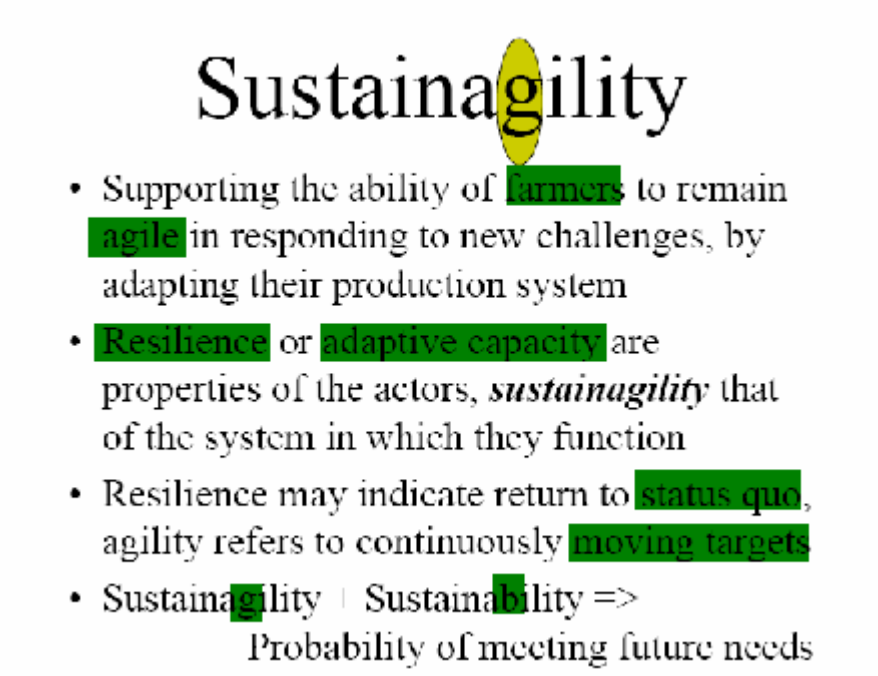


Figure 1. Sustainagility as the complement of sustainability at multiple scales

Sustainability at any scale (meeting current needs without compromising the future) can be achieved by persistence of all subsystems, or by maintaining options for change ('sustainagility') at the lower levels. on learning in the realities of the landscape as well as by reflection, analysis and synthetic models. The way multiple spatial and temporal scales relate to multiple stakeholders, objectives and interests isn't just an afterthought, but is the core of the problem to be investigated.

Sustainagility: Properties of a system that support actors to cope with change, to be adaptive and resilient.



Picture 1: A small town in W. Australia shows that continuous change is a key characteristics of the rural as well as urban landscape – but it involves cross-sectoral switches that rely on more advanced forms of human and social capital than we usually consider in 'agricultural research'

The science of both sustainability and sustainagility is still young, and depends on learning through direct engagement in the 'action', testing ideas at scale in the real world, as the scaling rules for experiments' are unknown. Rather than sitting in the ivory tower of independent research, the researchers and their concepts and constructs are part of the overall dynamic and need to be cognisant of their evolving roles. The interface of knowledge and action for the various stakeholders and actors can be described as 'boundary work', done by 'boundary agents' and leading to 'boundary objects'.

Advise for boundary work at the interface of local, public/policy and scientific/ modelers ecological knowledge. Boundary objects making replication easier, but not leading to blueprints. Tropical forest margins have many stakeholders, who all plan and justify their actions based on their knowledge, while learning in the process. Three main groups of stakeholders are: local people, government and associated leaders of public opinion and scientists. If science is to help in enhancing the stability of forest margins, reducing poverty and securing long-term conservation of forest resources, it has to communicate effectively with the two other knowledge-action pairs, as well as with the many shades of opinion within their group. In more than ten years of work in the tropical forest margins, the ASB-Partnership has tried various approaches. A recent effort to take stock, reflect on what has worked well and what the main challenges are, distinguished:

(i) Local ecological knowledge or LEK, embedded in local context.

(ii) Public space/policy ecological knowledge or PEK, concerned with short-term 'impact'.

(iii) Scientific or modelers' ecological knowledge or MEK, seeking generic 'mechanisms'

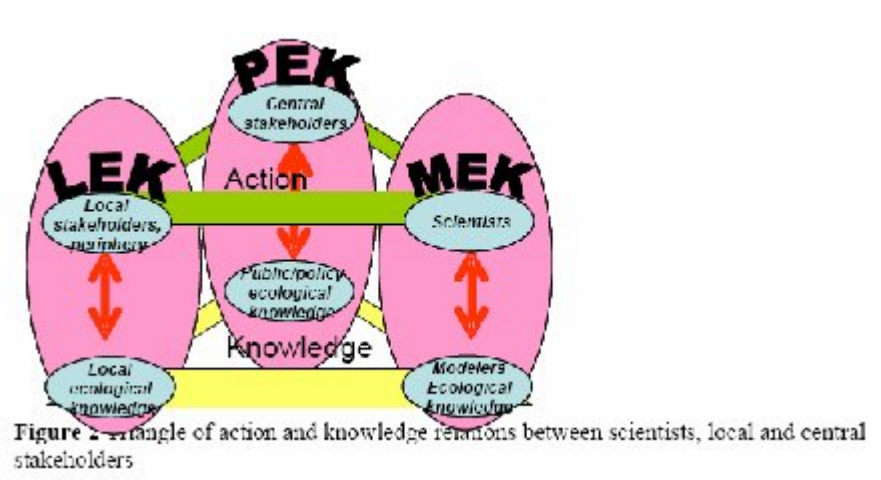


Figure 2 – Triangle of action and knowledge relations between scientists, local and central stakeholders

Two simple approaches have not worked:

(i) Scientists + farmers generating new technology will not in itself lead to forest conservation.

(ii) Scientists (or NGO advocates) advising policy-makers on how to handle forest margins for global benefits.

It appears that real progress will have to engage all three K□A pairs, but how? What can independent scientific enquiry add to an already complex situation? Management of the science – action boundary is needed for free flow of ideas, but how far will current levels of 'control' by funders and regulators have to be relaxed before creativity gets a chance? How can multistakeholders negotiations make progress in the midst of conflicts and widely divergent ambitions? Dynamic knowledge-action linkage may need to build a shared understanding of the landscape and a facilitated process of negotiations, in a 'safe space' protected from external interference, initially. How can 'boundary work' in such settings be done effectively?

2.0 VIRTUES AND RISKS OF INDEPENDENT SCIENTIFIC ENQUIRY

Linking newly acquired or well-established knowledge with actions for sustainable development can only work where 'lack of knowledge' is among the key constraints. In the past the model ('version 0') where science leads to international public goods that will be spontaneously taken up by well-intended private sector or public institutions had its advocates. With an increase in the two-way interaction between science and practice, however, uptake of results increased, alongside direct rewards for scientists who promised to deliver exactly what was demanded. Such 'demand driven' research, may require some form of protection from interference. Institutions managing the semi-permeable boundary arose, stimulating the flows of ideas but protecting science from 'interference'. ('version

1'). In fact, in the application of new knowledge the complexity of local stakeholders and the scarcity of 'win-win' solutions, make that uptake of new ideas requires negotiations along the various tradeoffs ('version 2').

Trade-offs increase the complexity for the 'boundary agents', who may need to understand and manage the biases in access to external knowledge by less-empowered local stakeholders. In confronting these models with the recent experience in developing countries, a fourth model appeared ('version -1') in which there is no 'boundary problem', as there is no independence of research. Only statements supporting the status quo will pass the acceptability test. This is the version that has dominated in human history, and has only been slowly (and partially…) abandoned in some societies.

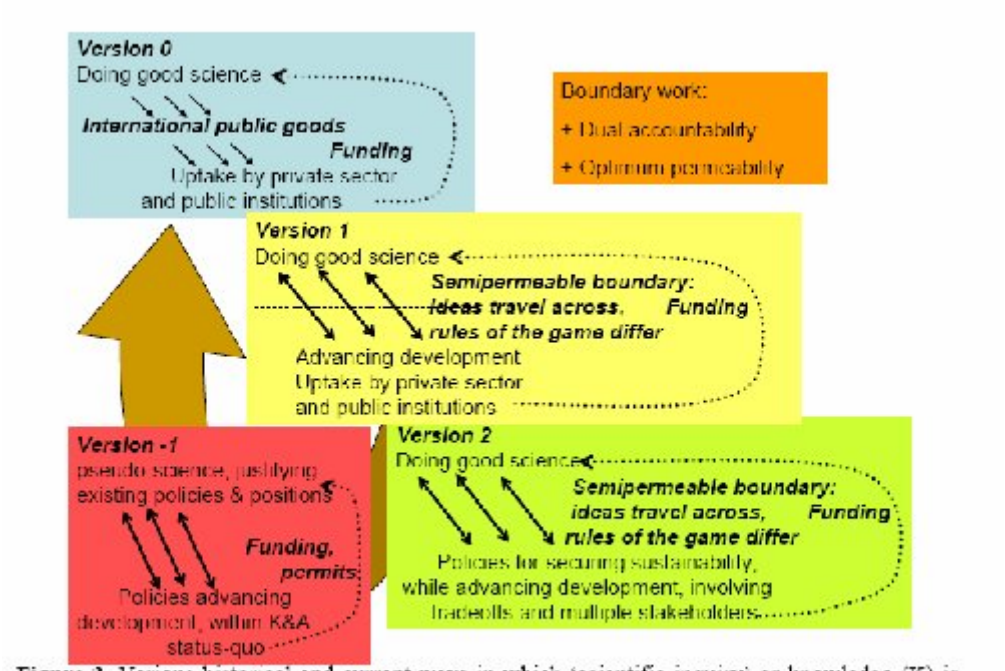


Figure 3. Various historical and current ways in which 'scientific inquiry' or knowledge (K) is linked to policy and development action (A)

The linkage between knowledge and action thus needs to be evaluated as a two-way process in which the capacity for scientific enquiry to come up with new analyses of problems and potential solutions is dependent on the arrangements at the boundary: complete independence will lead to missed opportunities for early application, strong control will suppress independence.

Management of the boundary is urgent and may require more explicit recognition and institutions than currently exist.

3.0 MULTI-STAKEHOLDER NEGOTIATIONS IN THE KNOWLEDGE+ACTION WORLD

The 'Negotiation Support System' was developed by ASB scientists to assist local communities in the forest margin and government authorities to step outside of their history of conflict and agree on secure tenure for 'squatter' communities in exchange for protection of the remaining forests and transformation of monoculture to multi-strata coffee gardens. It engages all in the creation of new 'reality' in the local context, challenging existing paradigms. For example, in the governments initial mind all types of coffee destroy watersheds and only natural forest or trees planted by foresters can secure for water-flows. Scientific data analysis helped to create space for change, at least at the local level. Subsequent change at the central level will require the engagement of both these local and scientific stakeholders, to address the rationale and formats of regulation and create space for learning. In fact this example shows a 'new' way for scientific knowledge (KSCI in fig. 4) to influence action at the public/policy level APOL. Previous approaches had focused on pathway 3 (scientists advising policymakers on what to do) and pathway 1 (scientists assisting policymakers to learn and chart their course of action). Pathway 3 rarely works, pathway 1 requires 'boundary organizations' to manage the interactions. A 4th pathway, aims at 'empowering' local stakeholders in their interaction with central policy knowledge/action pairs.

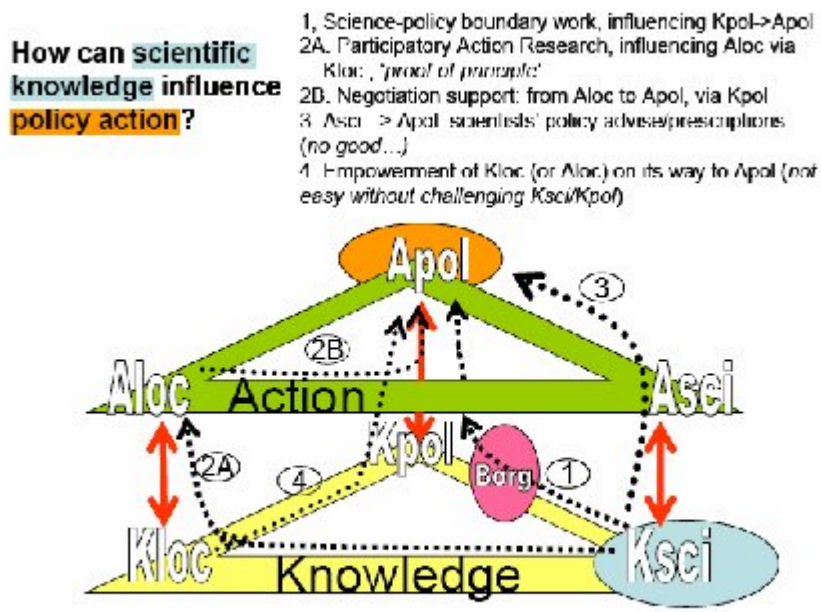


Figure 4. Various pathways for linking scientific knowledge (K_{sci}) to central policy action (A_{pol})

Where existing policy has a monopoly over the use of 'science' to justify its positions, this may not work. Pathways 1 and 2 are not mutually exclusive, and may well

be tried in conjunction. Assisting change at local level probably lowers the threshold for assisting change at more central level – as long as it is not seen as too much of a 'threat' for the powers that be.

Combining pathways with shortcuts into the public debate may work, depending on the urgency of the issue Isn't all this 'natural resource management' work too site-specific for 'international public goods' production? Replicability can be obtained via 'boundary work' simultaneous at local and central level, leading to linked 'boundary objects' and through training of 'agents' with competence and skills.

4.0 TEN POINTERS IN PREPARING FOR 'BOUNDARY WORK' ON 'SUSTAINAGILITY'

(v) Expect the more complex case of multiple actors with their associated knowledge, contesting at both A and K levels, all using their own version of 'history' as justification; on this basis, never underestimate nor overestimate the ability of stakeholders to set their own course of action.

(vi) Engage in interdisciplinary/collaborative dialogues and consultations with stakeholders. Create open, safe space for intellectual enquiry: appreciate diversity, as long as it does not clash; refrain from value statements about other K; respect community norms and rules in use.

(vii) The meaning of words lies in the context of their use: don't trust that the meaning of the same words is the same for different groups

(viii) Learning will often require the direct experience and empirical confirmation that alternative options do really exist: salience ('so what' outcomes), credibility ('how does it work' mechanisms) and legitimacy ('here, now and us' context, absence of foreign agenda's)

(ix) Provide time for trust building : often a technical entry point can help to provide legitimacy to your engagement willingness to listen and answer questions of local stakeholders goes a long way to establish a 2-way relationship

(x) Every type of boundary work requires double accountability, in moral if not formal sense; ensure backup and understanding at higher levels, as there may be times that the 'safe space' isn't quite so safe. Organisations may need to 'embed' boundary agents in appropriate structures and provide incentives to individuals to go beyond the call of duty, exploring ways of continually improving practice, encouraging people to listen

(xi) Guard the permeability of the boundary: 'ideas' can flow freely, 'control over what is true'; when 'politically incorrect' views or conclusions emerge, clarity is needed on the separate domains for empirical/scientific and public/domain knowledge

(iv) The K sharing may aim not for maximum clarity (the researchers' aim) but *optimal ambiguity:* multiple K level interpretations can coexist, as long as they do not clash at the A level

(v) Live and walk the talk about separating scientific K from influencing conclusions: "although I personally had hoped otherwise, the outcome of the analysis/experiment is..." Ensure that content/substance and process of engagement are compatible and maintained

(vi) Explore jointly how KA linkages may have co-evolved, once there is awareness and appreciation of the relativity of all knowledge systems; Note that process is as much

important as the technical content/substance of the boundary work. Build a matrix for measuring program success.

SUB-THEME 6: AGRICULTURE AND ENERGY

INTEGRAL VALORISATION OF BIO-PRODUCTION

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ABSTRACT
Integral valorisation of bio-production including agriculture, forestry and aquaculture for the production of safe food products and renewable production of products, materials and energy is a vital aspect of a rapid expanding bio-based economy.

The organisation of a graduate course on MSc and PhD level in this field is linking the gap between traditional teaching programmes in the field of agriculture and food sciences with the multidisciplinary approach in new developed curricula dealing with a simultaneous conversion of renewable resources for food and non-food uses.

1.0 BIO-BASED ECONOMY AND INTEGRAL VALORISATION OF BIO-PRODUCTS

Bio-production, including agriculture, horticulture, fisheries and forestry is becoming increasingly more market-driven worldwide and there is increasing concern about the effect of these activities on the global environment. During the last decade there has been a significant growing effort to relieve these pressures by focusing on the total agri-production chain involved in the production of safe, quality food and the effective use of the renewable co-products of these activities.

Integral valorisation is an essential part of a bio-based economy using bio-production in agriculture, horticulture, fisheries and forestry as primary resources for food and feed, biomaterials, chemical and pharmaceutical products and bio-fuels (biodiesel, bio-ethanol and biogas).

Bio-based economy is a milestone in the economical evolution. There is a growing tendency to be less dependent on the political situation in the world especially for raw materials and energy resources. In addition there is a limited availability for fossil resources and gas resources.

Another advantage of using renewable resources are the ecological and environmental benefits due to the integration in a closed carbon cycle.

In addition bio-production is very efficient and sustainable in order to provide renewable resources as alternative sources (e.g., waste streams) can be transformed in useful products using emerging technologies. These developments are favoured by their green image and the consumer assessment of sustainable production and clean technologies.

Over the last century consumers have assumed food and energy resources in the western world will continue to be readily available. However, it is now realised that natural resources are extremely limited. A more efficient use of materials, waste minimization and especially integral valorisation must be integrated into bio-system management and biomaterial use. Integral valorisation is the production of safe and healthy food and renewable resources for materials and energy production, with the aim of achieving an efficient and complete use of each bio-product at every step in the agri-bio-chain. Integral valorisation must be the basic concept driving the design of new processes for food, biomaterials and bio-energy production to achieve sustainable development. This will necessitate the optimal utilisation of all co-products and waste streams. The conversion of bio-products into food and non-food materials on the same production site is novel. However, ‘white’ or industrial biotechnology, ‘green’ biotechnology or agricultural biotechnology and the principles of bio-refining, which is the sequential extraction of commercially valuable components have been recently developed.

Bio-refinery can be defined as integrated bio-based industries, using a variety of different technologies to produce food and feed ingredients, chemicals, biomaterials, bio-fuels and power from biomass raw material.

2.0 ECOLOGICAL ECONOMY: FOOD VERSUS NON-FOOD APPLICATION

Integral valorisation of food, biomaterials and bio-energy is based on bio-refining principles that combine agriculture and forestry, bio-production with the use of these materials to produce food, chemicals, materials and energy. However, such use of renewable resources can be accomplished by several approaches. One approach is a self-sustaining model on a local production scale, involving raw material suppliers (agriculture, forestry), decentralised energy producers (power plants, bio-gas) and consumption of locally produced energy. This is a successful approach for food and energy production and optimum use of co-products and waste streams. This sustainable rural development scheme is illustrated by a combination of agricultural-forestry production, biodiesel production, waste management and energy.

An important asset in the production and use of renewable bio-resources is the fact that the products can be used either for food production and for non-food applications. In this way more flexibility towards the market is built into business. In this way the formation of self-sustaining ecological production sites with cyclic utilisation of preferably locally available resources must be favoured. Besides the production of food and non-food preferably on one location attention is given to the valorisation of waste materials from biological processes. Companies are realising that developing a useful outlet for side products and waste streams can contribute to the sustainability and economical and ecological health of their processes. Mostly, waste streams contain valuable products but the separation on processing them has been neglected until now. The integral valorisation of bio-production is illustrated by a number of cases such as corn, vegetable oils and bio-diesel production. As corn crops have a high yield, it may be regarded as a good crop for widespread integral utilisation. The integral valorisation scheme of corn illustrates different possibilities for main- and by-products (in small or large amounts) of equivalent importance from the point of view of total utilisation. Changes in market opportunities can be partially levelled if different outlets are available.

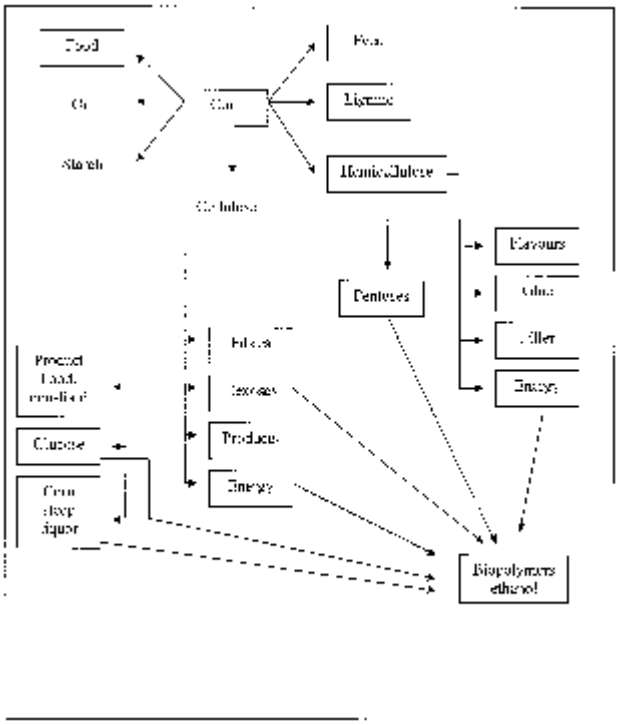

Figure 1: Integral valorisation of corn

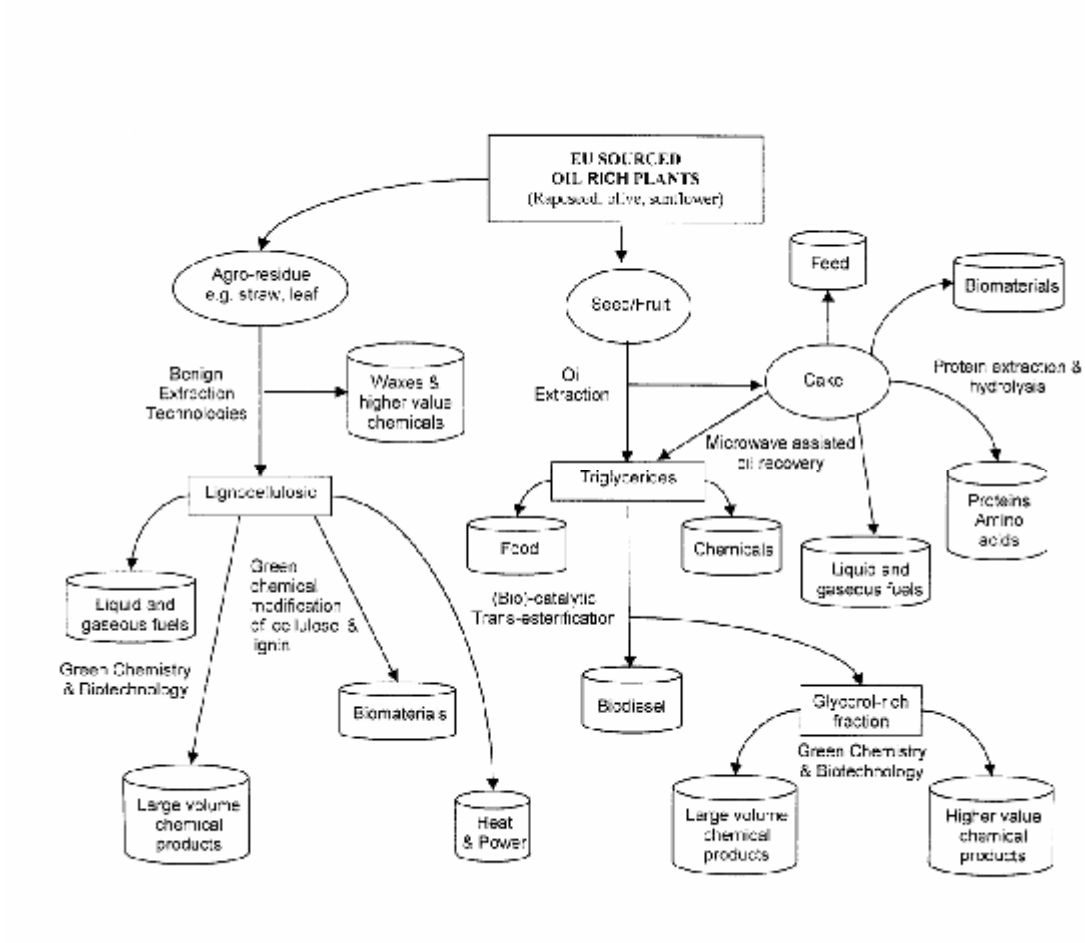

Figure 2: The oilseed bio-refinery

A very important aspect is that the technology for use of renewable resources for non-food applications need to exist and preferably similar to the technology for fossil-derived products. For example the production of biopolymers can only be successful if they can be produced with the equipment which is used in the chemical industry.

Another example of this concept is an oil mill for bio-diesel production, combined with power plants (electricity, heat: CHP), using waste from bio-diesel production, used cooking and frying oils, with wood residues and biogas also partially supplied by waste from the diesel production.

Processing of locally grown rapeseeds provides biodiesel and protein-rich feedstock. The feedstock is redistributed in aliquots to the farmers. Any surplus is sold or utilised in the energy power plant. In order to increase the biodiesel capacity, used frying oils are collected and transformed in biodiesel. The glycerine (by-product) of biodiesel production can be used in two ways. It can be mixed with wood waste and sawdust to produce power of in biogas production combined with agricultural and food waste and manure.

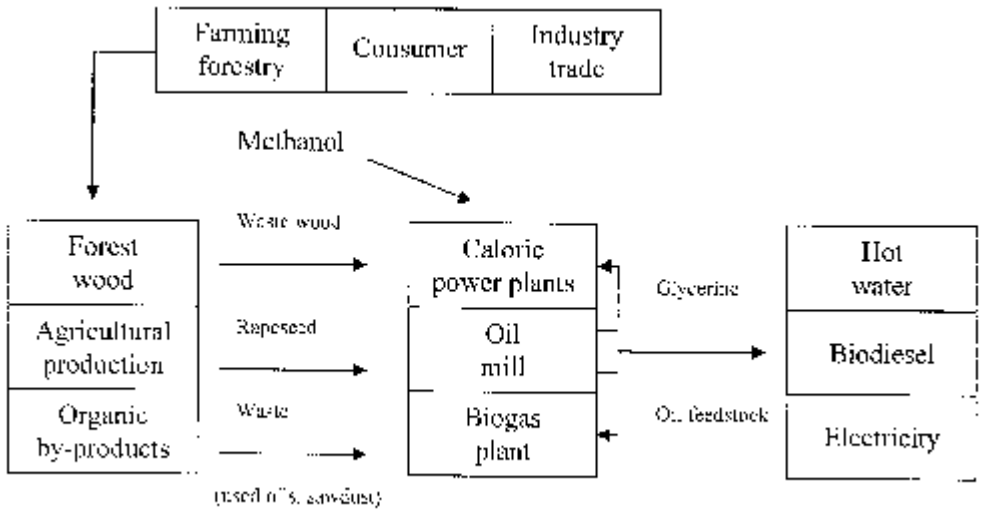

Figure 3: Integral valorisation of bio-products

The principle of integral valorisation of bio-production has been applied on an industrial scale at Ghent. A consortium Ghent Bio-Energy Valley Ghent has been created by the City of Ghent, Harbour of Ghent, Ghent University and various industrial partners with the aim to produce on one location, which was originally a food plant, food, feed and bio-fuels. On this site soy or rapeseed are extracted and refined to produce edible oil which is used either for food or the production of biodiesel. The cake is used for feed, power or biogas. At the same site corn and wheat are processed for food and for bio-ethanol via fermentation and distillation. The residual waste products are sold as feed or transformed into biogas. Also the blending of bio-fuels with the fossil fuel are performed on the same location.

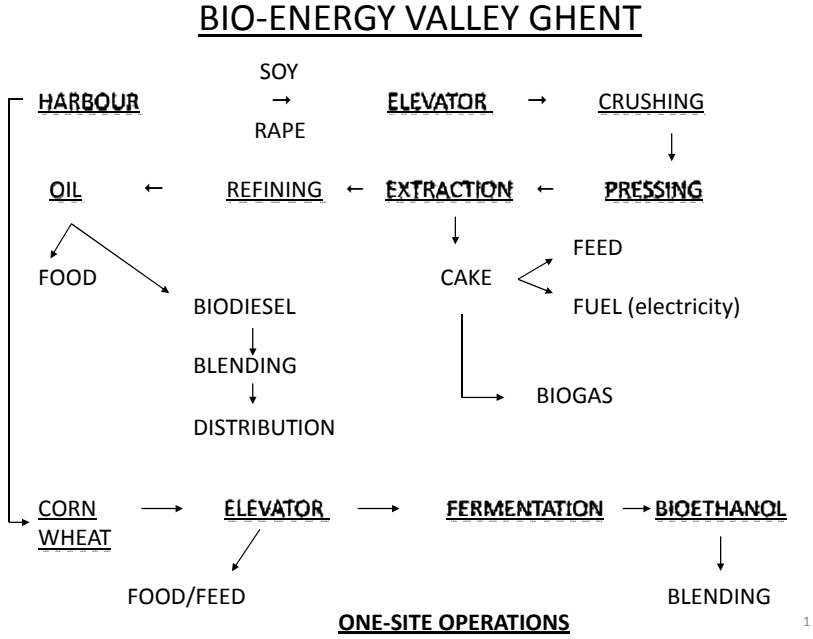

Figure 4: Bio-energy valley Ghent

Taking into account the experiences mentioned "integral valorisation of bio-production" is a successful development applying the following conditions:

(i) Self-sustaining model on local production scale.
(ii) Simultaneous production of food and energy.
(iii) Integration of the total bio-production chain from raw material to final product.
(iv) Optimal use of co-products and waste streams.
(v) Combination of bio-production, bio-refinery, waste management, clean technology and energy.

3.0 SPECIFIC ASPECTS OF BIO-PRODUCTION

The change of attitudes in production processes involving integral valorisation and sustainability is giving rise to new developments in the economical organisation.

Using agricultural and natural materials has some disadvantages compared to production schemes using fossil resources. Especially the changing quality of resources due to agricultural production conditions can be harmful for food production and non-food applications. Therefore quality control of products from crops, animals is an essential condition. This has been illustrated by problems with BSE, PCBs and dioxins.

Using renewable resources for food and non-food applications will need quality control in order to product a constant quality. Mixing of resources is a solution very well known in food production but is more difficult to perform for non-food applications in addition to a stable and reliable availability.

Another drawback is that bio-production is limited to a certain period of the year so that the yearly consumption has to be produced and downstreamed in a short period.

This is leading to a production capacity which is bigger than in the case of fossil raw materials.

Essential is the stability of the intermediate during storage. This is very well known in food industry and these processes are also used in non-food applications stressing the complimentary of both applications.

The use of preservation techniques (e.g., anti-microbial, anti-fungal) and additives (e.g., anti-oxidants) are applied both for food and non-food applications.

Therefore the search for stable intermediates from bio-production which can serve as basic products is one of the highlights of the bio-refinery. The production of methanol, ethanol, acetic acid are being promoted to mimic the position of ethylene in the petrochemistry.

4.0 INTEGRAL USE OF RENEWABLE, AN INTERESTING CONCEPT FOR DEVELOPING COUNTRIES

During the last century, the western countries shifted progressively from agriculture and moved to petrochemistry (petroleum, natural gas) as a source for materials and industrial products. This tendency is one of the main reasons for the economical and social gap between North and South. The increased interest in the Western world of utilising renewable resources for food and non-food can be an important signal to similar sustainable technologies for developing countries.

Food production will be the main concern but the application of the integral use and processing of bio-production will be a stimulus for regional developments and for regional developments and especially valuable for small communities. It can increase the number and the qualification of jobs and the societies become less dependent on imported goods. A good example was the production of biodiesel (4000 l/day) on palm oil refineries in Ivory Coast and Cameroon. These communities became less dependence from important diesel oil without disturbing the food supply due to the use of palm oil fractions less suitable for human consumption.

There is no doubt that integral valorisation for food and non-food products will generate more jobs with higher qualifications and reduce the tendency to move to cities and reduce the need for import of expensive Western products.

5.0 CURRICULUM DEVELOPMENT: INTEGRAL VALORISATION OF BIO-PRODUCTION

Integral valorisation of bio-products from agriculture, horticulture, forestry, fisheries and aquaculture for food and non-food uses is a new and innovative area for curriculum development in graduate courses leading to MSc and PhD degrees. At this moment the majority of western study programmes in agriculture, biotechnology, chemistry, chemical engineering and food science and technology cover only a fraction of the relevant current knowledge and is not making connection and link between the food production and non-food application neither in the primary raw materials and in the final products. This is due to the traditional specialisation either for food science or non-food renewable bio-resources. Consequently study programmes that combine these expertise do not exist, despite the fact that both fields using the same raw materials and similar processing, technologies, logistics and management. In addition this study field is applying the same

basic sciences (mathematics, physics, chemistry, biology and engineering). With the increasing use of agricultural food products and non-food renewable materials and energy, there is an urgent need in the industrial world for graduates and experts combining knowledge of both food and non-food biomaterial processing and management.

The objectives and aims of the curriculum development of graduate courses in "integral valorisation" are:

(i) To train critically reflective experts in new developments in the bio-production chain, providing technical and scientific education for the implementation of integral food, non-food and energy production.
(ii) To enable students to a critical evaluation of the introduction and acceptance of interdisciplinary technologies, new products and evaluation of the environmental impact.
(iii) To train bio-experts to understand and to analyse the variation in quality and safety of production and technologies.
(iv) To ensure students of the importance of global environment, sustainable production and technologies, consumer perception and ethics.

The curriculum of "integral valorisation of bio-production" involves a multi- and interdisciplinary approach applying the principle of the "total production chain". The following fields are the subject of the curriculum:

(i) Primary production of renewable bio-resources from plant, animal, forestry and biomass.
(ii) Technologies and processing of renewable bio-production for food and non-food products.
(iii) Food technology and engineering.
(iv) Biotechnology.
(v) Quality and safety of bio-products.
(vi) Bio-economics and management.

The idea of "integral valorisation of bio-production" has been realised in the framework of the EU-US exchange programme Atlantis in which 3 EU universities (Ghent University Belgium; INP Toulouse, France and Karl-Franzen University Graz, Austria) together with 3 US universities (University of Arkansas, Fayetteville, Iowa State University, Ames and Kansas State University, Manhattan) have taken the initiative to develop a graduate degree course together with a student and staff mobility programme, organisation of short (2 weeks) intensive programme (in 2009: 2 organisations: Ames and Graz) and the preparation of teaching material.

A model for a graduate course in "integral valorisation of bio-production" should involve modules dealing with:

(i) Primary production of renewable bio-resources, plant, animal, forestry.
(ii) Technology and engineering of renewable bio-production for food and non-food applications.
(iii) Principles of food science and technology.
(iv) Quality and safety of bio-products.
(v) Renewable biomaterials from carbohydrates and wood: fibres, biopolymers.

(vi) Renewable biomaterials from lipids and proteins: e.g. biopolymers, detergents, lubricants.
(vii) Production of bio-fuel: bio-ethanol, biodiesel, bio-gas, pyrolysis of biomass.
(viii) Production of high value-added products: e.g., herbs, pharmaceuticals, perfumes/flavours, bio-colorants.
(ix) Principle of bio-refining.
(x) Waste prevention and conversion of waste-streams.
(xi) Clean technologies in food and industrial engineering.
(xii) Life cycle analyses and exergy.
(xiii) Principles of bio-economy and management.
(xiv) Bio-ethics: conflict food versus non-food.

The course will clearly emphasise the importance of a simultaneous conversion and/or modification of raw bio-resources for food and non-food applications.

The course is representing a unique opportunity to create a multidisciplinary approach for students from various disciplines and orientations to use food and non-food technologies and products and it will also allow the development of graduates with unique skills which are not currently available.

Industry is actively searching for such employees who are experts in these new innovative and expanding fields.

It also will provide opportunities for academic staff to create multidisciplinary teaching programmes and modules by simultaneous integration of various disciplines while also involving multiple teaching and research institutions.

6.0 CONCLUSION

The concept of a bio-based economy and integral valorisation of bio-production is creating a unique opportunity for the integration of various educational disciplines emphasising the importance and added values of a simultaneous conversion and/or modification of renewable bio-resources into food products and non-food applications. The development of new curricula in these fields will create new opportunities for institutions of life sciences and new openings for students in a rapid expanding and innovative bio-economy.

GROUP DISCUSSIONS

SUB-THEME 1: AGRICULTURE AND FOOD SECURITY

What type of investment, research and education systems are required and practical to achieve the targeted increase in agricultural output of 10% over the next 20 years?

Chairman: Martin Schneider

Rapporteurs: Alice Nderitu and Maina Mwangi

The session Chairman opened by informing the participants of some facts on challenges facing mankind. He noted that 10% of all grain (about 220 million tons) is lost due to poor handling and storage methods and that in 2008, 48 million tons of rice was lost due to poor handling. Between US$ 14 – 30 billion is required to address these and other related challenges.

Other gaps identified during discussion include:

(i) Underfunding in agriculture education and research.

(ii) Dependence on government as sole or main source of funding untenable due to:
- Competition from other more critical issues, e.g., contagious diseases (avian flu, swine flu, HIV/AIDS).
- Dwindling sources of government revenue, e.g., impacts of recent global economic downturn.

(ii) Policies imposed on governments in the last 10 – 20 years by World Bank/IMF have had far-reaching adverse impacts on capacity of institutions to carry out training and research in agriculture. Critical gaps are identified in human capacity and infrastructure.
- Without investments in higher education it is difficult to produce manpower to generate the required technologies to drive increased agricultural productivity.
- Weak institutions may have difficulties attracting and constructing effective partnerships.
- Poor infrastructure compromises the quality of training provided.

Noted:

(i) A critical mass of well trained people is necessary who can use knowledge appropriately.

(ii) Investments are needed at different training levels, not just tertiary.

(iii) In Europe, 70 % of university funds are obtained externally through individual effort of professors. This can happen in Africa.

(iv) Quality of training should be given to agriculture students.

(v) The level of preparedness of graduates to meet the needs/ demands of the job market is uncertain.

(vi) It may be detrimental for graduates to be too specialised in specific themes.

(vii) Multidisciplinary is necessary:
- Provides graduate with better capacity to fit in job market.
- Makes agriculture more interesting and attractive to students.

Important:

(i) To what extent should training be oriented towards formal employment sectors?

(ii) Can trained youth apply the knowledge to venture into agribusiness within rural areas?

(iii) How can graduates in agriculture be facilitated with resources, e.g. microfinance arrangements, to venture into self employment?

(iv) Observed that all necessary knowledge cannot be obtained at once or in one place. Thus innovative strategies needed, e.g.:
- Continuing education opportunities for agriculture graduates.
- Deliberately sequenced training, e.g., BSc first then MSc to follow after timed exposure of graduate to work environment.

(iii) Availability and applicability of relevant agricultural information/knowledge.
- After training many scientists are likely to engage in 'office' or non-field activities, thus the knowledge they hold may not readily flow to end-users.
- Often the information may not be well packaged for ready utilisation by farmers.
- Capacity of scientists to package information for use by farmers needs strengthening.
- Significant disparity between available extension agents and the population of farmers.

(iv) Agriculture not attractive to students:
- Employment opportunities not readily available in public service.
- Working locations are mostly in rural areas where life may be harsh and not all amenities are available as in urban areas or in universities. This reverse experience (from institutions with superior facilities to areas with only basic amenities) may contribute to negative perception.
- Agriculture seen simply as production of crops and livestock.
- Noted that Agriculture as an option subject has been dropped from the Kenyan high school curriculum.
- Noted there is need to integrate agriculture into other subjects taught in high school, e.g. biology, geography.

Observed:

(i) Agriculture should not be confined to only the production of food.

(ii) Need to detach agriculture from subsistence level farming.

(iii) Rather agriculture should be presented to students as a much more interesting and dynamic science that entails more including non-food application of agricultural products, e.g., industrial processes.

(iv) This approach has led to increased enrolments in agriculture in some universities in Europe.

(v) This should be adopted as a good model by African Universities.

(v) Relevance of curriculum for job markets and inclusion of emerging issues, e.g.,
- Climate change, phytosanitary issues and trade, energy farming (biofuels), etc.
- Need for stakeholders to contribute to curriculum review exercises.
- Basis for revising/reviewing curriculum need careful thought to ensure focus/goals are achieved. Should not be done for the sake of it but should orient to meeting needs of the workplace.

Suggested Solutions

(i) Enhance and improve partnerships:
- These to encompass diverse public-private and private-private partnerships.
- Access to advanced equipment and other infrastructure can be improved through partnerships, e.g. modern genomics capacity at Biosciences east and Central Africa Hub located in Nairobi Kenya. Using these will improve quality of training.
- Private sector can create partnerships with universities to support generation, evaluation and validation of technologies that contribute to their profit.
- Through attachments/visits, private and public sector institutions can provide a window for students to appreciate opportunities available for graduates in agriculture.
- Partnerships that enable universities to influence teaching of agriculture at high school level.
- Seek/create opportunities for marketing agriculture to students at high school level, e.g. through high school heads association.

(ii) Regular review of curriculum to ensure relevance to needs of employers and also to strengthen ability of graduates for self employment:
- This can only be effectively accomplished when the fate of past graduates is known. Where do they end up? Tracer studies should be conducted before curriculum review.
- Other stakeholders need to be involved in curriculum review, especially those affected by such reviews.

(iii) To promote a positive perception of agriculture:
- Universities should develop strategy to get involved in training of agriculture teachers in high schools.
- Lobbying to retain agriculture in high school curriculum;
- Curriculum needs to be structured in a way that ensures coverage of the entire value chain, from basic production to consumer point. Agriculture should not be seen only as being about crop production.
- Institutions can set aside some resources to be used for positive publicity (marketing) to promote agriculture courses.

(iv) Universities need to diversify income sources, e.g.
- Produce and market produce, e.g., unique products that universities have good capacities in;
- Levy to be instituted on those who use trained manpower or other inputs generated/produced through participation of universities (e.g. in Kenya this could be part of the levy on exported horticultural produce collected by HCDA/ KEPHIS).

(v) Improved methods of disseminating information to farmers:
- Regional centers for synthesising and packaging information that is locally relevant (possibly into languages easily understood locally).
- Use opportunities availed by current technologies, e.g., ICT.
- Establishing effective feedback loops. Obtaining information from farmers makes them partners in innovation.

(vi) To improve quality of training:

- It is necessary to improve mentoring and acquisition of teaching skills (pedagogy)
- Invest in good infrastructure or enhance partnerships to access the necessary infrastructure.
- Involve stakeholders in developing curriculum.

How prepared to respond to new demands or emerging challenges in agriculture and economies are agricultural universities and research institutions?

Chairman: Elenimo B. Khonga

Rapporteurs: Mary Abukutsa, Alexander Kahi and Ngugi Kahiu

Emerging Challenges/New demands:

(i) Need for sustainable energy. There are moves to use agricultural products to produce energy. There is the need to find a balance between agriculture for energy and for food security
(ii) Climate change.
(iii) Degradation and management of resources.
(iv) Market linkage.
(v) New kind of farmers. Famers are literate and clearly demarcated and there is need to be ahead of farmers. We should note that we are dealing with different customers who are well informed.
(vi) Food safety especially with regard to GMOs.
(vii) HIV and AIDS problems.
(viii) Land fragmentation.
(ix) Reduced enrolment into agricultural courses
(x) Gender issues.
(xi) Globalisation and internationalisation of agriculture.
(xii) Human resources development
(xiii) Policy framework.
(xiv) New tools, e.g., ICT.
(xv) New gap – between farmers and emerging supermarkets (high standard demanded).
(xvi) Increasing population.

How prepared are we?

Our level of preparedness is not optimal. However, there is the need to change our approach to development of curriculum by

(i) Involve stakeholders/public and private sector – to address the needs of the practitioners.
(ii) Regular review of curriculum.

Problems

(i) Most university lecturers and students are not hands-on. This is opposed to the situation in medicine where most lecturers are also involved in the treatment of patients.
(ii) Past negative experiences.
(iii) Other changes needed – in promotion criteria, teaching methods
(iv) Pedagogy important – lecturers need to be prepared for their duties.
(v) Measure of success? – Is it certificates, student numbers, impact on society and economic development, or ability to solve problems?
(vi) Attitude towards agriculture. Admission is based on grades and not really the attitude. Need for strategies on how to make agriculture attractive to the younger generation.

Research Institutions

How best to improve research institution to meet emerging demands:

(i) Retooling of researchers?
(ii) Researcher specialisation versus. Interdisciplinarity. Researchers should be encouraged to adopt interdisciplinary approach.
(iii) Research agenda priorities (even for universities) especially where there are no research councils like in some developing countries
(iv) Linking research with extension – e.g. farmer field school/farmers' day (open day) – important source of researchable topics
(v) Regular research review at different levels with involvement of stakeholders

Way Forward

(i) Involve stakeholders to answer their needs.
(ii) Need for coordination/collaborations for benefit of farmers.

Change necessary in response to challenges. Collaboration between Universities and research institutions also important to avoid duplication.

What is the potential of agriculture in meeting the MDGs and how can this be exploited?

Chairman: Marten Soerensen
Rapporteurs: Gatahi Mwago and Raphael Wahome

Millenium Development Goals (MDG's)

(i) The millennium goals required investment of USD 403 billion.
(ii) Agricultural research and infrastructure was targeted to cost USD 109 billion or a quarter of the total estimate, but few countries have increased their national budget for agriculture to comply with this target.
(iii) Although agriculture can contribute to all the eight goals that were set, it is directly concerned with goals number one and seven. These goals desire to:
(iv) Eradicate extreme poverty and hunger. Reduce by half the proportion of people living in absolute poverty (poverty measured by inability to earn more than one US$

per day).

(v) Ensure environmental sustainability

The role of Agriculture in the SSA

(i) A large proportion (47%) of SSA's people lives under the poverty line of one USD per day.

(ii) However, 85% of the poor depend entirely on agriculture. The people are further encumbered with traditions or culture that minimises choice of permitted food.

(iii) For example, cactus is a major vegetable grown in Mexico for food. It also grows widely in SSA, but people are generally not familiar with its potential as a vegetable food.

(iv) Contribution of agriculture to MDG depends on overcoming national constraints, prejudices and exploiting the opportunities presented by a largely untapped resource of agro-biodiversity

(v) A large proportion (47%) of SSA's people lives under the poverty line of one USD per day.

(vi) However, 85% of the poor depend entirely on agriculture. The people are further encumbered with traditions or culture that minimises choice of permitted food. For example, cactus is a major vegetable grown in Mexico for food. It also grows widely in SSA, but people are generally not familiar with its potential as a vegetable food.

(vii) This is true for many exotic foods, but even previously well-known (orphaned) and ecologically highly specialised traditional crops are currently disappearing in spite of their remarkable potential.

(viii) The contribution of agriculture to MDG depends on overcoming national constraints, prejudices and exploiting the opportunities presented by a largely untapped resource of agro-biodiversity

The Options Available To Agriculture in Development

(i) The opportunity lies either in raising productivity per unit of land or alternatively/additionally utilise the land areas defined as marginal or even arid by (re) introduction of agro-biodiversity capable of producing under such conditions. The two complimentary strategies should be to both intensify agricultural production as well as increasing the land area by novel or reintroduced crops and practices. From among the options available the following render themselves to actions with potential for success.

(ii) Improved Water management through:

- Rainwater harvesting during the rains to mitigate dry seasons and droughts. Examples include use of dams or water pans protected from evaporative water loss
- Access to irrigation using appropriate technologies within reach of small holders is needed. Examples are drip irrigation and tread pumps with sprinklers. Small scale water and soil management improvement may reduce drought effects by more than 50%.
- Increase production by the use of water efficient crops / drought tolerant crops,

and this may be accomplished by utilising a range of traditional crops locally selected for their adaptability to marginal and/or arid lands or novel introductions of agro-biodiversity from regions with limited water availability.

Soil Management Practices

(i) Use of conservation agriculture.
(ii) Organic production practices
(iii) Intercropping.
(iv) Use of high value crops, where possible.
(v) Use of varieties tolerant or resistant to pests and diseases.
(vi) Use of transgenic crops.

Efficient Water Management

(i) Water harvesting during the rains to mitigate dry seasons and droughts. Examples include use of dams or water pans protected from evaporative water loss
(ii) Large irrigation schemes for smallholder systems may not work. Irrigation using appropriate technologies within reach of small holders are needed. Examples are drip irrigation and tread pumps with sprinklers. Small scale water and soil management improvement may reduce drought effects by more than 50%.
(iii) Use of water efficient crops might work, but they require more land space.

Crop and Livestock Diversification

(i) There is need to identify the major issues constraining crop production and determine which to address first. However green revolution emphasised increase in yield through increased water and fertilizer use. This could be tried all over again but is it sustainable?
(ii) Drought tolerant crops adoption or breeding. To address food security and poverty, focus should be on staple crops. These normally form 65% of smallholder value added crops and employment. People's preference for introduced crops that were accepted as staples may need to be changed. But difficulties are foreseen because of attitudes and practices that have been built over time. Opportunity to change over exists through starting in the marginal areas
(iii) Intercropping may reduce reliance on a few crops and increase resilience.
(iv) Use of new high value crops, where possible.
(v) Use of varieties tolerant or resistant to pests and diseases.
(vi) Intensive raising of high yielding breeds.
(vii) Judicious use of transgenesis. For example, use of transgenic crops may have possibilities of contaminating the pre-existing wild type genomes. In addition, there non-scientific objections to their use making them not immediately useful. They may have a positive role in reducing use of chemical fertilizers; but will consumers be convinced about their quality. There is also a danger that domination of seed production by some nations or companies may limit their usefulness
(viii) Use of new high value crops, where possible.
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Post Harvesting Handling and Processing

(i) Avoiding harvesting, handling and storage loss:
- Encouraging post harvesting value addition
- Market development to encourage market oriented production.

New Options

(i) New agro-ecological approaches such as Combination of trees and grazing allows use of animals normally stressed by heat.
(ii) Bio-fuel crop production that give the farmer some income for poverty reduction but may also reduce food production

Unlocking Potential

(i) The potential lies in directing research towards development of appropriate technologies, more vigorously disseminating those already developed and most specifically encouraging market development and value addition. Simple solutions that multiply yields may lead to over-exploitation of the production resources making the increase unsustainable.
(ii) Nevertheless, new agro-ecological approaches such as combination of trees and pasture to minimise heat stress on animals, may allow use of more efficient breeds while bio-fuel crop production could give the farmer some extra income for poverty reduction but may also reduce food production

Resolutions / Recommendation

(i) In summary agriculture based on plant derived staples representing a wide range of crops will ensure the essential demand for food security, sustainability, nutritionally attractive diets and improved livelihood.
(ii) Using agriculture as the basis for economic growth in the agriculture-based countries requires a productivity revolution in smallholder farming.
(iii) The role of agricultural university education is to train and focus students to develop, extend and implement the relevant technologies needed for the smallholder based production revolution.

SUB-THEME 3: AGRICULTURE AND HEALTH

What are the highest priority areas for agricultural policy in support of health issues and how might higher education instructions and extension services integrate agriculture and health? Are there models to learn from?

Chairman: Jeffrey Adelberg
Rapporteurs: Barack Owuor and Jayne Njeri Mugwe

In this session, there was a presentation by Jefferey Alelberg, followed by discussions of key points emerging out of the presentation

Key Issues in the Presentation

Integrated farm systems dominate smallholder farms of Africa. The system integrates crops, animals and humans and has high levels of interaction. They are among the most sustainable systems because of high efficiency and interrelationships. However, there are heath issues resulting from interactions of the crop management, animal husbandry and benefits acquired by human beings. Health issues arise from 4 main areas:

(i) Fruits and vegetable sanitation.
(ii) Meat and dairy products.
(iii) Herbs and spices medicine.
(iv) Shrubs and fodder veterinary.

There are two pertinent issues in agriculture and health:

(i) Food and nutrition.
(ii) Health and wellbeing.

Food and Nutrition

Humans feed on contaminated products arising from agricultural practices, harvesting, post handling storage and utilisation.

Main issues

(i) Animal and veterinary diseases; Microbes are opportunists and responsible for transfer of diseases from animals to humans.
(ii) Milk and pasteurisation: Use of raw animal products are a health hazard, e.g., use of raw milk is responsible for brucellosis
(iii) Use of animal waste to improve soil fertility: It is a health hazard due to microbes present from the animal system. Use of this in compost is recommended
(iv) Use of sewage water in urban and peri-urban farming, e.g., growing vegetables creates risk of humans consuming foods contaminated with heavy metals and microbes
(v) Pesticides and insecticides is a source of direct contamination and also through the food chain
(vi) HIV and AIDS: Affects labor force due to weakness and absenteeism, and use of available funds to buy drugs instead of investing in agriculture
(vii) Informal milk marketing is a source of contaminated milk especially with chemicals. Milk is usually adulterated in order to increase profits to the traders:

Health and Well-being

It was noted that medicine has been part of agriculture since time immemorial and knowledge and information has mainly been transferred through generations using oral means

Successful models of herbal medicine include the Chinese and Indians. For example, there are 7,295 medicinal plants in china of which 1,500 have been validated. Of the 1500, 140 are included in modern medicine.

It was noted that Africa has not been given a fair share in writing history of its medicinal plants. Africa is the cradle of mankind and scholars must write history to include Africa as a centre of pharmacological diversity. In Africa, traditional use of herbal medicine is through recipes and portions, but this needs to be validated and documented.

Huge market in the range of $100 B for natural products but the share to Africa is quite small.

Recommendations

Policy matters:

(i) Develop mechanisms for encouraging farmers to engage in growing medicinal plants for market and pay them for both growing and information. Natural medicine is diversified, indigenous, it is more profitable for farmers and medicine is more prestigious.

(ii) Address impediments to marketing. Currently marketing of medicinal plants is faced by a myriad of problems that include lack of access to capital for investment, inadequate information on marketing leading to poor prices, post harvest and packaging and inadequate technical information.

(iii) Governments should develop mechanism for availing necessary information, knowledge and technologies that can spur growing of medicinal plants by farmers

(iv) A major problem is over-exploitation that has led to some species becoming threatened, e.g., *Prunus africana*. Government should come up with exploitation and marketing policy framework that allows fair marketing and control over-exploitation

(v) The smallholder farming communities face problems of health resulting from agricultural practices, food handling and utilization. Government should have extension personnel posted to rural areas to assist farmers address these constraints. Water is an important commodity in sanitation and governments should intensify their efforts in availing clean water to all citizens

Training Institutions and Agricultural Research

(i) More efforts to document history of medicinal plants in Africa

(ii) Validation of efficacy of medicinal plants supported by data. Be aware of experimental error to interacting factors in humans. It would be better to first exploit animals

(iii) Review curriculum in institutions of higher learning to include topics of medicinal plants and safety in agricultural practices and food handling (harvesting and processing)

(iv) Review of curriculum in middle level colleges to include topics in safety in agriculture and especially harvesting, handling and utilization. The resulting graduates to be

posted to educate communities on hygiene and safety methods of handling and utilisation of food

(v) Need for capacity building for food handlers, processors and farmers in matters of agriculture and health. This can include short term training at the grassroots

SUB THEME 4: AGRICULTURAL CHALLENGES AND GRADUATE PROFILE

Do the existing curricula equip students with life skills and emerging issues?

Chairman: N. Kumar
Rapporteurs: Wariara Kariuki and Vitalis Opondo

A few universities may do but generally many are not able to, but there are differences

(i) In Europe, courses prepare students to solve problems and are not specific to a career path. More general courses are being offered regardless of later places of work
(ii) Inclusion of English language in Mexico and India to prepare students to work anywhere on the globe.
(iii) Need to emphasise cultural activities to better prepare students for the world they will face, need for integrated approach to learning, compulsory in some universities
(iv) Harmonise training with job market requirements.
(v) Review of curricula to specify learning outcomes and other expectations (skills and knowledge), including consultations with stake holders.
(vi) Graduates should be relevant in any part of the world, regional institutions(e.g., in Europe and America) involved in ensuring this-challenge for Africa
(vii) Students not getting skills to think broadly, too much specialization e.g., on agricultural production; need to train to face challenges in work environment-innovativeness in problem solving, leadership skills, entrepreneurship etc. Need for more extra-curricula activities
(viii) Problem in pedagogy, continued use of outdated methods, need to change and be updated on new teaching methods; done mostly in the developed countries only
(ix) Need to focus on teaching approaches, demand in job market for soft skills, analytical skills, attitudes, emotional intelligence etc. Employers value hands-on experience thus in many cases less interest in technical skills
(x) Alumni associations are useful in assessing the relevance of agricultural training courses to students.

Do the graduates posses the knowledge and skills required for promoting sustainable development?

(i) Semester system results in compartmentalisation of knowledge, with students losing interest in a course after the exam, need to demand application of knowledge and skills acquired early in later semesters
(ii) How do we balance needs of the universities and requirements of the employers?
(iii) May reduce quantity of learning and focus on quality, allowing students to have time to learn about global issues
(iv) How flexible are universities with regard to dynamism in the world?
(v) Stakeholders should be involved in curriculum development from inception, involve them also in implementation of curricula e.g., teaching, supervision
(vi) Student mobility should be encouraged, current university administration and governments need to be flexible, e.g., to allow students to gain experience in other countries/universities

(vii) Too many students and inadequate facilities to allow proper skills development, many cases on demonstrations done. Instructor to student ratio too small as well as too many other activities and commitments for instructors.
(viii) Too heavy workloads for both instructors and students, not allowing time for other important issues such as research and innovations
(ix) Governments should make efforts to institute periodic training sessions for both graduates in the field and farmers.

Are the universities effectively sensitising prospective and in-coming students to make agriculture a career of choice?

(i) The people who first come in contact with new students may have no knowledge of agriculture
(ii) May need to set up marketing/publicity units to communicate with prospective students. Universities should visit schools to create interest in agric as is done in Mexico, explaining the various prospects and career choices with Agricultural education
(iii) Interest in Agric can only improve if the sector is attractive to students, e.g., by being profitable. Agric in many countries associated with poverty and drudgery.
(iv) Have excellent/model commercial units in the universities so that the students can see the benefit/profitability of agric activities
(v) Involve policy-makers in visibility of prospects in agriculture.

SUB-THEME 5: CLIMATE CHANGE

What are the effective mechanisms and policy challenges for making farming systems of rural poor less vulnerable to climatic change?

Chairman: Redimio M. Pedraza Olivera
Rapporteurs: David M. Mburu and Peter Mwirigi

There is need to formulate or modify existing policies on climate change adaptation and mitigation that would include:

(i) Farmer education on climate change by different organizations in the rural communities.
(ii) Prioritization of areas needing urgent attention.
(iii) Identify factors that lead to climate change.
(iv) To help the farmer to micro manage the climate.
(v) Appropriate cultivation practices.
(vi) Investigate the current policies and assess the level of implementation.
(vii) Efficient water use policy in terms of conservation and recycling.

The role of universities in Research and Development

(i) The Universities' core business is instruction and education.
(ii) Clearly identify research topics and solicit research funds.
(iii) Intensify research on climate change.
(iv) Documentation and dissemination of technologies and information on climate change.

Tools to overcome climate change

(i) Awareness creation.
(ii) Accountability
(iii) Change in attitude of communities and individuals regarding climate change.

In addition:

(i) Farmers need to use the climate change information more efficiently.
(ii) It is not only the climate changing, but the ecology is also changing.
(iii) Adoption of new technologies that can cope with climate change.

How should universities integrate climate change adaptation and resilience into agricultural curriculum? Are there models to learn from?

(i) Climate change is affecting all disciplines of learning for example it is in medicine, agronomy, engineering etc. Hence needs integration.
(ii) The climate science is not only one part. Majority of people think that climate is more of meteorology, which is wrong! This is a practical science!
(iii) The main goal of the universities is to prepare man for his/her future and should also include politicians. The university has a greater role in shaping the society as whole.
(iv) For curriculum to be successful there is need for universities to emphasize more on outreach programs than previously done.

(v) The issue of climate change can be incorporated in the curriculum whereby it is made a core course.
(vi) Retraining extension staff to new conservation approaches-Teachers needs also to take refresher courses on climate change.
(vii) Mainstreaming climate change into the education curricula like the way HIV-Aids is taught in most other programmes.
(viii) Make environmental studies to be attractive to students.
(ix) Integrate climate change into the social sector even at family level to change the attitudes of people towards climate adaptation and mitigation.

Are there models to learn from?
(i) Example from Cuba. Education from instruction and values encouragement.
(ii) Participatory model based on a bottom-up approach
(iii) Predictive/forecast model based on *scientific studies*.

Recommendations/way-forward
(i) Revise the curriculum to incorporate issues on climate change.
(ii) Mainstreaming climate change in the existing curriculum
(iii) Less reliance on fossil fuels since this is the largest contributor to climate change-look for alternative sources of fuel.
(iv) Increase genetic variation of crops and animals for specific agro-ecological zones.
(v) Implementation of adequate policies and establishment of subsidy on agricultural inputs especially those that directly relate to climate change.
(vi) Integration of climate change issues into all programs and disciplines is needed.

RESOLUTIONS

SUB-THEME 1: AGRICULTURE AND FOOD SECURITY

(i) Universities should involve stakeholders at all stages of research process from formulation to dissemination of the results. The research should address the national and international development agenda.

(ii) Universities and research institutions should forge functional collaborations and partnerships to enhance productivity and avoid duplication.

(iii) Universities and other stakeholders should advocate for increased investment in agricultural research, innovations and technology transfer.

(iv) Universities should promote crop diversification to ensure food security and sustainability.

SUB-THEME 2: AGRICULTURE AND SUSTAINABILITY

(i) Universities should strive to be centres for development and increase their visibility in development processes and policy formulation.

(ii) Universities should produce students who are innovative and equipped with technological know-how to address the challenges in the agricultural value chain.

(iii) Universities should forge strategic public-private partnerships for quality, scope and up scaling and commercialisation of technologies.

SUB-THEME 3: AGRICULTURE AND HEALTH

(i) Universities and research institutions should develop cost-effective technologies for ensuring production of high quality and safe food and medicinal products

(ii) Universities and research institutions should produce human resources with knowledge and skills to address botany, agronomy, processing and pharmacology of medicinal plants.

(iii) Universities and research institutions should adopt systems approach in research and training with cross-cutting themes involving human, animal and ecosystem health.

(iv) Universities and Research Institutions should develop human resource to manage new and emerging infectious diseases.

SUB-THEME 4: AGRICULTURAL CHALLENGES AND GRADUATE PROFILE

(i) Universities should market agricultural programmes actively and innovatively by re-defining agriculture for relevance, literacy and building consensus for change.

(ii) Universities should develop aggressive recruitment and retention strategies by encouraging internships for students, connecting discovery and education and creating a linkage between students and industry.

(iii) Stakeholders should be involved in curriculum development and review from inception to implementation.

(iv) Universities and governments should promote student and staff mobility and flexibility to allow them gain experience in other countries/institutions.

(v) Universities should set up marketing/publicity units to communicate with prospective students and promote a positive perception of agriculture.

(vi) Universities should create excellent/model agricultural commercial units to serve as learning models and sources of income.

(vii) Universities need to apply integrated approach to learning to impart soft skills, analytical skills, attitudes and emotional intelligence to students.

SUB-THEME 5: CLIMATE CHANGE

(i) Universities and governments should adopt integrative and interdisciplinary approaches to climate change.
(ii) Universities should develop research models and education strategies to mitigate and adapt to the effects of climate change.
(iii) Universities should include/mainstream agro-forestry and climate change training in university curriculum.
(iv) Universities should seek active involvement in the formulation of appropriate policies that relate to climate change.

SUB-THEME 6: AGRICULTURE AND ENERGY

(i) Universities should develop new curricula in food sciences, bio-renewable energy and agro-resource sciences to create new opportunities and openings for students in a rapid expanding and innovative bio-economy.

(ii) Universities should seek active involvement in the formulation of appropriate policies and legal framework that relate to renewable energy.

CLOSING SPEECHES

CLOSING REMARKS

Prof. Mabel Imbuga
Vice Chancellor, Jomo Kenyatta University of Agriculture and Technology

The Minister for Agriculture, Hon. William Ruto, cabinet ministers, permanent secretaries, distinguished guests, ladies and gentlemen.

I am pleased once again to address this auspicious gathering as I did couple of days ago - this time as we witness a momentous occasion, the closing ceremony of the 6th Conference for the Global Consortium of Higher Education and Research for Agriculture (GCHERA). Painful as it is to part, dear participants, I am certain that the lessons acquired in the forum will remain in our memories for a long time to come.

Ladies and gentlemen, to claim that the conference was merely an eye-opener is indeed an understatement, for a lot has transpired since the opening ceremony four days ago. We have, during the conference, come to terms with experiences met in virtually all corners of the globe. We have heard of many success stories resulting from the input of committed agricultural researchers and scholars. We for instance followed keenly strategies that were put in place to raise student enrolment in a number of agricultural institutions of higher learning in various parts of the world. We were guided through the rigorous process that led to some agricultural training institutions raising their status into major producers and exporters of agricultural products, thanks to painstaking resilience and a focused approach to research. The conference also reached at several resolutions, key among them being the urge to universities to involve all stakeholders at all stages of research; the call on universities to improve methods of disseminating information to farmers; the need for universities to increase interactions with policy makers; the importance of involving stakeholders in curriculum development; building up of a new infectious diseases workforce, and, equally important, encouragement of student mobility. On the other hand, the conference also served to bring us closer to the grim reality facing the agricultural sector all over the world. That the youth in most parts of the globe are increasingly steering clear of agricultural courses in favour of disciplines they deem more lucrative is no longer a whisper. Likely, our deserts are expanding by the day and weather patterns getting unpredictable, making agricultural investment a risky business undertaking, and worsening the already pathetic food security situation in many parts of the world.

Ladies and gentlemen, it is imperative that we all join hands together – under our umbrella of hope, GCHERA – to counter the said challenges if the ordinary farmer, and the entire agricultural sector, is to continue being relied upon for human survival. Agricultural universities and research institutions have a great role to play here – providing leadership informed by research tailored to address problems of the day. As it has been reiterated on several platforms, the agricultural sector will for ever remain moribund if our professors restrict their working lives to delivering lectures and papers without practically getting in touch with happenings at the grassroots level. Let us all rise to this challenge, dear participants – we must show the path, we must lead the way.

As I conclude, I wish to once again extend my sincere thanks to GCHERA Executive Committee, the Local Conference Organising Committee and the various sub-

committees for the arduous work that culminated in the remarkable success we have seen in the running of this conference. Equally, I thank the Bill and Melinda Gates Foundation, Alliance for Green Revolution, DAAD and Kenya Institute of Management for material partnership with Jomo Kenyatta University of Agriculture and Technology that enabled the smooth handling of various logistical issues in the run up to, and during the conference. The Government of Kenya, through the Office of the President, Ministry of Higher Education, Science and Technology and Ministry of Agriculture also deserve special recognition for assistance extended to us at various levels during preparations for this conference. Importantly, I am most obliged to note the great role played by all participants who have made the conference a success.

As we look forward to the next GCHERA Conference in France in June 2011, I call upon the Executive Committee to devise viable means of keeping the consortium active during the intervening period, and indeed in between successive conferences in the coming years. This will make GCHERA active and continually relevant to future generations. For the participants, I need not to emphasise that there remains much to be done within our crucial agricultural sector, as we have seen in this conference. Wherever we shall be, let us in one way or another make a contribution towards the betterment of our immediate environments.

Ladies and gentlemen, while wishing you success in all agricultural endeavour back at home, I once again thank you for your role in this conference. For us at Jomo Kenyatta University of Agriculture and Technology, the 6th GCHERA Conference is a major historical event that will keep our spirits high for many generations to come.

May I now wish you God's blessings as you travel back to your homes and various work stations. Happy Christmas season and prosperity in the coming years.

Kwaheri!

CLOSING SPEECH

Hon. William Ruto
Minister for Agriculture, Kenya

Distinguished guests, ladies and gentlemen.

I am greatly elated to preside over this closing session of the 6th Conference of the Global Consortium for Higher Education and Research for Agriculture. To us in the Ministry of Agriculture and Kenyans at large, it will remain a lasting source of pride that a local institution of higher learning, Jomo Kenyatta University of Agriculture and Technology, has had the opportunity to host the conference for the first time in Africa.

Through hosting the conference, we in Kenya and others, especially those in the developing world, have had a priceless chance to pick up useful lessons for our agricultural sector, especially as regards University level training. I am therefore urging key players in this area to seek ways of responding with urgency to the relevant resolutions raised in this conference for the sake of our national development. My ministry on its part will continue, as we have always done, supporting viable initiatives aimed at ensuring stability in the agricultural sector, and by extension food security for our populations.

Ladies and gentlemen, I have no doubt that we in this gathering are all aware of the challenges facing the agricultural world at the moment – some of these being water scarcity and drought, unpredictable weather patterns occasioned by global warming and the never ending crises in the energy sector. The said hurdles have been further compounded by the global recession which has spared no economic sector or sub-sector worldwide. I am happy that these are the critical areas that this conference particularly focused on. It is in this regard quite gratifying that the academic fraternity is coming out full force to address the major problems afflicting the society, rather than remaining mere trainers and researchers operating remotely from the masses. Indeed, this laudable path is the ideal one for our institutions of higher learning – we must strive at all times to be responsive to the needs of the communities we operate in. As geographical patterns such as weather, global temperatures and sea levels continue taking hitherto unwitnessed trends, participants in such conferences as this should provide leadership and guidance on such matters as viable seed and livestock varieties, and water and energy conservation measures, so that the ordinary peasant farmer is not at any time adversely exposed to these occurrences. Dear participants, it will be imprudent for us to spend heavily on higher education training and research while at the same time maintaining heavy reliance on donor food assistance. This is a challenge we should strive to respond to with satisfaction.

Finally, ladies and gentlemen, I wish to underscore the continuing close relationship between my ministry and institutions of higher learning in Kenya, especially universities offering agricultural courses. We have for years developed partnerships aimed at improving lives to the ordinary Kenyans, and many more are in the pipeline. I wish to hereby call upon our agricultural universities and other players in the sector not to hesitant to seek our hand in partnership should any viable idea come to the fore – we will always be willing to take up such challenges.

It is now my great pleasure to declare the Sixth Conference of the Global Consortium for Higher Education and Research for Agriculture officially closed.

Thank you very much.