Bioversity
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Learning agrobiodiversity: options for universities in Sub-Saharan Africa

Proceedings of a regional workshop
21-23 January 2009, Nairobi, Kenya

Per Rudebjer, Boudy Van Schagen, Sebastian Chakeredza, Henry Kamau, *editors*

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Bioversity International is an independent international scientific organization that seeks to improve the well-being of present and future generations of people by enhancing conservation and the deployment of agricultural biodiversity on farms and in forests. It is one of 15 centres supported by the Consultative Group on International Agricultural Research (CGIAR), an association of public and private members who support efforts to mobilize cutting-edge science to reduce hunger and poverty, improve human nutrition and health and protect the environment. Bioversity has its headquarters in Maccarese, near Rome, Italy, with offices in more than 20 other countries worldwide. The Institute operates through four programmes: Diversity for Livelihoods, Understanding and Managing Biodiversity, Global Partnerships and Commodities for Livelihoods.

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Local vegetable market in Stown Town, Zanzibar, courtesy of © Frances Ferraiuolo, Bioversity International.

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Contents

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Acronyms

ABIA	Agricultural Biodiversity Initiative for Africa
ACP	Africa, Caribbean and Pacific
AHT	Africa Humid Tropics
ALVs	African leafy vegetables
ANAFE	African Network for Agriculture, Agroforestry and Natural Resources Education
AnGR	Animal Genetic Resources
ASB	Alternatives to Slash-and-Burn Programme
CBD	Convention on Biological Diversity
CBO	Community-based organizations
CGIAR	Consultative Group on International Agriculture Research
COL	Commonwealth of Learning
COMESA	Common Market for Eastern and Southern Africa
CTA	ACP-EU Technical Centre for Agricultural and Rural Cooperation
DACUM	Developing a curriculum
EAPGREN	East Africa Plant Genetic Resources Network
ECA	Eastern and Central Africa
FAnGR	Farm animal genetic resources
FAO	Food and Agriculture Organization of the United Nations
FARA	Forum for Agriculture Research in Africa
FFS	Farmer field school
FNPP	FAO-Netherlands Partnership Programme
ICRAF	World Agroforestry Center
ICT	Information and communications technology
IK	Indigenous knowledge
IPR	Intellectual property rights
LMO	Living modified organism
MA	Millennium Ecosystems Assessment
NAFT	National Agricultural Forum for Training
NARES	National agriculture research and extension systems
NARS	National agricultural research systems
NGO	Non-governmental organization
NTFP	Non-timber forest product
PAR	Platform for Agrobiodiversity Research
PBRs	Plant breeders' rights
PGR	Plant genetic resources

PRA	Participatory rural appraisal
PRSP	Poverty Reduction Strategy Paper
RAFT	Regional Agricultural Forum for Training
RUFORUM	Regional Universities Forum for Capacity Building in Agriculture
SA	Southern Africa
Sahel	the Sahelian countries
SRO	Subregional organization
SSA	Sub-Saharan Africa
SUCAPRI	Strengthening of University Capacity for Promoting, Facilitating and Teaching Rural Innovation Processes
TRIPs	Trade Related Intellectual Property Rights
UNEP	United Nations Environment Programme
UPOV	Union for the Protection of New Plant Varieties

Preface

Agricultural biodiversity includes the diversity of plants, animals, fish, trees and microbes that are used directly or indirectly for food and agriculture. The human race could not survive without access to this diversity, which enables plant and animal species to evolve and adapt to different growing conditions. Yet we have both undervalued this critical resource and squandered it, with the result that agricultural biodiversity is at greater risk now than at any time in recent history.

While the value of agricultural biodiversity is not widely known, over the past few decades a growing number of scientists and policy-makers have started to take it more seriously. Nowhere is this more evident than in the sector of crop diversity, where a lot of work has been done by various organizations and countries. However, even in the domain of crop diversity, a lot more effort has been put into *ex situ* conservation and much less on *in situ* conservation and use and the management of diversity on farms. There is also the matter of policy and public awareness in relation to advancing the causes of better management and use of agricultural biodiversity. All these are areas that require greater efforts in research, education and development.

Bioversity International, as the world's largest research organization dedicated solely to the conservation, management and use of agricultural biodiversity, has been playing a leading role in this area. Bioversity recognizes the important role that education plays in the proper management and use of biodiversity and has, over the last decade, contributed substantially to strengthening capacity development in plant genetic resources and lately in the management and use of agricultural biodiversity. Bioversity has collaborated with universities in developing MSc programmes in this field of learning, including work on plants, animals, fish and microbial biodiversity and the processes that sustain functional agro-ecosystems. The socio-cultural aspects associated with the knowledge of biodiversity are also key elements of this work. It is time to take stock of how this broader concept is being taught in higher education and how training curricula in universities could be strengthened.

In recent years, policy-makers and scientists have been paying increasing attention to agricultural biodiversity. The effects of climate change, actual and potential, have given even more weight to the importance of this resource and the urgency for its conservation. Climate change will have a great impact on biodiversity, including agrobiodiversity. But agrobiodiversity also holds a key to strategies for adaptation to climate change; it encompasses the genes that will be needed to adapt varieties and species to the new conditions in any given future climate. Currently, agricultural biodiversity is a thematic programme under the Convention on Biological Diversity. The International Treaty on Plant Genetic Resources for Food and Agriculture, which entered into force in 2004, has secured the open access to germplasm of 64 of the world's most important food and fodder species and genera. On the conservation side, there is an increasing awareness that production landscapes – where farmers are custodians of agricultural biodiversity – will play a critical role in biodiversity conservation.

Because of these developments, agrobiodiversity needs to enter university curricula in a broader fashion, to prepare graduates for a future where there is an increasing need for both conserving and using agrobiodiversity sustainably. Consultations with universities and surveys of curricula have revealed that agrobiodiversity rarely features as an entity in the university curriculum, or even as a dedicated course. Innovative approaches for integrating agrobiodiversity into curricula are needed.

This regional workshop is the first regional consultation to address agrobiodiversity education in universities in Sub-Saharan Africa. It is important that universities, educational networks and policy-makers take note of the results of this workshop and take action to start integrating this important area of learning into Africa's higher education system.

Kwesi Atta-Krah
Deputy Director General, Bioversity International

Executive summary

The workshop '**Learning agrobiodiversity: options for universities in Sub-Saharan Africa'** was held in Nairobi from 21 to 23 January 2009. This first regional workshop of its kind gathered 46 participants from universities and international organizations in 16 African and two European countries. The **objectives** of the workshop were to:

- share knowledge and experiences on the current status and trends of the science, practice and policy of agrobiodiversity
- discuss the implications for and feasible approaches to, mainstreaming agrobiodiversity in higher education in Sub-Saharan Africa
- explore modalities and mechanisms for strengthening agrobiodiversity education and research in Africa through networking and joint learning.

The opening session of the workshop was chaired by Prof. John Saka, the Board Chair of the African Network for Agriculture, Agroforestry and Natural Resources Education (ANAFE), who also gave an opening address. Opening remarks were given by Dr Mikkel Grum, Acting Regional Director, Bioversity International, Dr Dennis Garrity, Director General, World Agroforestry Centre and Dr Judith Ann Francis, Senior Programme Coordinator, Science and Technologies Strategies, ACP-EU Technical Centre for Agricultural and Rural Cooperation (CTA). Dr Aissetou Yayé, Executive Secretary of ANAFE then introduced the workshop programme. **Part I of these proceedings summarizes the opening session and gives a background to the workshop**.

Dr Paul Kibwika, a consultant, facilitated the workshop process, which was designed to identify options for mainstreaming learning of agrobiodiversity in universities in Sub-Saharan Africa. 'Buzz-groups' were formed to extract key issues emerging from expert presentations. Working in groups and in plenary, the participants then made a four-step analysis.

- **Situation analysis of agrobiodiversity and the context of its teaching and learning:** definitions of agrobiodiversity; megatrends and patterns impacting on agrobiodiversity; stakeholders.
- **Analysis of curricula and key issues for mainstreaming agrobiodiversity content:** opportunities and niches for agrobiodiversity education in higher education; gaps in content relating to agricultural biodiversity; critical issues for mainstreaming agrobiodiversity in higher education.
- **Job profiles of graduates and approaches and options for mainstreaming:** profiles of graduates; approaches to facilitate agrobiodiversity education; options for mainstreaming of agrobiodiversity in higher education.
- **Action Plan, Task Force and agrobiodiversity curriculum framework.**

The **results of the workshop sessions are presented in Part II of these proceedings.** These outputs include:

- a **draft curriculum framework**, consisting of 10 learning 'clusters' (Annex 2). For each cluster, the rationale, key learning points and suggested content were identified. These would be further developed after the workshop, in dialogue with the workshop participants and other key stakeholders

- five different options for **mainstreaming of agrobiodiversity** in higher education were identified and their advantages and challenges listed (page 17)
- a joint **Plan of Action** was agreed upon and a Task Force was set up to lead the work to follow up on the workshop results (page 19).

Part III of this report contains presentations by experts from national and international organizations on the many dimensions of agrobiodiversity. Similarly, educational experts talked about educational issues of relevance to agrobiodiversity. The presentations provided the thematic background for the working groups and aimed to harmonize participants' knowledge and build awareness of the complexity of agrobiodiversity conservation and use. This part of the proceedings may be used as a resource book in future curriculum development.

In conclusion, the need for mainstreaming agrobiodiversity in higher education in Africa was confirmed. Given the positive results of this workshop, efforts should be made to offer a similar workshop for French-speaking Africa. Because of the complexity of teaching the multi-disciplinary subject of agrobiodiversity, the Task Force should seek advice and draw lessons learned from related areas of education, such as agroforestry or integrated farming systems.

Part I. Opening and setting the scene

Why this workshop?

Agricultural biodiversity - the subset of biodiversity important for food and agriculture – is a source of products that sustain livelihoods and services that maintain ecosystem functions. Agrobiodiversity and sustainable development are intimately related. Agrobiodiversity provides resilience to livelihood systems through the ability to mitigate and adapt to systems change and shocks. Agrobiodiversity maintains ecosystem functions through water and nutrient cycling, pest and disease regulation and pollination. Agrobiodiversity is also a part of our cultural heritage.

The pressure on ecosystems is higher than ever before. The Millennium Ecosystems Assessment (MA) found that 60% of the ecosystem services examined were degraded or used unsustainably. One key finding was that *'The degradation of ecosystem services could grow significantly worse during the first half of this century and is a barrier to achieving the Millennium Development Goals.'* [1] The sense of urgency to act is reflected in the environmental conventions on climate change, biodiversity conservation and desertification, all of which have a strong link to the management of agricultural biodiversity.

The availability of well-educated professionals who can perform research on agrobiodiversity, advise on its use and undertake proper conservation, is critical to successfully meeting these challenges. The relatively recent concept of 'agrobiodiversity' is subject to a rapidly increasing body of research, covering a wide range of disciplines and methodologies, including cutting-edge molecular genetics, traditional breeding and pre-breeding[2], environmental services, market analysis and value-chain enhancement, traditional knowledge and cultures, etc. This research has generated a body of state-of-the-art knowledge that needs to enter curricula.

A 2007 survey of selected universities in eastern and southern Africa revealed an absence of comprehensive agrobiodiversity education programmes, or dedicated courses on agrobiodiversity. Isolated courses related to agrobiodiversity are taught at some universities but an agreed approach to teaching and learning the subject is lacking. Graduates would therefore not be fully aware of the role of agrobiodiversity for enhancing the value, productivity and sustainability of African agro-ecosystems.

It is time to review current approaches to agrobiodiversity education, analyse gaps in content or delivery and advise on ways forward, in order to making the most of agricultural biodiversity. This effort is in line with World Bank recommendations to address shortcomings in Sub-Saharan agriculture education by, among others, 'training a new generation of agricultural professionals with different skill sets' [3].

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[1] Millennium Ecosystem Assessment, 2005. Ecosystems and Human Well-being: Synthesis. Island Press, Washington, DC.

[2] Pre-breeding is a form of genetic enhancement and refers to all activities designed to identify desirable characteristics and/or genes from un-adapted materials.

[3] World Bank 2007. Cultivating Knowledge and Skills to Grow African Agriculture. Agricultural and Rural Development Notes. Issue 29, December 2007.

Bioversity International therefore partnered with the African Network for Agriculture, Agroforestry and Natural Resources Education (ANAFE), the Regional Universities Forum for Capacity Building in Agriculture (RUFORUM) and the ACP-EU Technical Centre for Agricultural and Rural Cooperation (CTA) in organizing the workshop 'Learning agrobiodiversity: options for universities in Sub-Saharan Africa' in Nairobi, on 21-23 January 2009.

This partnership ensures that the workshop outputs reach the majority of African universities and beyond:

- ANAFE is a network of 131 educational institutions in 35 African countries whose objective is to strengthen the teaching of multi-disciplinary approaches to land management
- RUFORUM is a consortium of 25 universities in eastern and southern Africa, with a mandate to oversee graduate training and networks of specialization in the Common Market for Eastern and Southern Africa (COMESA) countries
- CTA has a mission is to strengthen policy and institutional capacity development and information and communication management capacities of ACP (Africa, Caribbean and Pacific) agricultural and rural development organizations.

In total 46 participants, from 16 African and two European countries, attended the workshop. They represented universities, national agricultural research systems (NARS), regional education networks and genetic resources networks and international organizations. Most participants had a background in agriculture or forestry, while there was a limited representation of, for example, livestock and social science disciplines.

Opening address

The Opening Session of the workshop was chaired by **Prof. John Saka, ANAFE Chair Person**, who also gave an opening address. Prof. Saka said that ANAFE was very happy to be associated with this workshop because the objectives were consistent with those his organization. He told the workshop participants that ANAFE was launched in 1993 and is now one of the largest networks of educational institutions in Africa, with member institutions covering the whole of Sub-Saharan Africa. It has a membership of 128 African universities and colleges in 34 African countries, working to transform agricultural education and improve its quality, relevance and application. The World Agroforestry Centre has played an important role in launching and nurturing ANAFE and now hosts the ANAFE Secretariat at its headquarters in Nairobi, Kenya.

The initial objective of ANAFE was to incorporate agroforestry and multi-disciplinary approaches into agricultural education. This initiative has resulted in major and significant success. Many colleges and universities are teaching agroforestry as a part of agriculture, forestry or natural resource programmes and also as a separate discipline. Over the years, the ANAFE mandate has been expanded to include the overall transformation of agriculture and natural resources education.

In June 2007, ANAFE was registered as an international non-govermental organization (NGO). ANAFE's current mission is 'To improve agricultural education for impact on development'. This can be achieved through a wide range of activities including policy advocacy, institutional reforms to link education to development, review of curricula, development of learning resources, facilitating knowledge sharing, promoting women and youth in agriculture, HIV/AIDS mitigation, sound environmental practices, mitigation and adaptation to climate change, quality education assurance and risk management in agriculture.

ANAFE is a decentralized organization that conducts its work through four regional chapters known as RAFTs (Regional Agricultural Forums for Training) There is one RAFT each in Eastern and Central Africa (ECA), Southern Africa (SA), the Sahelian countries (Sahel) and the Africa Humid Tropics (AHT). Under the RAFTS, there are 21 ANAFE national chapters known as NAFTs (National Agricultural Fora for Training).

On behalf of the ANAFE Board and the joint organizing committee comprising also Bioversity, CTA and RUFORUM, Prof. Saka thanked all participants for accepting the invitation to this important meeting. He thanked the partners for excellent networking in the conceptualization and realization of this workshop. He also commended ICRAF for hosting and the regional office of Bioversity for facilitating the workshop. Finally, he thanked the leading partners, especially CTA and Bioversity, for funding the workshop and all partner institutions including Heads of Universities and Colleges for allowing their staff to participate.

He expressed the hope that all participants would devote their energies to a successful and productive workshop and that the next actions led by the joint Task Force will ensure implementation of the workshop recommendations. He noted that ANAFE was pleased that the four institutions are working together – ANAFE has a memorandum of understanding with RUFORUM – and expressed the hope that this will be the case also with matters of capacity building.

Prof. Saka then declared the meeting open, wishing all a productive workshop and looking forward to valuable outputs and a clear road map.

Opening remarks

Dr Mikkel Grum, Acting Regional Director, Bioversity International, in his opening remarks noted that agricultural biodiversity is a challenging subject. In its broadest definition it encompasses all aspects of general biodiversity conservation and use. Wild relatives of crops, domestic animals, trees and fish exist in wild ecosystems, along with pollinators, pests, diseases, weeds and many other organisms that impact on agricultural production systems.

In a narrower definition, agrobiodiversity is the diversity within agricultural production systems, developed through intensive management by humans. The fate of this diversity is entirely in the hands of human beings. On closer inspection it becomes obvious that there are no clear boundaries between domesticated and 'wild' agrobiodiversity.

Dr Grum said that the challenge that lies before us includes looking at how we deliver a topic of such complexity and with so many nuances to the next generation of scientists, in ways that will enable them to provide real solutions to real world problems.

On behalf of Bioversity and its Regional Director, Dr Jojo Baidu-Forson, Dr Grum welcomed participants to Nairobi and wished them fruitful deliberations.

Dr Dennis Garrity, Director General, World Agroforestry Centre, made his opening remarks on behalf of the hosting organization of this workshop. He emphasized that agrobiodiversity is a 'frontier issue' to students and universities. Dr Garrity noted the importance of conserving and nurturing agrobiodiversity. He expressed hope in quotes from President Barack Obama's inauguration speech, where he talked about 'restoring science to its rightful place' and 'harnessing the sun and the winds and the soil'.

Dr Garrity said that agrobiodiversity is important at different scales, from plot level to the global scale. The enormous genetic diversity in trees is a particular challenge and one is humbled by the task of characterizing this diversity and applying appropriate conservation and management options.

In his address, Dr Garrity also highlighted the Second World Congress on Agroforestry, being organized by the World Agroforestry Centre and the United Nations Environmental Programme (UNEP), to take place on 23-28 August 2009 and expressed hope that the congress will be linking universities and science.

Dr Judith Ann Francis, Senior Programme Coordinator, Science and Technologies Strategies, ACP-EU Technical Centre for Agricultural and Rural Cooperation (CTA) mentioned in her opening remarks that CTA recognizes that agriculture is underperforming and that agrobiodiversity is important, not only its conservation, but also its contribution to wealth creation. Recognizing the interdisciplinary nature of biodiversity she noted that collaboration and networking is an opportunity to charting a way for the future.

Learning and science are central to CTA's approach. Since a 2005 meeting in Paris, CTA has included biodiversity in its programmes. Dr Francis said it is necessary to engage with policy-makers and emphasized the need for curriculum reform at all levels. The capacity and quality of innovators and enterprises need to be enhanced to take African biodiversity into the future.

Finally, she encouraged the workshop organizers and participants to transfer lessons from this workshop to other regions.

Overview of workshop objectives, outputs and programme

Dr Aissetou Yayé, Executive Secretary, ANAFE then introduced the workshop programme, attached in Annex 1. Dr Yayé said that advancing higher education is all about collaboration; south/south collaboration in particular. We are trying to avoid isolation, she pointed out. ANAFE is working closely with RUFORM to build capacity of African universities. The networks look forward to strengthening south/south collaboration further.

Dr Yayé then gave an overview of the workshop objectives and expected outputs and emphasized that outputs should be extended beyond the English-speaking world to French- and Portuguese-speaking countries.

Finally she thanked all the Vice Chancellors and Deans who are supporting this process. She said that she was looking forward to a powerful document coming out of this conference, which could also be presented at the World Agroforestry Congress.

Partner organizations

Launched in April 1993, **the African Network for Agriculture, Agroforestry and Natural Resources Education** (ANAFE) presently (2009) comprises 131 universities and colleges in 35 African countries. Initially created to incorporate agroforestry and multi-disciplinary approaches into agricultural education, ANAFE's mandate has expanded to include agriculture and natural resources education. ANAFE's current mission of 'improving agricultural education for impact on development' is achieved through activities including policy advocacy; knowledge sharing; promoting women and youth in agriculture; HIV/AIDS mitigation; mitigation and adaptation of climate change; review of curricula and development of learning resources, etc. ANAFE works through four regional chapters known as RAFTs (Regional Agricultural Fora for Training)—one each in Eastern and Central Africa (ECA), Southern Africa (SA), Sahelian countries (Sahel) and the Africa Humid Tropics. ANAFE has national chapters, NAFTs (National Agricultural Fora for Training) in 21 countries.

The Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA) is a non-political organization of the National Agricultural Research Systems (NARS) of ten countries—Burundi, D. R. Congo, Eritrea, Ethiopia, Kenya, Madagascar, Rwanda, Sudan, Tanzania and Uganda. Through ASARECA, agricultural scientists in the 10 countries work together and in partnership with farmers, extension, private sector, scientists of regional and international institutions, and development partners to come up with new innovations for agricultural-led economic growth, poverty eradication and improved livelihoods in Eastern and Central Africa. **The Eastern Africa Plant Genetic Resource Network** (EAPGREN) is a project under the Agrobiodiversity and Biotechnology program of ASARECA whose primary aim is to enhance capacity development for sustainable utilization and conservation of plant genetic resource in eastern Africa.

The Commonwealth of Learning (COL) is an intergovernmental organization created by Commonwealth Heads of Government to encourage the development and sharing of open learning and distance education knowledge, resources and technologies.

The Technical Centre for Agricultural and Rural Cooperation (CTA) was established in 1983 under the Lomé Convention between the ACP (African, Caribbean and Pacific) Group of States and the European Union Member States. Since 2000, it has operated within the framework of the ACP-EU Cotonou Agreement. CTA's tasks are to develop and provide products and services that improve access to information for agricultural and rural development, and to strengthen the capacity of ACP countries to acquire, process, produce and disseminate information in this area. CTA is financed by the European Union.

The Food and Agriculture Organization of the United Nations leads international efforts to defeat hunger. Serving both developed and developing countries, FAO acts as a neutral forum where all nations meet as equals to negotiate agreements and debate policy. FAO is also a source of knowledge and information. The Organization helps developing countries and countries in transition modernize and improve agriculture, forestry and fisheries practices and ensure good nutrition for all. Since its founding in 1945, FAO has focused special attention on developing rural areas, home to 70 percent of the world's poor and hungry people.

The Regional Universities Forum for Capacity Building in Agriculture (RUFORUM) is a consortium of 25 universities in Eastern, Central and Southern Africa established in 2004. The consortium had previously operated as a program of the Rockefeller Foundation beginning in 1992. It has a mandate to oversee graduate training and networks of specialization in the Common Market for Eastern and Southern Africa (COMESA) countries. Specifically, RUFORUM recognizes the important and largely unfulfilled role that universities play in contributing to the well-being of small-scale farmers, and economic development of countries throughout the Sub-Saharan Africa region. RUFORUM's vision is a vibrant agricultural sector linked to African universities which can produce high-performing graduates and high-quality research responsive to the demands of Africa's farmers.

Part II. Workshop objectives, process and results

Objectives and expected outputs

The **objectives** of the workshop were to:

- Share knowledge and experiences on the current status and trends of the science, practice and policy of agrobiodiversity
- Discuss the implications for and feasible approaches to, mainstreaming agrobiodiversity in higher education in Sub-Saharan Africa
- Explore modalities and mechanisms for strengthening agrobiodiversity education and research in Africa through networking and joint learning.

The expected **outputs** were:

- Synthesis of trends and emerging issues in agrobiodiversity and their implications for higher education
- Curriculum guidelines/framework for agrobiodiversity education, including outline of key curriculum components
- Options for mainstreaming biodiversity education in higher education identified
- An action plan for mainstreaming agrobiodiversity in higher education in Africa
- Mechanism for interaction between communities of agrobiodiversity researchers and educators for continued learning and sharing of knowledge and experiences
- Workshop proceedings.

Workshop process

The 3-day workshop included two main parts. The first part aimed at capturing the state-of-the-art knowledge of agricultural biodiversity: what it is, why it is important, the issues that are emerging and the methodologies available for enhancing conservation and use of agrobiodiversity. Continuing efforts to strengthen higher agricultural education in SSA were considered, with an emphasis on regional initiatives, networks and innovation systems. Experiences regarding curriculum needs and reforms were shared.

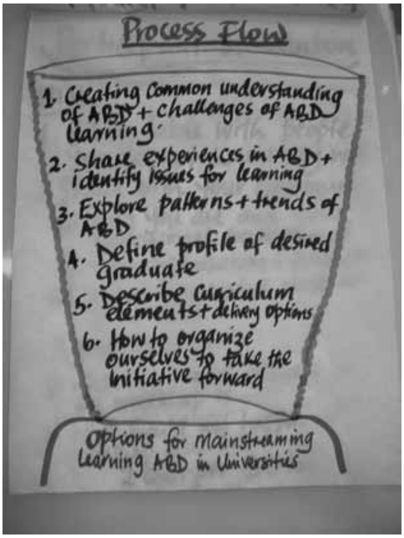
The second half of the workshop was a participatory process, led by an external facilitator, to identify options for mainstreaming agrobiodiversity in curricula, to develop a draft curriculum framework and to prepare an action plan for future implementation of workshop recommendations.

The workshop process and facilitation principles were introduced by **Dr Paul Kibwika, Facilitator** of the workshop. He described the expected workshop 'process flow', in six steps:

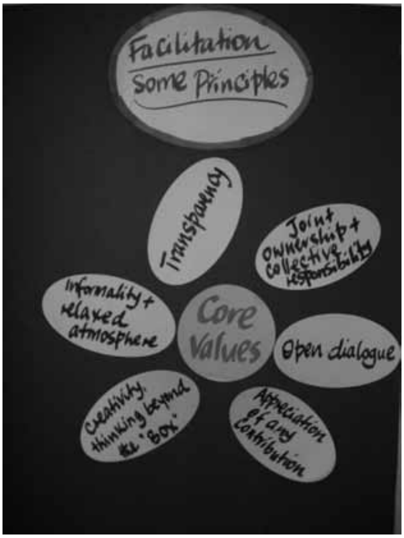
- Create a common understanding of agrobiodiversity and challenges of agrobiodiversity learning
- Share experiences in agrobiodiversity and identify issues for learning
- Explore patterns and trends in agrobiodiversity
- Define profile of desired graduates
- Describe curriculum elements and delivery options
- Define how to organize ourselves to take this initiative forward.

Dr Kibwika also introduced six workshop principles:

- Joint ownership and responsibility
- Open dialogue
- Appreciation of all contributions
- Creative and innovative thinking
- Informal interaction and atmosphere
- Transparency.



The workshop's process flow



Core values of the workshop

Building on the expert presentations (Part III of these Proceedings) and participants' knowledge and experience, a series of workshop sessions – 'buzz group' discussions, group work and plenary discussions – analysed the needs for teaching and learning of agrobiodiversity in universities in Sub-Saharan Africa. The work proceeded as follows:

1. **Situation analysis of agrobiodiversity and the context of its teaching and learning**
   - Definitions of agrobiodiversity
   - Megatrends and patterns impacting on agrobiodiversity
   - Stakeholders
2. **Analysis of curricula and key issues for mainstreaming agrobiodiversity content**
   - Opportunities and niches for agrobiodiversity education in higher education
   - Gaps in content relating to agricultural biodiversity
   - Critical issues for mainstreaming agrobiodiversity in higher education
3. **Job profiles of graduates and approaches and options for mainstreaming**
   - Profiles of graduates
   - Approaches to facilitate agrobiodiversity education
   - Options for mainstreaming of agrobiodiversity in higher education

- Action plan, task force and agrobiodiversity curriculum framework
- Action plan and task force
- Agrobiodiversity curriculum framework.

Situation analysis of agrobiodiversity and the context for its teaching and learning

Definitions of agrobiodiversity

A discussion emerged in the workshop on the definition of agrobiodiversity. The working groups therefore studied several different definitions, two of which are cited here:

Convention on Biological Diversity (CBD)

'Agricultural biodiversity is a broad term that includes all components of biological diversity of relevance to food and agriculture and all components of biological diversity that constitute the agricultural ecosystems, also named agro-ecosystems: the variety and variability of animals, plants and micro-organisms, at the genetic, species and ecosystem levels, which are necessary to sustain key functions of the agro-ecosystem, its structure and processes' (Conference of the Parties decision V/5, appendix).

Source: www.cbd.int/agro/whatis.shtml

United Nations Food and Agriculture Organization (FAO)

'The variety and variability of animals, plants and micro-organisms that are used directly or indirectly for food and agriculture, including crops, livestock, forestry and fisheries. It comprises the diversity of genetic resources (varieties, breeds) and species used for food, fodder, fibre, fuel and pharmaceuticals. It also includes the diversity of non-harvested species that support production (soil micro-organisms, predators, pollinators) and those in the wider environment that support agro-ecosystems (agricultural, pastoral, forest and aquatic) as well as the diversity of the agro-ecosystems.'

Source: www.fao.org/docrep/007/y5609e/y5609e01.htm

Megatrends and patterns impacting on agrobiodiversity

Working in five groups, the participants identified megatrends and patterns now and in the next 15 years that would make it crucial to mainstream learning and teaching of agrobiodiversity in university education. The groups' analyses focused on: food and agriculture, science, technology and innovation, environment and ecosystems, socio-cultural values and income and partnerships involved.

Group 1. Megatrends – food and agriculture

Changing food and nutrition patterns:

- More people needing food security
- People consuming more animal products as a result of increased income

- Growing interest in 'exotic food'
- Increase in organic food, fair trade, etc.
- Awareness of nutrition and health benefits of agrobiodiversity (including medicines).

Impact of changing food habits on land use and agricultural biodiversity:

- Globalization, market influence on agrobiodiversity
- Mono-cultures more dominating
- Continued conversion of land use to agriculture, rather than intensification
- Increase in use of modern crops/varieties
- Loss of traditional, indigenous crops and varieties, creating vulnerability
- Increased fish farming
- Biofuel vs. food production issues
- Increased use of agrobiodiversity (e.g. interest in neglected and underutilised species).

Group 2. Megatrends – science, technology and innovation

Changing use of agrobiodiversity:

- Discovery of new products (for food, nutrition, health and other uses) from plants and animals
- Medicinal and aromatic plants playing a more significant role in human health
- Increased prospecting for biodiversity in Africa
- More demand for underutilized plant and animal species
- More domestication of plant and animal species
- Information and communication technologies (ICT) playing a more significant role in managing agrobiodiversity.

Advances in breeding:

- Agriculture will rely more on wild species for the transfer of desired traits (modern biotechnology)
- Conventional breeding will use genes as diverse as possible
- Indigenous knowledge incorporated in modern science
- Improved documentation of agrobiodiversity.

Group 3. Megatrends – environment and ecosystems

Changes of agro-ecosystems:

- Increasing human population and growing demand for goods and services from the environment
- Increasing livestock population
- Deforestation and forest degradation in Africa will continue to increase
- Changes in natural habitats of species
- Loss of biodiversity and threats to biodiversity hot spots
- Erosion of biodiversity for food and agriculture
- Expansion of monocultures (e.g. rice, sugarcane, maize, wheat, forest plantations, livestock)
- Change in land use towards biofuels
- Decreasing availability of sources of fuel.

Global environmental impacts, including climate change:

- Increased pollution – air, land and water
- Increased invasive and alien species in ecosystems
- Reduced fish stocks in natural water systems
- Reduced availability of fresh water; some lakes and rivers will dry up
- Concern for impact of climate change on agricultural biodiversity
- Increased occurrence of extreme weather events, such as flooding and drought
- Changing rainfall patterns
- Increasing need for data and new knowledge on agrobiodiversity and the environment:
    - How climate change will influence agrobiodiversity
    - How agrobiodiversity changes will influence ecosystem sustainability.

Group 4. Megatrends – socio-cultural values and income

Demographic trends and impacts on agriculture:

- Population expansion
- Increased demand for food
- Urbanization, associated with:
    - Changing food habits and markets
    - Food substitution
    - Supermarket revolution in food marketing
    - Shift from traditional to modern diets
- Increased pollution
- Pressures on natural recourses for agricultural purposes
- Need for fast-growing crops
- Need for irrigation
- Need for drought-tolerant genotypes.

Changing food preferences:

- Awareness of and increased demand for, healthy and quality food
- Likely re-introduction of traditional foods
- More emphasis on producing high-value plants and animals.

Social and institutional trends:

- Loss of indigenous knowledge
- Increased awareness of gender issues
- Empowerment of women and youths in African societies leading to equity and equality
- Improved education and use of ICT
- Improved entrepreneurship.

Group 5. Megatrends – Partnerships

The fifth group discussed the status of partnerships relating to agrobiodiversity education and research (Table 1).

Table 1. Current and desired status of partnerships for agrobiodiversity education and research

	Current	Desired
Universities	Poor links between public and private universities Duplications	Strong networks to create synergism and quality performance Credit transfer South-south partnerships Partnerships with all stakeholders
Research institutions	Poor links between research institutes and disciplines Duplications	Research platforms Focus on relevance South-south partnerships

Stakeholders

The workshop participants also identified key stakeholders in agrobiodiversity education. These would need to be mobilized to support the process of mainstreaming agrobiodiversity education. The key stakeholders include:

- Farmers and natural resource managers
- Ministries, departments and agencies of agriculture, forestry, fisheries and environment
- Policy-makers
- Universities
- Research organisations and networks, including national agriculture research and extension systems (NARES)
- NGOs and community-based organizations (CBOs)
- Private sector
- CBD
- Consultative Group on International Agriculture Research (CGIAR)
- Platform for Agrobiodiversity Research (PAR).

Analysis of curricula and key issues for teaching and learning agrobiodiversity

Opportunities and niches for agrobiodiversity education in higher education

What are the opportunities and niches for teaching and learning agrobiodiversity in higher education programmes? The groups identified six opportunities and niches that could facilitate mainstreaming agricultural biodiversity in higher education (Table 2).

Table 2. Opportunities and niches for mainstreaming agrobiodiversity in higher education

Opportunities/niches	Aspects and mechanisms to consider
Concerns for climate change and initiatives to take action	Improved knowledge of climate change Adaptation to climate change
Increasing interest in and awareness of the importance of agrobiodiversity for ecosystem sustainability	Global interest in biodiversity Agrobiodiversity is important at different levels: farmer, landscape, national and global Growing interest in diversification Need for agrobiodiversity learning
Existing related programmes in universities and existing human capacity	Existing programmes in universities and colleges can be enhanced with agrobiodiversity content Many aspects of agrobiodiversity are already being taught in universities The region has experience in curriculum development and review Existing agrobiodiversity courses and institutional frameworks Existing staff capacity
Existing networks and platforms can be tapped to facilitate mainstreaming agrobiodiversity in universities	Networking of institutions for harnessing resources Existence of key networks working in areas relevant to agrobiodiversity, e.g. ANAFE, RUFORUM Use of existing platforms (ANAFE, RUFORUM) in capacity building Make use of existing resources in CGIAR and NARS to develop learning resources Identify/develop ‘centres of excellence’ Existing knowledge centres on agrobiodiversity National and international platforms Exchange programmes - human resources exchange across universities (short/log term) Sharing information through existing or creating agrobiodiversity newsletter
Interested agencies to support the mainstreaming of agrobiodiversity	Fellowships Supportive international institutions: CTA, Bioversity, ANAFE, etc.
ICT as a mechanism for exchange of knowledge and delivery of agrobiodiversity programmes	Use of ICT in sharing and disseminating agrobiodiversity information More ICT-based learning

Gaps in content relating to agricultural biodiversity

Having identified opportunities and niches for agrobiodiversity, the participants sought to answer the question 'What are the glaring gaps in agrobiodiversity education?' (This workshop did not specifically review current curricula.) The participants responded to this question based on their personal experiences as lecturers or research and development professionals. The five working groups captured their ideas on cards, which were then organized into clusters during a plenary session. Eleven 'gap areas' relating to agrobiodiversity curriculum content emerged (Table 3).

Later in the workshop, these areas were re-visited, to form the first draft curriculum framework (Annex 2).

Table 3. Gaps in content relating to agricultural biodiversity

Area of content	Topics
The value chain of agrobiodiversity	Effect of trade on agrobiodiversity
	Markets
	Marketing of new products
	Utilization and value addition
	Processing
	Economic valuation of agrobiodiversity
	Value chain, traditional vs. modern
	Value chain up-scaling
	Commercialisation of agrobiodiversity, including underutilised species
	Benefits of products
Effect of climate change on agrobiodiversity	Impacts of climate change on agrobiodiversity: modelling
	Impact of agriculture intensification
	Threats to agrobiodiversity and management of those threats
Socio-economic issues, conflicts, demographic dynamics	Agrobiodiversity linking to livelihood
	Inter-linkages between agrobiodiversity and nutrition and health
	Nutrition and food science, socio-economic anthropology
	Food security
	Nutritional security
	Food composition
Ecosystems services, including carbon sequestration	Links between agrobiodiversity and ecosystems services
	Payments for environmental services
	Environmental accounting
	Ecotourism
	Influence of fragmentation on natural habitats

Table 3. Gaps in content relating to agricultural biodiversity (cont.)

Area of content	Topics
Genetic resources: plants, animals, microbial biodiversity	Domestication of agrobiodiversity Animal genetic resources Below-ground biodiversity Aquatic biodiversity Breeding, including biofortification Pollination ecology, pollination aspects and effects Taxonomy Neglected and underutilized plants
Awareness/promotion of agrobiodiversity potentials	Public-private partnerships (internships/research) Optimisation of public/private interests
Conservation through use	Skills for agrobiodiversity conservation Traditional conservation strategies (*ex situ*) On farm conservation Inter- and intraspecies diversity Revitalisation of disappearing crops and animals
Local knowledge	Traditional conservation strategies Agrobiodiversity and farmer innovations Sensitisation to the value of indigenous knowledge on agrobiodiversity Databases
Systems approach to teaching and learning agrobiodiversity	What to conserve? How much to conserve? Underutilized and neglected species Mosaic landscapes
Cross-cutting areas of knowledge	Data collection methodology, biometrics and statistics Participatory learning

Critical issues for mainstreaming agrobiodiversity in higher education

What are the key issues for ‘mainstreaming’ the conservation and use of agrobiodiversity in universities’ teaching and learning? The participants identified seven critical issues and listed a series of constraints/observations, that need to be considered by universities interested in enhancing their teaching of agrobiodiversity (Table 4).

Table 4. Critical issues for mainstreaming agrobiodiversity in higher education

Key issue	Constraints/observations
How to stimulate interest and make agricultural-related disciplines relevant so that they are attractive to stakeholders, including students	Limited job opportunities Little interest in studying agriculture; limited career opportunities
How to integrate relevant disciplines and develop a holistic approach to learning and teaching agrobiodiversity	Fragmentation of components of the value chain Lack of convergence in traditional disciplines Poor understanding of genetic variation within species Lack of integration of agrobiodiversity across sectors Lack of integration of indigenous/local knowledge with scientific knowledge Neglect of local knowledge Lack of systems approach in extension and teaching Lack of multidisciplinary collaboration Lack of mechanisms for fostering interdisciplinary integration Failure to approach agrobiodiversity teaching, learning and research from a multi-disciplinary perspective
How to clarify and distinguish the concept of agrobiodiversity	The concept of agrobiodiversity is not well known Lack of clear definitions of agrobiodiversity Unclear/wide scope of agrobiodiversity: holistic, interdependent, both biotic and abiotic, landscape systems, etc.
How to address agrobiodiversity issues in a comprehensive and holistic manner at all levels of university training	No agrobiodiversity curriculum Rigid existing curricula structures: need to regularly review and change when necessary Identify the entry point, e.g. an undergraduate core course for agriculture and natural resources' management; environmental studies
How to reorient academic staff in emerging issues and enhance their abilities to facilitate learning of agrobiodiversity	Inadequate competence of staff in agrobiodiversity Human capacity Lack of emphasis on learning vs. teaching Lack of capacity and expertise in agrobiodiversity among trainers Limited availability of knowledge on diverse species Rigid mindset Limited capacity to conceptualize and facilitate learning in agrobiodiversity
How to build and sustain partnerships and networks for enhancing the learning and teaching of agrobiodiversity	Poor/unclear linkage between research and action Weak networks of research and training Weak links between conservationists and universities
How to mobilize resources to support mainstreaming of agrobiodiversity in university education	Limited financial support Lack of learning resources Unclear policy on agrobiodiversity Infrastructural development for teaching and learning

Job profiles of graduates and approaches and options for mainstreaming

Profile of graduates

What should a graduate (at professional level) be able to do, in order to appropriately respond to megatrends relating to agricultural biodiversity? The participants listed the following tasks (Table 5).

Table 5. Job profile of graduates relating to agrobiodiversity

Area of competence	Tasks
Sustainable livelihood	Determine relations between agrobiodiversity and livelihood and manage agrobiodiversity for sustainable livelihood
	Support use of neglected and underutilized species
	Demonstrate the contribution of agrobiodiversity to sustainable livelihood and ecosystems
	Manage and facilitate use of different forms of knowledge, including indigenous knowledge, in use and conservation of agrobiodiversity
Conservation of genetic diversity	Assess diversity in agro-ecosystems, using participatory methods
	Understand ecological principles of agro-ecosystems
	Design conservation strategies, *ex situ*, *in situ* and on farm
Integrated natural resources management	Apply a systems approach to management and conservation of agrobiodiversity
	Identify, map and characterize all components of agrobiodiversity
	Manage integrated, complex systems
	Design and implement adaptive management strategies on agrobiodiversity
	Communicate agrobiodiversity issues at various levels
	Constructively operate in interdisciplinary/multidisciplinary teams
	Work with people in related disciplines
	Mobilize and coordinate activities of all stakeholders for effective management and sustainable use of agrobiodiversity
	Create and facilitate platforms for interaction, dialogue and joint action on agrobiodiversity issues, engaging a wide range of stakeholders
Policy advocacy and implementation	Advise farmers, policy-makers, etc. on policy issues
	Lobby, advocate and dialogue to influence policy reforms to promote and integrate agrobiodiversity in the value chain
	Articulate and consciously apply policy and legal requirements at national, regional and international levels, to ensure fairness and equity in sharing benefits of agrobiodiversity
	Implement policies, e.g. the International Treaty on Plant Genetic Resources for Food and Agriculture
Research and development	Facilitate and undertake research on agrobiodiversity
	Design and conduct research in agrobiodiversity using available tools and methods
	Think critically and facilitate collective initiatives for conservation, rehabilitation and restoration of agrobiodiversity
	Stimulate and support enterprise development for increasing benefits of agrobiodiversity to individuals and the society (value addition)

Approaches to facilitating agrobiodiversity education

Against this analysis, the workshop participants then suggested a set of approaches that could facilitate the mainstreaming of agrobiodiversity (Table 6).

Table 6. Approaches to facilitate the mainstreaming of agrobiodiversity education

Educational approaches	Aspects/mechanisms to consider
Participatory design of education, responding to market needs	Respond to the demand of students in renaming and redesigning degree programmes for the job market
	Have a bottom-up approach based on problem-solving and addressing knowledge-to-action
Inter-disciplinary design and delivery	Teach agrobiodiversity as a multi-disciplinary subject
	Integrated agrobiodiversity courses
	Participatory and multi-/inter-/intra-disciplinary curricula development
	Joint academic programmes between faculties and between universities within a region
	Teach health issues, working with medical doctors
Experiential and practical-oriented delivery methods	Examining students on the application of knowledge-into-action
	Attachments and internships for students, including practical attachments
	Mentoring of the next generation, e.g. through paid assistance-ships
Flexible learning approach	Introduce modular learning

Options for mainstreaming of agrobiodiversity in higher education

How should universities respond to this need for developing competences for conserving and managing agrobiodiversity? Working first in groups, then in plenary, the workshop participants suggested five different, but complementary, options for mainstreaming of agrobiodiversity in higher education, each one with its advantages and challenges (Table 7):

- Option 1. Integrate agrobiodiversity in existing curricula
- Option 2. Short courses in agrobiodiversity (on-the-job training)
- Option 3. Diploma in agrobiodiversity
- Option 4. Postgraduate Diploma
- Option 5. MSc and PhD options.

Table 7. Options for mainstreaming of agrobiodiversity in higher education

Option	Advantages	Challenges
Integrate in existing curricula	Cost effective: use of existing resources Value-addition to the programme – integrates emerging issues Integration can be 'soft' and gradual Easy to implement Easy to be approved by the bureaucratic process Catalyses change	Complete profile of agrobiodiversity graduate not realized Difficult to integrate due to inflexibility of programmes Limits the coverage of agrobiodiversity issues
Short courses	Easy enrollment Easily fit in individuals working schedules Easier to mount Easier to get resource persons Cost effectives No age limits Flexible in time, venue etc Does not require formal approval Targets those in the job market May be offered by distance learning Can target/tailor user groups Can be platform for sharing across stakeholders Can be adapted for e-learning	Limited time for delivery Limited number of participates per enrollment Heterogeneity of participants Limited depth
Diploma in agrobiodiversity	Provide a pool of field oriented technicians Work closer with stakeholders Cost-effective because it is cheaper to train large numbers More women are enrolled in Diploma programmes Take less time to graduate	Limited value addition because graduates have too narrow competence Inadequate basic sciences limits students understanding of agrobiodiversity Limited knowledge as the Diploma programme is short Less chance of employment

Table 7. Options for mainstreaming of agrobiodiversity in higher education (cont.)

Option	Advantages	Challenges
Postgraduate Diploma	Learn content fast	Less research competence
	Allows specialization and diversification after acquiring basic agriculture knowledge	Does not add to the number of people in the labour market
	Students have field experience	
	Can be upgraded to Masters	
	Students can work with farmers	
	Can attract more women	
MSc and PhD options	Greater scope for in-depth studies (basics already covered)	Human capital, resources at local and regional levels
	Thesis and dissertation – research, publications	Takes longer to develop a program and get approval (long term strategy)
	Opportunity to create new programs – flexibility in program design	Situation analysis/needs assessment required to establish readiness of labour market for the graduates
	Existing platform at regional levels (facilities, human resources, finances)	
	May attract students if properly designed	

Action Plan, Task Force and agrobiodiversity curriculum framework

Action Plan and Task Force

A **Task force** on agrobiodiversity education was established at the workshop, consisting of representatives of Bioversity International, RUFORUM, ANAFE and CTA.

The Task Force will lead the implementation of the workshop recommendations, which were captured in a draft Action Plan (Table 8).

Agrobiodiversity curriculum framework

Building on the workshop results described above, the participants started developing a curriculum framework. First, ten ‘clusters’, or topics, of the curriculum were agreed upon. Secondly, the clusters were assigned to small working groups, who describe them in greater detail. For each cluster, the groups drafted: Introduction; Main learning points; Contents; Methods; Bibliography and; Internet resources. The curriculum framework, consisting of the preliminary clusters or topics is attached in Annex 2. NOTE: This framework is incomplete and preliminary and will require further consultation post-workshop, a process which is lead by the Task Force. The aim is to publish a final document, preliminary entitled ‘Guidelines for Developing Agrobiodiversity Curricula’ in 2010.

Table 8. Action Plan for mainstreaming agrobiodiversity education

Task	Process	Who?	Time frame	Notes
Establish a Task Force on agrobiodiversity education	Develop Terms of Reference for Task Force An inclusive process is important Main actors to confirm in writing RUFORUM and ANAFE influencing universities Bioversity has a key supporting role, (e.g. sharing scientific information) and can contribute staff time of from its Capacity Development Unit in Nairobi and Rome	ANAFE RUFORUM Bioversity CTA Chair: to be confirmed (ANAFE has been suggested)	February	RUFORUM and ANAFE playing complementary roles Collaboration a key for success
Workshop proceedings	Editing Printing Distribution	Bioversity taking the lead (Per Rudebjer), in consultation with the Task Force and Paul Kibwika	Mid-May	Production and distribution sponsored by Commonwealth of Learning
Finalize the curriculum framework	On-line Wiki dialogue Hosted at Platform for Agrobiodiversity Research (PAR) http://www.agrobiodiversityplatform.org/	Boudy Van Schagen (lead) + committed WS participants + additional interested stakeholders	1st draft by end February	Involve other ANAFE/ RUFORUM members Participants to propose other interested persons
Finalize a strategy for mainstreaming agrobiodiversity at different levels of education	Analyze and validate the options for mainstreaming identified in the workshop Reach a consensus on strategic approach for enhancing agrobiodiversity abilities at the respective level of education: BSc, MSc and short courses Meeting is needed to discuss how to move forward	Task Force		The framework should be an open source, for everyone to use
Summary paper/ workshop brief	Capture key messages from the workshop Used for creating awareness within universities and among other stakeholders To facilitate resource mobilization	ANAFE, RUFORUM	May	Review and inputs of Bioversity, CTA and other partners
Engaging/ informing other stakeholders	Plan an awareness 'campaign' to inform relevant stakeholders, including Association of African Universities (AAU), SROs and others Inform Deans and Vice Chancellors of relevant faculties	ANAFE, RUFORUM	To be decided	
Sharing workshop process and outputs with West and Central Africa institutions	Detailed process to be developed Assess needs for a follow-up workshop for Francophone countries Seek funds for translation of workshop outputs in French	Task Force	To be decided	

Table 8. Action Plan for mainstreaming agrobiodiversity education (cont.)

Task	Process	Who?	Time frame	Notes
Verifying needs through additional data collection on agrobiodiversity education.	Approach to be discussed and agreed upon Using the themes of the curriculum framework to analyse how these are addressed in training programmes could be one way forward Status of agrobiodiversity education verified, documented and shared Comparisons between regions an option	Task Force	To be decided	
Share the workshop outputs at World Agroforestry Congress 23-29 August, 2009	Synergies between agrobiodiversity and agroforestry a starting point Inform the Congress about what is happening in African Universities The logical place for a contribution would be the Technical Session on 'Integrating Disciplines through Agroforestry Education', which Aissetou Yaye is leading ANAFE to discuss with the conference's global organizing committee and report back to the Task Force Format to be decided (presentation or poster?)	ANAFE to discuss with the conference's global organizing committee and report back to the Task Force Task Force to prepare the workshop paper/ poster	August 2009	
Resource mobilization	Build a case for the need to facilitate mainstreaming of agrobiodiversity in higher education Process to be defined Need to identify clearly defined outputs What does the Task Force want to get out of the process? Phased approach Realistic budget Potential co-funding partners to be identified Bring stakeholders together	Task Force	?	

Part III. Presentations

Session 1 – Creating a common understanding of agrobiodiversity and challenges of teaching agrobiodiversity in universities

Chair: Mikkel Grum

Keynote presentation: Agrobiodiversity in food systems, ecosystems and education systems

Per G. Rudebjer
Scientist, Capacity Development Unit, Bioversity International

Introduction

The worlds' food system needs to feed a growing population at a time of rapid change in consumer demands and threats such as those posed by climate change. To increase food security, the general approach has been intensification through a combination of genetic, agronomic and agrichemical measures, in an increasingly globalized market.

Some Asian countries, like China and Vietnam, have used this approach successfully (but often at environmental costs). Many other countries, especially in Sub-Saharan Africa, still fall short of the MDG targets for food security, leaving millions of poor farmers hungry at least part of the year. These farmers often live in marginal areas less suitable for modern 'green revolution' agriculture, or else lack capital and resources to purchase improved seeds, fertilizer and agrochemicals required for such varieties to thrive.

Farmers in marginal areas often depend on agriculture based on locally domesticated landraces of a wide variety of species, including wild species. Low external inputs and informal seed systems are key features. Risk mitigation, rather than maximum yield, is often a key strategy. Preferred varieties tend to be robust and resistant to stresses such as drought or pests. Yet, scientists in agricultural science and development have only recently started to work with farmers to understand and enhance such traditional systems.

Farmers are also custodians of valuable genetic resources that have often vanished from modern agricultural landscapes and that contain traits that might be used for breeding new varieties, such as those required in the adaptation to climate change. Farmer-managed genetic resources also play a key role in the implementation of the conventions on biodiversity, combating desertification and climate change. Agrobiodiversity, including below-ground microorganisms, contribute to providing ecosystems services that are necessary for a sustainable agriculture.

This paper first discusses agrobiodiversity in food systems, comparing modern intensive agriculture with traditional agriculture systems. Secondly it discusses the function and trends of agrobiodiversity at the ecosystems level. Lastly, the paper reflects on how university education today is addressing agrobiodiversity in its education programmes and what might be desirable for future curriculum reviews.

Agrobiodiversity in food systems

Global agriculture has come to depend on a very narrow range of crops. Only three – rice, wheat and maize – account for about half of the world's intake of calories and protein and 30 crops provide 95% of our food energy. This is to be compared with the estimated 7000 plant species that have been used for food or animal feed globally at one time or other, or around 150 that are commercialized on a global scale (Wilson, 1992).

Tropical agricultural development has, since the 1960s Green Revolution, followed a shift from a traditional to a modern agricultural approach (Table 9). This shift has succeeded in raising the production many-fold in Asia's 'rice bowls' or in high-potential wheat- and maize-growing areas. It has been less successful in other environments such as the uplands in Southeast Asia, or in the dryland areas of Sub-Saharan Africa. In such areas, hundreds of neglected and underutilized plant and animal species continue to be important locally or sub-regionally, in particular for poor communities.

Table 9. Comparison of modern and traditional agricultural approaches

Modern	Traditional
High yield strategy	Risk management strategy
Few species	Many species, including those collected in the wild
Commodities with global market chains	Short market chains
Supermarket dominance	Subsistence/local markets (some also have important regional markets);
Standardized products, to meet market requirements	Variable products, lack of standards and regulations
Specialization along the value chain	Integrated systems
Modern varieties, including hybrids, designed for specific environments	Robust landraces to withstand stress
Breeding by research centres and seed companies	Traditional variety selection by farmers
Formal seed systems, including private sector	Informal seed systems (often exchanged for free)
High input of seeds, fertilizers, agrochemicals, irrigation	Low input – low output
Advanced agricultural technologies, including food processing	Limited/low-tech post-harvest processing
Policy-intensive, including competition with subsidized production in the North	Neglected by policy-makers
Scientific knowledge system	Traditional knowledge system
Fast food - dominates research and development investments in agriculture	Slow food - limited investment in innovation and education

Modern agriculture is often linked to negative environmental impacts, including: loss of biodiversity, unsustainable water use and pollution of soil and water by agrochemicals and excess fertilizers.

There is an alarming erosion of the genetic complexity of agrobiodiversity, caused by substitution of modern varieties for local landraces, by habitat loss and by degradation, both in natural and agricultural ecosystems. For example, in Nepal, the area planted to modern rice varieties increased from only 7000 hectares in 1965 to 1.16 million ha in 2000 (Figure 1), leading to an alarming loss of local cultivars. Some of these varieties and their wild relatives, are conserved in genebanks, but not all can be saved that way. Conservation of genetic resources *in situ* and on farms is a critical complement to genebanks.

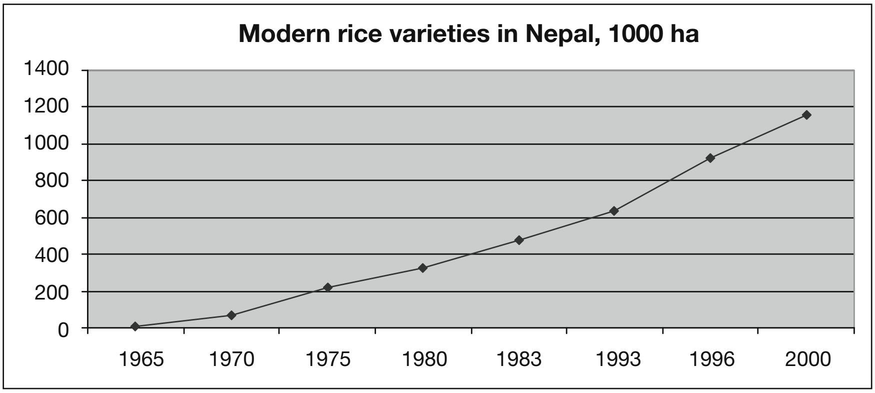


Figure 1. Area (1000 ha) planted (or harvested) to modern varieties of rice in Nepal. Source: FAOSTAT Database, 2006, Rome.

Similarly, the world's animal genetic resources for food and agriculture are threatened and many breeds have been lost in the last 100 years. It is estimated that 20% of the worlds' breeds are at risk and that 9% are already extinct (FAO, 2007).

Forest genetic resources, on which millions of people depend for food and traditional medicines and many other products, are under great stress, given the continued deforestation and degradation of forest resources, as reported by FAO's Forest Resource Assessment (FAO, 2005).

A key question is: can the worlds' food systems make better use a broader range of agrobiodiversity? Some recent trends give hope: Globally, there is an increasing interest in exotic food, facilitated by cheap transport and effective market chains. Supermarkets now sell food from all over the world, products that were hard to find only a few years back. Organic agriculture and fair trade are growing fast too. Speciality foods, such as cacao or coffee, have a brisk market, at premium prices. Such trends provide new opportunities for farmers to participate gainfully in the market chain.

There is a growing awareness of the value of using a wider range of diversity in the food systems. Traditional/local grains, pulses, vegetables and fruits can also often be very nutritious. Neglected and underutilized species, such as minor millets, leafy vegetables or local fruits, are starting to gain increased attention in research, development and marketing. The launch, in November 2008, of 'Crops For The Future' www.cropsforthefuture.org/, to promote, inform and share knowledge about neglected and underutilized species, is one example of this recognition.

Bioversity International has in the last decade led successful projects to commercialize species such as quinoa in Peru, African leafy vegetables in Kenya, minor millets in India or rocket salad in Italy. Many more species are waiting to be 'discovered'.

The tools and methods developed for such enhancement can now be scaled up for a wider range of crops and in a broader geographic area. The tools differ from main-stream agronomy because they require a focus on the entire production and marketing chain and a strong emphasis on participatory action research. This is in stark contrast to the specialization along the market chain that is found in commodity crops. These differences have repercussions regarding what and how to teach.

Agrobiodiversity in ecosystems

Not only does agrobiodiversity include includes plant, animal and forest genetic resources. It also provides services such as pollination, soil processes, watershed services and carbon and nutrient cycling, all of which are required for sustainable agriculture development. Agrobiodiversity contains the genetic variation that is required for continued adaptation and evolution of species (essential for the adaptation to climate change). Accordingly, the Convention of Biological Diversity (CBD) includes ecosystem functions in its definition of agrobiodiversity:

> '… all components of biological diversity that constitute the agro-ecosystem: the variety and variability of animals, plants and micro-organisms, at the genetic, species and ecosystem levels, which are necessary to sustain key functions of the agro-ecosystem, its structure and processes' (CBD, 2000).

In the past decade, policy-makers have become aware of the role of agrobiodiversity in sustaining production systems for future generations. Originally not mentioned in the Convention on Biological Diversity, agrobiodiversity was added in a decision at the third Conference of the Parties in 1996 (CBD, 1996). Agrobiodiversity is currently a thematic programmes under the CBD. The UN Convention on Combating Desertification also depends on agricultural biodiversity for its implementation.

Recognizing the multi-disciplinary nature of agrobiodiversity, FAO established a Commission on Genetic Resources for Food and Agriculture. The Commission plays an important role in monitoring the status of agricultural biodiversity, coordinating the development of global plans of actions and advising on their implementation.

Many agro-ecosystems are under great stress, as a result of a range of well-known drivers. Is it possible to move towards a more agrobiodiversity-friendly agriculture approach? What alternative options are available that can slow down, or reverse the decline of ecosystems services? A few examples can be mentioned:

- conservation organizations have in recent years adopted a landscape approach to biodiversity conservation. Protected areas cannot do the job alone. It is recognized that farmer-managed landscape mosaics play important roles in conservation strategies
- schemes for payments for environmental services – biodiversity conservation, watershed functions and carbon sequestration – can provide alternative income opportunities or other benefits such as secure tenure rights
- some farmer-managed landscapes, such as multi-storey agroforests can sustain a very high level of biological diversity and maintain many of the functions of a natural ecosystem
- agro-tourism is expanding as an alternative income source.

Agrobiodiversity in educational systems

Managing biodiversity in agricultural ecosystems is a complex, dynamic process, involving multiple stakeholders at multiple scales. Agrobiodiversity is influenced by a range of biophysical, socio-economic, cultural and policy drivers. Not infrequently conflicts arise over natural resources. Given such complexity, how should universities teach agrobiodiversity, to develop graduates with ability to facilitate the conservation and sustainable use of agricultural biodiversity?

A fairly new concept, agrobiodiversity has only recently started to appear, in a rather limited way, in some university curricula. Full programmes on agrobiodiversity hardly exist and even courses on agrobiodiversity are hard to find, as confirmed by two surveys conducted by Bioversity International, in Eastern and Southern Africa and Latin America, respectively.

It is time to review how to teach and learn agrobiodiversity. This would also be a direct response to international policy commitments. For example, the Global Plan of Action for Animal Genetic Resources, in its strategic areas for action, includes 'Policies, Institutions and Capacity Building' as one of four strategic priority areas (FAO, 2007). It notes that a 'lack of trained personnel is a major impediment to developing and implementing animal genetic resources policies, strategies, programmes and projects'. It emphasizes that education and training to build sustainable capacity in all priority areas is required.

More specifically, the Plan of Action for Animal Genetic Resources identified the following actions, in relation to the strengthening of national educational and research facilities:

- identify needs for research and education
- promote the formation of relevant cadres of experts, nationally or through international training
- review national research and education capabilities in relevant fields and establish targets for training.

- establish or strengthen relevant research, training and extension institutions to support efforts to characterize, inventory and monitor trends and associated risks, sustainably use and develop and conserve animal genetic resources
- review the national educational need of livestock keepers, while respecting traditional knowledge and indigenous practices.

Similar capacity development targets can be found in many other policy instruments of relevance to agricultural biodiversity, including the Convention on Biological Diversity, the UN Framework Convention on Climate Change and the UN Convention to Combating Desertification. Strengthening capacity on agricultural biodiversity is also required for implementing the Agricultural Biodiversity Initiative for Africa (ABIA), currently being developed by the Forum for Agriculture Research in Africa (FARA) and Bioversity International.

This workshop is convened to discuss how to mainstream agrobiodiversity in university programmes in Sub-Saharan Africa. The workshop will take stock of the dimensions of agricultural biodiversity, consider how universities address them at present and how they should be taught in future. Some of the key questions to explore include:

- the niche for agrobiodiversity in education systems dominated by commodity crops
- managing plant, animal and forest genetic resources in an integrated way
- the role of socio-economics and nutrition and health in agricultural and forestry programmes
- learning approaches for developing abilities to enhance neglected and underutilized species
- what can be learnt from educational innovation in related areas such as agroforestry, integrated pest management or farmer field schools?

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Keynote presentation: Challenges and approaches to learning and teaching agrobiodiversity

Lenah Nakhone
Egerton University, Kenya

Learning points

- Learning agrobiodiversity is an incentive to sustainable utilization and conservation of agrobiodiversity.
- Research in agrobiodiversity will create new knowledge that can be used by universities for its effective learning and teaching.
- Integrating agrobiodiversity modules in existing curricula will enhance the learning of agrobiodiversity in universities in Sub-Saharan Africa.
- A paradigm shift in the training and education system to participatory, inclusive approaches focusing on the reality at farmers level. General willingness to draw lessons from experience is vital in learning and teaching agrobiodiversity.
- Development of enabling and responsive policies on agrobiodiversity depends on the level of awareness of the policy-makers and professionals in agriculture and related disciplines.

Overview of the topic

Agrobiodiversity encompasses the variety and variability of animals, plants and microorganisms that are necessary to sustain key functions of the agro-ecosystem, its structure and processes for and in support of, food production and food security. As an approach to development and cooperation strategies, agrobiodiversity focuses on improvement of poor people's livelihoods through sustainable utilization and management. Local knowledge and culture can be considered an essential part of agrobiodiversity as it is the human activity of agriculture which conserves this diversity.

Agrobiodiversity is an important asset for people's livelihoods. Its rapid decrease affects most directly the people who are living in close relationship with and depend upon it. Africa's greatest challenge is poverty, food insecurity and nutrition-related problems. The sustainable use and conservation of agrobiodiversity is an important element in achieving food security. Applying agrobiodiversity in farming is a skill that is learned either through experience or formal learning. To promote agrobiodiversity, we must influence the farmers' capacity to manage it. This requires professionals in agriculture and related fields who can carry out research in agrobiodiversity, disseminate the acquired knowledge and conserve agrobiodiversity.

Training is an important incentive for the use and conservation of agrobiodiversity. It is a motivating influence for the use and conservation of agrobiodiversity. In the past, professionals have been trained in techniques and methods of identification and conservation of agricultural genetic resources. These skills need to be complemented with an increased understanding of the linkage between the natural resources and people's livelihoods, the sustainable utilization of agrobiodiversity and appreciation of the local knowledge of the farmers. It is therefore necessary to build capacity through learning and teaching at universities in Africa, to be able to promote the sustainable utilization and management of agrobiodiversity to counteract poverty, food insecurity and generally meet the Millennium Development Goal of poverty alleviation

However, there are several challenges to learning and teaching agrobiodiversity. There is need for a paradigm shift in the training and education system towards participatory, inclusive approaches that focus on reality at the farmer level. There is need for a change in attitude of researchers, policy-makers and extension workers and a willingness to draw lessons from experience available from successful case studies. Integration of agrobiodiversity can only be supported by those researchers and other professionals who are eager to experiment with farmers to conserve agrobiodiversity. It is necessary to integrate farmer knowledge, innovation and practices in research and extension. The attitude of superiority in the custodianship of knowledge by university staff and researchers is a major challenge.

For effective learning, there is a need to develop university curricula that are relevant to the farmers situation 'on the ground'. Currently, modules that integrate agrobiodiversity in various disciplines are lacking. Research in agrobiodiversity is needed to generate new knowledge that may be included in curricula and also in extension. A combination of local and scientific knowledge in research and extension can translate into relevant curricula.

In addition, getting the relevant courses into university programmes is a challenge, especially at undergraduate level. The approval of a new programme takes time. There are several stages where different committees assess the curriculum before approval is given by the university Senate. An alternative option may be to incorporate modules on agrobiodiversity into existing programmes and courses. This may be done during the regular curriculum review.

Another major challenge is the dwindling interest in agriculture. There is a dramatic decrease in the number of students who opt to take agriculture-related courses in Kenyan universities. This has been attributed to lack of employment opportunities for graduates in this field. So whereas appropriate curricula may be developed, the numbers of available students to learn agrobiodiversity may be limited.

Lack of awareness of agrobiodiversity by decision-makers and professionals can create an obstacle in learning and teaching agrobiodiversity. Public information and awareness creation should serve as a basis for change in attitudes and development of interest and understanding of agrobiodiversity. In Kenya, the existing policy frameworks and legal regimes have not been responsive to activities of agrobiodiversity conservation and its sustainable use. The draft environment policy of 2008 proposes a broad range of measures and actions responding to key environmental issues and challenges. There is need for enabling, effective and responsive policies and legal frameworks that will create institutional structures that address agrobiodiversity conservation and sustainable use. Some of the policy actions may include capacity building at institutional levels. This will provide professionals who can support farmers in the conservation and use of their resources.

Approaches to learning are varied depending on the age of the learners. Learning has shifted from only knowledge to the ability to perform tasks. For a person to do this there is need to have a combination of necessary knowledge, skills and attitudes. Generally, building on prior experience is an efficient way of learning, especially so in agrobiodiversity. At university, the teaching of agrobiodiversity needs to be based on the active participation of the learners. Experimentation with farmers and support to farmers through research should be adopted by the university staff. Experiential learning is central in communication on agrobiodiversity, which indeed is a cross-cutting issue. In general, competence-based education is the way forward for universities if we are to succeed in teaching agrobiodiversity.

Recommended reading

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Useful websites

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The World Bank. Indigenous Knowledge Program: www.worldbank.org/afr/ik/what.htm

Session 2 – Sharing experiences and perspectives on agrobiodiversity: Agrobiodiversity conservation

Chair: Oudara Souvannavong

Conservation of plant genetic resources, including crop wild relatives

Dr. Zachary Muthamia
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Learning points

- Genebanks are important as repositories of germplasm
- For effective conservation, sound standards need to be adhered to
- Strong links with users are crucial
- Need for capacity building in modern tools e.g. biotechnology, taxonomy, pre-breeding
- Need for collaboration with other plant genetic resources institutions
- Importance of sharing information.

Overview of the topic

Genebanks support crop improvement by providing important genes in the form of seeds of crops and their wild relatives. They provide breeders and other users with useful germplasm for crop improvement and other related research activities. They are the only security in case of the loss of important germplasm. Genebanks act as a back-up for germplasm in other countries.

Techniques for conserving orthodox seeds involve drying seeds to low moisture content and storing them in low temperature in special containers. The physiological storage behaviour and inherent longevity of each species will dictate the mode of conservation. Seed storage is most preferred due to its practicality. This is the main conservation method for species producing orthodox seeds that tolerate desiccation to low moisture content and storage at low temperatures. Most arable, forage and forest species fall in the category of orthodox seeds. Some other seeds also tolerate combinations of desiccation and low temperatures. Recalcitrant seeds do not survive desiccation and low temperatures. These require different techniques for conservation.

Most genebanks have organized their operations as follows:

- Exploration and collection
- Seed science and conservation
- Characterization, regeneration and multiplication
- On-farm conservation
- Documentation and information dissemination.

Assembling accessions involves collections in the field, or through donations. Once received samples are added to the existing collection, they have to meet the required quantity and quality standards and accompanying information requirements including passport data and other collection information. The seeds are cleaned, moisture determined, dried, viability-tested and packaged.

High levels of seed viability are required. The routine monitoring of this viability will determine when to regenerate the accession. To minimize genetic drift, adequate numbers of plants are grown and sampled. Controlled pollination and isolation should be maintained.

Seeds should be harvested on reaching physiological maturity and processed under optimal conditions to ensure high viability. Low humidity allows fast drying of the seeds while high humidity will delay seed drying leading to deterioration.

Challenges in genebank management

- Inadequate funding and bureaucracy
- Inadequate human resources and infrastructure
- Inappropriate institutional arrangements
- Absence of supportive national policies and laws
- High maintenance costs
- Inadequate networking, hence low germplasm utilization
- Risks associated with germplasm conservation include climate change and genetic erosion
- Appropriate information management is key to sound database and information dissemination.

Areas that should be strengthened

- Scientific capacity building in areas such as pre-breeding, biotechnology tools, taxonomy, documentation and characterization
- The central position that universities play
- Collaborative activities, e.g. seed biology studies, collection
- Research methodologies in conservation of plant genetic resources
- Joint theses supervision
- Hands-on training, e.g. student attachment programmes, linking theory and practice
- Importance of information sharing
- Supportive policies that address the following:
    - Implementation of the International Treaty for Plant Genetic Resources for Food and Agriculture, e.g. Material Transfer Agreements
    - Plant genetic resources legislation and institutional arrangements
    - Access and benefit-sharing regimes
    - Bio-prospecting and patenting.

Recommended reading

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Overview of the state of animal genetic resources

Okeyo A Mwai and Julie Ojango
International Livestock Research Institute (ILRI)

Learning points

- What are animal genetic resources (AnGR) and what roles do they play?
- How are AnGR distributed; what key factors drive the dynamics in AnGR?
- How can AnGR be sustainably managed/conserved
- What are the current gaps in knowledge and opportunities for application of new technologies and for research?

Introduction

Animal genetic resources (AnGR) comprise all animal species, breeds and strains that are of economic, scientific and cultural value or interest to humankind in terms of food and agricultural production now and in the future. Farm animal genetic resources (FAnGR or livestock) comprise the species, breeds and populations (strains and individuals) that are used for human food and agricultural production. With few exceptions, such as the wild boar (*Sus scrofa*) and the red jungle fowl, the ancestors and wild relatives of major FAnGR are either extinct or highly endangered as a result of hunting, changes to their habitats and in the case of the wild red jungle fowl, intensive cross-breeding with the domestic counterpart. In the State of the World's Animal Genetic Resources (FAO, 2007a) the number of livestock breeds in the world was estimated to be 7616, 86% of which occurred in only one country, while 14% were trans-boundary—occurring in more than one country. Of the trans-boundary breeds, 52% are international, while 48% occur in only one region of the world.

Livestock plays many roles, particularly in developing countries, where they provide food (milk, meat and eggs), draught power, fertilizer and fuels, industrial raw materials (hides and skins), direct employment and capital (cash, social and cultural values). In quantitative terms, 30-40% of the world's agricultural outputs are produced by livestock, while 70-80% of total farm incomes in the intensive crop-livestock production systems are derived from livestock.

Dynamics in animal genetic resources and the key drivers of change

Genetic resources naturally ebb and flow within ecosystems, resulting in the evolution of new species and the loss of others. The value of a vast majority of AnGR is poorly understood by scientists and policy-makers, yet it is estimated that on average, a breed disappears every month and 20% of the world's uniquely adapted breeds of domestic animals are at risk of extinction (FAO, 2007a). This risk is greatest in developing countries, where nearly 70% of the entire world's remaining unique livestock breeds are found. This loss of breeds is occurring while it is still unknown which breeds contain significant genetic diversity or specific genes that should be targeted for conservation and/or incorporation into breeding programmes (FAO, 2006).

It is noteworthy to recognize that despite the past and ongoing losses of distinct breeds, new populations and breeds have been created. Potential still exists for continued creations through planned crossbreeding, synthetic breed formation and through application of biotechnologies. Biotechnology has enabled an increase in the variety of genetic material available for different species of livestock (semen, embryos, oocytes, somatic cells and DNA).

Key drivers to the rate of change in AnGR include economic development and globalization; market demand for livestock products; environmental effects, especially climate change; science and technology and human population pressure on the limited natural resource base, among others (Seré *et al.* 2008). A sustained rise in demand for food of animal origin driven by growing populations, increasing consumer affluence and increasing urbanization has resulted in great structural changes along the whole animal food supply chain. The changes are accompanied by an increasing use of crops for livestock feed, rather than human food, raising questions about food security and poverty. The 'supermarket revolution' in urban areas is shaping an increasing demand for convenience, variety and quality assurance of livestock products. This consumer-driven change has great implications for livestock production and the players in the markets for livestock products.

Sustainable use of AnGR

Monitoring and characterization of AnGR

For efficient and sustainable use of AnGR within a country, the extent, distribution, basic characteristics and comparative performance of the different AnGR need to be understood. This information is the basic building block to guide decision making in livestock development and breeding programmes. Since genetic resources are not static, routine inventories and ongoing monitoring are needed. Few developing countries have current data on their AnGR to make an accurate analysis of their state.

In the areas of diversity measurement, conservation and utilization, new and cutting-edge genomic tools, such as dense single nucleotide chips, assays and re-sequencing, provide new opportunities to study genome-wide DNA variations. The availability of high computing power makes it possible to link such variations with various layers and levels of environmental variables. This enables better understanding of the complex co-evolution of AnGR and their relationship to the environment in which they are raised today, including predictions of their potential and options for their sustained utilization in the future.

Conservation of AnGR

The conservation of the diversity of AnGR is critical. Countries have a moral commitment to future generations to conserve the existing diversity as stated under the CBD. Genetically diverse livestock populations provide a greater range of options for meeting future challenges, whether associated with environmental change, emerging disease threats, new knowledge of human nutritional requirements or changing market conditions (FAO, 2007b).

The last decades have seen increasing possibilities for bio-banking (*ex situ, in vitro*) as a result of advances in cryobiology and reproductive technology. Semen and embryos can be obtained, cryo-preserved and used for most species of farm animals. More recently developed possibilities include the use of epididymal sperm, oocytes, ovarian tissue, stem cells and somatic cells. Reproductive techniques necessary to obtain and use these types of germplasm include embryo transfer, *in vitro* fertilization, ovum pick-up and generation of embryos by somatic cell nuclear transfer. Appropriate embracement of these, particularly in cases where the threats to AnGR are great and skills are available, would lead to sustainable management (improvement and conservation) of populations that are currently under-exploited. Further study is needed to calculate and compare costs for different strategies, which should include short-term and long-term costs and perspectives.

Needs and priority research areas for AnGR in developing countries

Inadequate human and institutional technical capacity, including poor infrastructure, currently constrain not only the improved understanding of AnGR, but also hamper their optimum utilization and conservation in developing countries. Inadequate understanding and domestication of global agreements (e.g. CBD, the Global Plan of Action) and the related, often too complicated, intellectual property rights issues around AnGR make it difficult to freely share them among counties and regions. What is needed to impact AnGR utilization in these countries includes:

- National policies and legal structures for sustainable utilization of AnGR
- Database (inventory) developments and monitoring to increase understanding of the state of AnGR and the characteristics of animal diversity
- Development of cost effective monitoring and conservation measures to ensure genetic diversity is maintained
- Integration of traditional and modern approaches and technologies in developing strategies for AnGR utilization
- Supporting infrastructure for domestic markets—particularly for poor farmers in remote villages where the majority of indigenous AnGR are kept
- Structures for national, regional & international cooperation
- Capacity building and basic institutional development for AnGR characterization, inventory & monitoring, breeding & conservation and utilization.

Priority areas for research

- Scientific guidance for strategic decisions with imperfect information
- Support for early warning and response mechanisms (geo-referencing of breeds)
- Genetic improvement strategies for low external-input environments, particularly in view of effects on livelihoods
- Methods for prioritization of AnGR for conservation beyond molecular information
- *In situ, in vivo* conservation strategies for developing countries
- Cryo-conservation methods covering all domesticated species
- Economic assessments (optimization) of alternative conservation strategies
- Facilitation of access to markets for small-holders (food-safety requirements might act as impediments)
- Identification of policy distortions (e.g. direct or indirect subsidies impacting AnGR)
- Exploring the need for a regulatory framework to ensure access and fair and equitable exchange of AnGR.

Learning resources

Biodiversity and Conservation, University of California, Irvine. http://darwin.bio.uci.edu/~sustain/bio65/

Lecture Notes, Short Course in Evolutionary Quantitative Genetics. Bruce Walsh, University of Arizona. http://nitro.biosci.arizona.edu/workshops/Aarhus2006/notes.html

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Animal Genetics Training Resource (AGTR), version 2, 2006. Ojango, J.M., Malmfors, B. and Okeyo, A.M. editors. International Livestock Research Institute, Nairobi, Kenya and Swedish University of Agricultural Sciences, Uppsala, Sweden: http://agtr.ilri.cgiar.org/

Convention on Biological Diversity: www.biodiv.org/

Domestic Animal Genetic Resources Information System (DAGRIS): http://dagris.ilri.cgiar.org
Domestic Animal Diversity Information System (DAD-IS): www.fao.org/dad-is

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Forest genetic resources and farmers' tree domestication

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Background issues

To address the big social, economic and environmental issues in the world we need to simultaneously restore:

- Biological resources and natural capital (soil fertility, water, forests, etc.)
- Livelihoods (nutrition, health, culture, equity, income)
- Agro-ecological processes (nutrient and water cycles, pest and disease control, etc.).
- Agroforestry can contribute to these objectives

Agroforestry promotes agro-ecological succession

Natural ecosystems progress from a 'pioneer' stage to ecological maturity. Likewise, each phase of an agro-ecological succession will be more bio-diverse, as 'planned' biodiversity (planted trees, crops and introduced livestock, poultry, fish, etc.) are enriched by 'unplanned' biodiversity (all those organisms, above and below ground, that find niches to fill among introduced plants and animals). Agroforestry contributes towards diversification to create mature or 'climax' agro-ecosystems.

Agroforestry promotes multifunctional agriculture

Agroforestry is the integration of trees into the farming system and provides a wide range of products and environmental services. Trees diversify farms and help to restore ecological services and environmental resilience. Such mixed farming systems can be developed to become more productive and generate income and employment opportunities, so that household livelihoods are restored. This can be facilitated by 'domesticating' trees into farming landscapes.

Agroforestry is uniquely suited to address the requirements for increased food security and biomass resources and the need to sustainably manage agricultural landscapes for their critical ecosystem services. Agro-ecological functions of agroforestry include:

- Improved soil structure and organic matter management
- Enhanced nutrient cycling - soil invertebrates, saprophytic and symbiotic fungal and bacterial associations
- Improved water use efficiency
- More effective crop pollination

- Enhanced food chains/life cycles - reduced pest, disease and weed outbreaks (these functions are scale dependent)
- Carbon/greenhouse gas sequestration.

The future of trees is on farms

Evolution has created 60 000 tree species. For thousands of years humans extracted what they needed from the forest. Today, the human population exceeds the extractive capacity of natural ecosystems. In 1850 there were 1 billion people; today there are 6 billion. Original global forest cover was estimated to be 70% of the land area, now it is 26%. Most tree species are wild but they need to be brought into cultivation to fulfil future needs as natural forest cover contracts and degrades.

Tree breeding practices

Tree breeding practices are largely based on:

- Recurrent selection for additively inherited traits
- The use of high selection intensities (1 in 100 000 trees)
- Recent breeding for hybrid vigour, e.g., tropical pines
- Recently clonal forestry to propagate superior types, e.g., rooted cuttings of eucalyptus
- Most recently, assisted selection using molecular markers is being practiced on a small number of species and a narrow range of transgenic trees are being developed (pulp yield, disease resistance, etc.).

Tree breeders have had success in increasing productivity, but they deal with very few species. Centralized breeding works best when one organization can control all steps in production: e.g. species trials, provenance/progeny tests, seed orchard establishment, seed collection and handling, nursery seedling production, plantation management. Compare this to agroforestry, where we have a diverse client group, at least 3000 useful tree species on farms and many organizations involved in the work. So tree domestication from an agroforestry perspective is not about tree breeding. Whilst trials and selection are important, it is also about the following activities that cannot be done in isolation:

- Priority setting - which trees do farmers want to plant? (important species and farmers' and markets' traits)
- Proactive seed multiplication of a range of species options
- Engendering best nursery practices among communities
- Appropriate tree management methods on smallholder plantings
- Extension messages on seed collection methods
- Working out how to deliver germplasm to decentralized producers in efficient ways
- The marketing of tree products in a way that benefits small-scale production
- Policies to support all of the above.

Domesticating agroforestry trees involves accelerated and human-induced evolution to bring species into wider cultivation through a farmer-driven and/or market-led process. This is a science-based and iterative procedure involving the identification, production, management and adoption of high quality germplasm. High quality germplasm in agroforestry incorporates dimensions of productivity, fitness of purpose, viability and diversity. In tandem with species strategies are approaches to domesticate landscapes by investigating and modifying the uses, values, interspecific diversity, ecological functions, numbers and niches of both planted and naturally regenerated trees.

Tree domestication is a farmer-driven process, which needs to consider questions such as:

- Is the research addressing farmers' problems?
- Are farmers involved in the work?
- Do farmers recognize and appreciate the benefits?
- Are the approaches used sustainable?
- Should efforts seek to increase production or maximize stability?
- Are we detrimentally skewing farmers' priorities?
- Do we understand farmers' decision-making processes?

Genetic variation in tropical trees in agroforestry systems

An important question is the following: what do we know about genetic variation in tropical trees in agroforestry systems and how do we link this knowledge to action for enhanced livelihoods and improved conservation? The nature of the problem is that:

- Farm productivity depends on both tree species diversity and genetic variation, but research on the latter has until recently not received the recognition it deserves
- When knowledge has become available, it has not been linked in any systematic way with management, indicating a 'disconnect' between research and practice.

Problems in gaining information on genetic variation

Practical and conceptual problems in gaining information on genetic variation in tree species in farm landscapes include:

- *Lack of recognition of the nature of the problem.* This is related to the persistence of trees in landscapes, meaning that it can be too late to intervene by the time the problem is recognized
- *An inability to assemble appropriate teams to undertake effective research.* The institutional frameworks within which researchers work rarely support the team-based approaches needed to assess genetic variation and then meaningfully apply knowledge. For agroforestry the situation is acute, as 'forestry' and 'agriculture' are traditionally considered as discrete schools of research that should be treated/taught separately

- *Difficulties in recognising and quantifying variation.* Genetic variation may be difficult to measure and important diversity may be 'cryptic'
- *The large number of species involved.* A very large number of tree species are found in agroforestry systems and comprehensive analysis of genetic variation in all taxa is impractical. Is the concept of 'model' species relevant?

Recent advances in assessing genetic variation

Recent advances have been made in both 'direct' and 'indirect' research approaches for measuring genetic diversity in trees.

Direct methods:

- *Morphological studies.* There has recently been an increased emphasis on using participatory survey techniques with communities and on farm-forest comparisons of trees, to assess useful morphological variation in stands, especially for fruit trees
- *Molecular studies.* There has been an increased use of molecular markers in more targeted ways that relate to addressing genuine farmers' problems and that deal with current concerns of the lack of practical application of these methods.

Indirect methods:

- *Source surveys.* Advances in methods that consult all the actors (nursery managers, local seed dealers, etc.) involved in sourcing germplasm for farmers have been made and these approaches have been used to provide indications of genetic variation in planted trees
- *Farm inventories.* There have been developments in the methods used to characterize tree species found in farms and in how to interpret such data in terms of genetic variation in agricultural landscapes, not just in terms of species diversity.

Current state of knowledge on genetic variation in farmland

Based on the types of approaches to research described above, it is observed that many trees are subject to poor germplasm collection practices in farmland that many species occur at very low densities and that a large number of taxa occur in aggregated (e.g., clumped, not well dispersed) distributions in farmland. These points all lead to the conclusion that the effective population sizes of trees species – and therefore their sustainability and productivity – in farm landscapes are on the decline. The consequences for an individual species will depend to some degree on the functional use to which it is put; consequences will be more serious for some categories of use – e.g., when trees are used for fruit production – than for others.

The current state of knowledge indicates that a range of interventions related to germplasm access is necessary to improve existing management practices, including:

- Enhancing community seed- and seedling-exchange networks, including the development of local commercial suppliers to support farmers with germplasm provision
- Improving access to genetic resources through 'diversity fairs' that include both tree and crop activities (this is especially relevant for fruit trees)
- Encouraging locally based, participatory tree domestication programmes that empower farmers' to collect their own genetic resources.

More difficult to address, but equally necessary, is the development of market structures that support genetic diversity in tropical tree species. Measures suggested include the development of niche markets that support a range of variation within a species (possibly using a 'Denomination of Origin' type approach). It is clear that tree seed and seedling supply and product (fruit, timber, medicine, etc.) sale need to be considered as parts of one value chain if germplasm- and market-based interventions are to be successful.

What resources have ICRAF and partners developed for teaching in this area?

ICRAF has developed a series of resources for teaching and learning in the domestication of agroforestry trees, including short courses, databases and publications.

Short courses

The just-concluded SII/World Agroforestry Centre project 'Advancing Agroforestry Research and Development through Training and Education', supported by The Netherlands' Ministry of Foreign Affairs, conducted 20 courses for training-of-trainers. Course materials are available on CD-ROM from ICRAF's Training Unit. A few recent courses on the topic of tree genetic resources and domestication are:

- **Agroforestry and tree genetics: making markers meaningful** (2008). This course enabled African scientists to more effectively deploy molecular genetic markers to the field management of tree species. It was about making the linkage between technical knowledge and ground application in the context of emerging challenges to agriculture
- **Delivering trees to farmers: improving strategies for germplasm supply** (2007). This course brought together the different actors involved in delivering planting material (tree seed and seedlings) to farmers, so that they can develop more productive, sustainable and environmentally friendly agroforestry systems (this course relates to the need for germplasm-access based interventions in managing diversity)
- **Training workshop on *Allanblackia* domestication** (2006). This course focused on developing more productive and sustainable farming systems by bringing into cultivation the *Allanblackia* tree, a new crop for edible oil production of interest to the global food industry. It is a case study of the tree domestication method, as a means to avoid excessive exploitation of natural resources and improve the incomes of farmers.

Databases

Most notable are the following:

- The **Agroforestree Database** provides information on more than 600 tropical trees – including timbers, fruits, fodder providers and soil fertility improving species – that are of interest for planting by smallholders. The database includes information on where species grow, how they can be propagated and managed, their uses and pests and diseases problems (most useful of ICRAF's online 'tree' databases for educational purposes) www.worldagroforestry.org/Sites/TreeDBS/aft.asp
- The **Tree Seed Suppliers Directory** provides information on the different suppliers of tree planting material. The database lists several thousand tree species, indicates where seed of these species can be obtained and provides information on the quality of different seed sources. The Directory allows users to make more informed choices about the trees that they plant (more useful for field managers than for education, but useful if need to access seed for research). www.worldagroforestry.org/Sites/TreeDBS/tssd/treessd.htm

Publications

ICRAF's training materials on tree domestication include:

- **Tree seeds for farmers: a toolkit and reference source.** This describes the technical methods involved in supplying tree seed and seedlings to farmer and how to go about making seed and seedling production a commercial concern
- **Tree seed education at agricultural and forestry colleges in eastern and southern Africa (FAO, ANAFE).** Describes a possible further education curriculum on the topic of tree seed supply
- **Training in agroforestry: a toolkit for trainers.** Describes the relevant methods for teaching agroforestry to students at different levels, but especially in a 'training-of-trainers' approach
- **Tree diversity analysis: a manual and software for common statistical methods for ecological and biodiversity studies.** Describes how to do various statistical analyses of biodiversity data (CD-ROM)
- **Molecular markers for tropical trees: a practical guide to principles and procedures.** Describes molecular marker methods and protocols and their relevance for tree research. The guide seeks to inform more practical application of methods. Information is presented in a format suitable for students at BSc, MSc and PhD levels
- **Indigenous fruit trees in the tropics: domestication, utilization and commercialization (ICRAF and CABI).** A recent publication (2008) that describes the current state of knowledge on indigenous fruit tree research across the tropics.

Session 3 – Use of agrobiodiversity for livelihood services

Chair: Jacob Mwitwa

Farmer innovations and indigenous knowledge which promote agrobiodiversity in Kenya: a case study of Mwingi and Bondo districts

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Introduction

Farmer innovations are important in agrobiodiversity. Such innovations are occasioned by necessity, changing conditions and curiosity. Farmers carry out experiments inspired by new ideas from their own thoughts, neighbours, extension personnel, researchers and the mass media. However, research and extension tend to ignore the importance of local innovations for agricultural development (Reij and Waters-Bayer 2001).

Farmer innovations and Indigenous Knowledge (IK) that promote agrobiodiversity go a long way in ensuring sustainable production of food. Indigenous knowledge is composed of ideas, beliefs, values, norms and rituals, which are native and embedded in the minds of a people and unique to a given culture or society (Warren *et al*. 1987). Areas of IK that are relevant to agrobiodiversity include preparation of recipes, agronomy, seed issues and herbal medicine, among others. Those with IK know wild plants with their traits such as earliness, lateness, cooking quality and drought tolerance. Indeed IK has played a key role in conservation and use of biodiversity.

FAO, in conjunction with the government of Kenya, established a programme on agrobiodiversity in 2005 meant to support ecosystems, rural livelihoods and food security. The programme, sponsored by FAO-Netherlands Partnership Programme (FNPP), selected two districts in which to implement the programme i.e. Mwingi and Bondo. Mwingi district is a semi-arid area whose agro-ecosystem is agropastoral, in Eastern Province. Bondo is found in the Lake Victoria basin in Nyanza Province and is therefore a sub-humid lake zone. The agro-ecosystem is composed of aquatic and terrestrial components.

The programme is in line with the farmer field school (FFS) approach, adopted by FAO, whose aim is to build farmer capacity to analyze their production systems, identify problems, test possible solutions and eventually adopt suitable practices. The aim of this paper is to contribute to the mainstreaming of agrobiodiversity through experiences gained from the two districts.

Farmer innovations and indigenous knowledge are important components to be considered when developing curricula for agrobiodiversity in institutions of higher learning.

Methodology

The areas of study were Mwingi and Bondo districts of Kenya (Figure 1). These districts host FAO's FFS pilot projects since 2001. The agrobiodiversity programme was introduced in the same districts in 2005 and therefore has documented information.

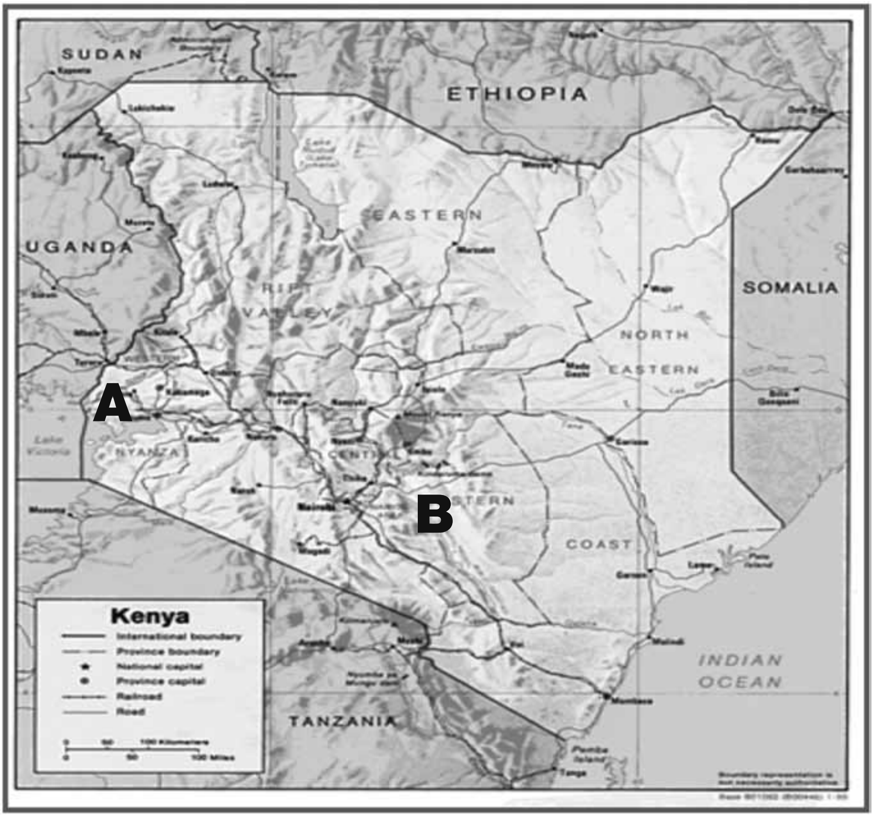

Figure 1. Map of Kenya showing the location of Bondo (A) and Mwingi (B).

Reports from participatory rural appraisal (PRA) and stakeholder workshops were the main sources of data. The PRA teams were composed of government officials from the Ministries of Agriculture, Forestry and Water, the FFS coordinator for the district and selected participating farmers. The team selected the study sites that captured diverse ecosystems. Information was collected in focused group discussions using a PRA checklist developed by FAO. Two divisions per district were selected: Central and Nuu divisions in Mwingi district and Usigu and Madiany divisions in Bondo district.

The workshops involved facilitators from the government and FAO as well as innovator farmers. Cross visits to nearby farms were made during the workshops. The Mwingi workshop attracted 19 innovative farmers while Bondo had 42. Further information was obtained at the FAO-Kenya office headquarters in Nairobi. The data were subjected to descriptive statistics to give summaries.

Findings and Discussion

FFSs in the two districts identified, verified and characterized some 230 innovative farmers. More than 20 categories of farmer innovations were identified. The main ones are in the areas of water harvesting (16%), irrigation (8%), ethno-veterinary (7%), soil and water conservation (6%) and biological pest control (6%). Other categories of innovation are livestock management, agroforestry, farm tools and machinery, poultry management, bee keeping, soil fertility management, crop management, tree crop farming, water storage, seed/crop storage, processing for export, seed crop bulking, agro-processing and water table management.

Innovations by farmers are occasioned by necessity, changing conditions and curiosity. In this context, innovation may be defined as the successful exploitation of new ideas (DTI, 2002). However, research and extension tend to ignore the importance of local innovation for agricultural development (Reij and Waters-Bayer, 2001). It is important that formal systems recognize these innovations and incorporate them to make a better impact in adoption of new technologies. Towards this end FAO has been at the forefront of identifying and analyzing innovative farmers and innovations.

In the case of Mwingi and Bondo, the innovative farmers were organized into groups that promote cross visits and exchange of ideas. Competitions are occasionally staged where the farmers are asked to present their innovations in drawings. Impressive art showing various innovations like good farm layout, contour farming and good husbandry are usually produced. Although more men participate, women too make significant contributions; innovativeness cuts across gender. This is an approach based on a combination of science and local knowledge systems, innovations and practices as part of integrated ecosystem management.

The IK system in food preparation uses a wide variety of plants and animals. In Mwingi, it includes porridge and *ugali* made from bulrush millet, sorghum and finger millet; processing and preservation of milk and milk products such as ghee and preservation of meat. Others are fermentation where mixing with various grains or ground tuber crops is done, cooking in ghee, ground sesame or groundnut paste and cooking with fresh or sour milk.

In Mwingi, focused group discussions established the number of indigenous crops that had been lost, or were disappearing and the number of crops that had been added to the farming systems. The balance sheet (Table 1) shows a net loss of nine indigenous crops. This trend is reducing agrobiodiversity and exposing populations to major risks in case of harsh conditions. The government of Kenya has announced that up to 10 million people are threatened with hunger. Failing rains have been cited as a major cause. The table below shows that even drought-tolerant crops like cassava are disappearing, yet it is at times like these that such crops come to the rescue. It is known that traditional foods are generally available before harvest and during periods of scarcity.

Table 1. Balance sheet comparing indigenous and introduced crops in Mwingi District

Lost crops (or disappearing)	Crops gained
Millet, finger millet, sorghum, *Dolichos*, arrowroot, pumpkin, cowpeas, banana, sweet potatoes, date palm, tamarind, cassava, dumbbell, '*ndakithi*', '*mbumbu*', '*thalama*'	Maize, pawpaw, mangoes, oranges, sisal, guava and loquat
Total = 16	Total = 7
Net loss = 9	

(Quotes = local names)

In Bondo, traditional foodstuffs embedded in farmers' IK include blood meal, ghee, milk, ugali from sorghum, ginger millet, groundnut paste, fish, dried local vegetables and honey. Others are quils (an edible bird), mushroom, pumpkin, sweetpotatoes and simsim. (Translations for the following foodstuffs could not be immediately established: Knoni Anang'a, Ovied, Nderema, Knon and Dek.)

The balance sheet for crops in Bondo shows a net loss of 11 while three livestock and 12 fish species had been lost (Table 2). Most of the loss in fish occurred in Lake Victoria as a result of predation from the Nile perch. The loss is alarming and requires concerted efforts to stop it. The importance of these local crops and indigenous fish is that they are rich in nutrients and help to prevent malnutrition, a fact that has been well documented.

Table 2. A balance sheet for indigenous and introduced crops, livestock and fish in Mwingi and Bondo districts

	Mwingi	Bondo
Lost indigenous crops (or being lost)	16	22
Introduced crops	7	11
Net loss (or gain)	**-9**	**-11**
Lost indigenous livestock (or being lost)	3	3
Introduced livestock	2	3
Net loss (or gain)	**-1**	**0**
Original fish stock (species)	-	16
Lost or unavailable	-	12
Currently available	**-**	**4**

Traditional rites do encourage sustainable production and utilization of animal and plant species for various uses, for example marriages, food and feed, medicinal, payment of debts and services, nutritional, etc.

Indigenous knowledge can sometimes prove modern ways wrong. As an example farmers in Mwingi were urged to stop 'ratooning' sorghum, fearing that pests would multiply. But, recent research findings by the Kenya Agricultural

Research Institute have upheld the IK on this issue. Ecologically adapted plant and animal species in Mwingi, generally, give better returns as they can do relatively well under adverse conditions. Most farmers in Mwingi still intercrop as a risk aversion strategy to adverse weather and diseases. Indigenous methods of pest control such as use of ash has little environmental impact, for instance there is little or no interference with pollinators.

Many of the agro-pastoral inhabitants have over the years used plant and animal behaviour to foretell climate variability. The behaviour of some birds and insects and plant shedding of leaves, are examples that were used to forecast weather. This is IK that is getting lost as plants and animals get depleted.

Although herbal medicines are known to be collected from the wild, there are some that are grown in Bondo. These are '*Luboga*' and '*Atipa*' which are combined to treat constipation, '*Apoth*' and '*Boo*' which are blended to treat malnutrition and '*Achak*' to heal stomach ache. (The botanical names could not be immediately established.)

Indigenous knowledge has a strong correlation with gender. Men tend to know about things in the wild and herbal medicine, whereas women have expert knowledge on agronomy and seed issues. For instance, preservation of seed in calabashes with ash and above cooking stones in kitchens is a preservation technology used by women. Women are indeed the custodians of plant genetic materials of most traditional crops. This is particularly important because private seed companies pay little attention to these crops.

In Bondo, it was observed that the informal seed sector supplies over 90% of seed needs, but related regulations give no support to development of the sector, including production, processing, maintenance, exchange and marketing. Existing seed policies target national seed requirements and large-scale farmers, neglecting small-scale farmers, especially women. Although women are the main players in the informal seed sector, their involvement in national seed policy and programs is limited. Most NGOs and CBOs involved in informal seed initiatives at the grass root levels are structurally weak, poorly resourced and lack recognition from state institutions and research process. Farmers have more trust in their own saved seed or seeds from relatives, as compared to certified seeds.

Indigenous knowledge is diminishing mainly due to changing values as globalization takes centre stage. Traditional values and related IK are thus shunned as outdated. Agrobiodiversity is being diminished by destruction of habitants for birds and insects, including pollinators, as well as forests and bushes that are sources of medicinal and dietary herbs. The much sought-after honey too is under threat. Commercialization focuses on a few high-yielding varieties at the expense of many adapted landraces. Traditional diets have largely been abandoned. The result is a loss of agrobiodiversity in plants and animals.

Conclusion and Recommendations

Farmer innovations and indigenous knowledge abound but are neglected by research and extension. The two can play a big role in promoting agrobiodiversity and food security. IK is embedded in the minds of people and is embedded in social-cultural norms. For adoption of new technologies to be easier, it is important to incorporate IK. Women are the main custodians of plant genetic resources through seed handling and therefore need to be assisted to improve selection, processing and storage of seed. Funding of innovative farmers is recommended, as well as visits and exposure tours among them. These farmers should be linked to the markets.

There is general loss of indigenous plants, animals and insects and subsequently of IK. Consequently, benefits like medicinal herbs, honey and pollinators are getting scarce. Measures are required to stem the tide and improve the balance sheets in their favour. A clear policy on conservation and sustainable use of agrobiodiversity in the Kenya is lacking and should be formulated. The ongoing process of mainstreaming agrobiodiversity is encouraged and it should be incorporated into curricula of higher learning to encourage better research and documentation of this new area.

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The impact of biodiversity and biofortification on nutrition and health for the majority of the poor

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Abstract

Biodiversity provides essential components of health, the environment and sustainable livelihoods. Agrobiodiversity includes the cultivated plants and animals that form the raw material of agriculture, the wild foods and other products gathered by rural populations within traditional subsistence systems and organisms such as pollinators and soil biota. Forest biodiversity contributes to food, medicine and products for sale among forest dwellers and farmers in the adjacent agricultural landscape.

Agro-biodiverse systems tend to comprise smaller quantities of multiple species for culinary, medicinal and cultural uses. Farmers often retain or encourage valuable wild plants within their fields, on field margins and in adjacent natural areas. These systems are characterized by a wide range of crops, many of which may be represented by numerous traditional varieties.

Biofortification is the system by which staple foods (e.g. beans, cassava) are improved with essential nutrients (e.g. zinc, iron) through conventional breeding. Agrobiodiversity is a potential source of genetic resources that plant breeders and scientists can use to add nutrients to foods, to reach the majority of the population cheaply with ‘nutrient-dense’ food. This action is necessary to reach the millions of poor rural people suffering from chronic diseases, food insecurity, HIV/AIDS and especially the devastating impact of climate change.

All these issues require integrated and multidisciplinary responses for sustained livelihoods and food, nutritional and health security. This paper discussed the importance of the study of the food/nutrition/health/nexus and the prospects of harnessing agrobiodiversity and biofortification to improve food-based approaches for better health among the poor, especially those who are hard to reach.

Session 4 – Cross-cutting issues: markets, environmental services and policies

Chair: Gorettie Nabanoga

Adding value to agrobiodiversity: developing the value chain for neglected and underutilized species

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Learning points

- Marketing issues and the market system
- Pro-poor growth, market and rural livelihoods
- Agro-value chain analysis and management
- Marketing audit
- Product transformation through agribusiness supply chain
- Support services in agricultural value chains

Overview of the topic

African leafy vegetables (ALVs) are important sources of essential macro- and micro-nutrients. They offer a source of livelihood when marketed as well as contribute to crop biodiversity. Despite these positive aspects, out of the 210 known ALVs species in Kenya only a few are grown, marketed and consumed. This neglect has been attributed to a number of factors including:

- Erosion of culture and breakdown of traditional systems that ensured production and consumption
- Emergence of exotic vegetables that were marketed as superior foods
- Loss of growing areas where these vegetables used to grow naturally, especially along the river banks, due to environmental degradation
- Lack of emphasis in agricultural training, research and marketing policy on traditional crops.

However since 2001, there has been a marked increase in the demand and supply of ALVs in both formal and informal markets around Nairobi. Research carried out in 2006 showed that the market gross values had increased by about 212% between the period 2001 and 2006. The main species traded were found to be African nightshade, leafy amaranth, cowpeas and spider-plant. The growth of this market has been greatly influenced by increased consumer demand due to a number of factors. These include promotional strategies of local NGOs, international organizations such as Bioversity International, increased health awareness and consciousness of Nairobi dwellers, effects of HIV/AIDs and improved ALV presentation in supermarkets and upmarket groceries. Supply has increased due to promotion of production in peri-urban and 'upcountry' key production areas by international organizations and local NGOs, especially Farm Concern International, provision of external marketing support by NGOs, enhanced farmers' capacity for self-organization and improvement of telecommunication technology. The placement of ALVs in major supermarkets in Nairobi has particularly helped to enhance consumers' rating of these vegetables. The demand has been matched with increased production mainly by small-scale farmers in the peri-urban areas of Nairobi as well as increased supplies from far-off traditional production areas of western and eastern Kenya.

According to one study, the major hindering factor the growth of the ALV market in Nairobi was the inadequacy of physical infra-structural development in terms of the transport network, storage facilities and actual physical trading space. Other hindering factors include unfavourable policies for production and marketing of ALVs, lack of capacity to regulate drastic supply fluctuations, lack of product differentiation and value addition and lack of credit and other forms of support to council markets' traders. Another drawback is the presence in the market of ALVs that are grown in unhygienic conditions, e.g. using sewer spillage, making potential consumers apprehensive about ALVs altogether.

To promote the market further, favourable policies for production and marketing of ALVs are needed. ALVs should be included as a scheduled crop in the Agriculture Act and training guidelines on production and consumption of ALVs should be developed, which could also be included in the curricula of all levels of agricultural training.

An analysis of the effect of market development on inter- and intra-specific on-farm biodiversity showed that market development had a negative influence on biodiversity. However, this was not statistically significant, but it is, nevertheless, an indication that the influence is important and should be monitored as it develops further, because supermarkets and other high value groceries only stock a few varieties with the highest demand.

From the study it is clear that to rediscover ALVs and develop a value chain the following aspects are necessary; curricula should endeavour to capture them:

- Initial exploratory survey to document information on ALVs (past and present)
- Value chain, stakeholder and market potential analysis
- Promotion and raising consumer awareness of ALVs to increase consumer demand
- Development of marketing strategy aimed at linking the small scale farmers to the market developed. This has two stages:
    - Collective action on the farmer's side to ensure bulking, continuous supply and entry to high value supermarkets
    - Training to ensure quality in production and handling and other value addition aspects; ensuring phytosanitary conditions, grading, transportation, acceptable quality standards, labelling, etc.
- Linking farmers to high-value markets as well as offering logistical support
- Orienting policy towards neglected and underutilized species (training and extension, pro-poor marketing policies, etc.)
- Development of market infrastructure for those in the open markets
- Rural support services including infra-structure, access to credit, etc.

Learning resources

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Useful websites

www.ids.ac.uk/
www.underutilized-species.org

Ecosystems services in mosaic landscapes

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Learning points

- Ecosystem services as an integrating concept/framework
- Overall trends and tradeoffs between ecosystem services
- High prevalence of mosaic landscapes across most of the developing world
- Importance of scale and stake in the ecosystem services generated by mosaic landscapes
- Potential for synergies and tradeoffs among ecosystem services in mosaic landscapes
- Limits on the effectiveness of regulations for safeguarding ecosystem services and growing interest in recognition, rights and rewards.

Millennium Ecosystem Assessment findings

The Millennium Ecosystem Assessment (MA) was initiated in 2001, bringing together over 1200 scientists under the auspices of the United Nations Environment Program. Its objective was to:

> 'to assess the consequences of ecosystem change for human well-being and to establish the scientific basis for actions needed to enhance the conservation and sustainable use of ecosystems and their contributions to human well-being'.

The MA framed its work around the concept of ecosystem services – the benefits that people obtain from ecosystems. The MA categorizes ecosystem services into:

- *provisioning* services such as food, water, timber and fibre
- *regulating* services that affect climate, floods, disease, wastes and water quality
- *cultural* services that provide recreational, aesthetic and spiritual benefits
- *supporting* services such as soil formation, photosynthesis and nutrient cycling.

Changes in ecosystems services influence the multiple constitutes of human well-being:

- *Basic material for a good life*, such as adequate livelihoods, sufficient nutritious food, shelter and access to goods
- *Health*, including feeling well and having a healthy physical environment, such as clean air and access to clean water

- *Security*, personal safety, secure access to natural and other resources and security from disasters
- *Good social relations*, including social cohesion, mutual respect and the ability to help others
- *Freedom of choice and action* and opportunity to achieve what an individual values doing and being.

Source: Millennium Ecosystem Assessment, 2005. Ecosystems and Human Well-being: Synthesis. Island Press, Washington, DC.

Status of services

In the last decades, there has been unprecedented change in structure and function of ecosystems. More land was converted to cropland in the 30 years after 1950 than in the 150 years between 1700 and 1850. Accordingly, the status of provisioning and regulatory and cultural services has in many cases declined (Tables 1 and 2).

Table 1. Status of provisioning services

Service		Status
Food	crops	↑
	livestock	↑
	capture fisheries	↓
	aquaculture	↑
	wild foods	↓
Fibre	timber	+/–
	cotton, silk	+/–
	wood fuel	↓
Genetic resources		↓
Biochemicals, medicines		↓
Fresh water		↓

Table 2. Status of regulating and cultural services

Regulating services	Status
Air quality regulation	↓
Climate regulation – global	↑
Climate regulation – regional and local	↓
Water regulation	+/–
Erosion regulation	↓
Water purification and waste treatment	↓
Disease regulation	+/–
Pest regulation	↓
Pollination	↓
Natural hazard regulation	↓
Cultural services	
Spiritual and religious values	↓
Aesthetic values	↓
Recreation and ecotourism	+/–

Degradation of ecosystem services often causes significant harm to human well-being. The total economic value associated with managing ecosystems more sustainably is often higher than the value associated with conversion. Conversion may still occur because private economic benefits are often greater for the converted system

Level of poverty remains high and inequities are growing

Economics and human development

- 1.1 billion people are surviving on less than $1 per day of income. 70% live in rural areas where they are highly dependent on ecosystem services
- Inequality has increased over the past decade. During the 1990s, 21 countries experienced declines in their rankings in the Human Development Index.

Access to ecosystem services

- An estimated 852 million people were undernourished in 2000–02, up 37 million from the period 1997–99
- Per capita food production has declined in Sub-Saharan Africa
- Some 1.1 billion people still lack access to improved water supply and more than 2.6 billion lack access to improved sanitation
- Water scarcity affects 1–2 billion people worldwide.

Industries based on ecosystem services are still the mainstay of many economies. The agricultural labour force accounts for 22% of the world's population and half the world's total labour force. Agriculture accounts for 24% of GDP in low income developing countries. The market value of ecosystem-service industries has been estimated to be:

- Food production: $980 billion per year
- Timber industry: $400 billion per year
- Marine fisheries: $80 billion per year
- Marine aquaculture: $57 billion per year
- Recreational hunting and fishing: >$75 billion per year in the United States alone.

Most direct drivers of degradation in ecosystem services remain constant or are growing in intensity in most ecosystems.

Multiple land use types in mosaics & forest margin areas

These change in ecosystems services lead to increasing importance of multiple land use types in mosaic landscapes and forest margin areas. Such systems have been studied by groups such as the World Bank (e.g. Chomitz, 2007) and the Alternatives to Slash-and-Burn Programme (ASB, www.asb.cgiar.org). A few of the findings are reported here. A summary of the global evidence on the biodiversity value of agricultural and mosaic landscapes is provided by McNeely and Scherr (2002).

ASB is well-known for its research on the tradeoffs associated with alternative land uses in benchmark sites located across the tropical forest margins of Asia, Latin America and Southeast Asia. A number of meta land uses were identified that span across the sites, with specific land uses differing somewhat across the sites. The meta land uses and specific land uses are listed in Table 3. Special attention was paid to intermediate land uses that combine trees and agriculture.

Indicators of farm-level returns, contributions to the national economy, agronomic sustainability, carbon stocks and biodiversity were measured in each of the sites. Findings for biodiversity, for example, show that intermediate land uses such as jungle rubber are nearly as rich in (functional) biodiversity as nearby forests. Figure 1 shows the species richness and tree density of natural forests, old rubber agroforests and productive rubber agroforests in the Jambi area of Indonesia.

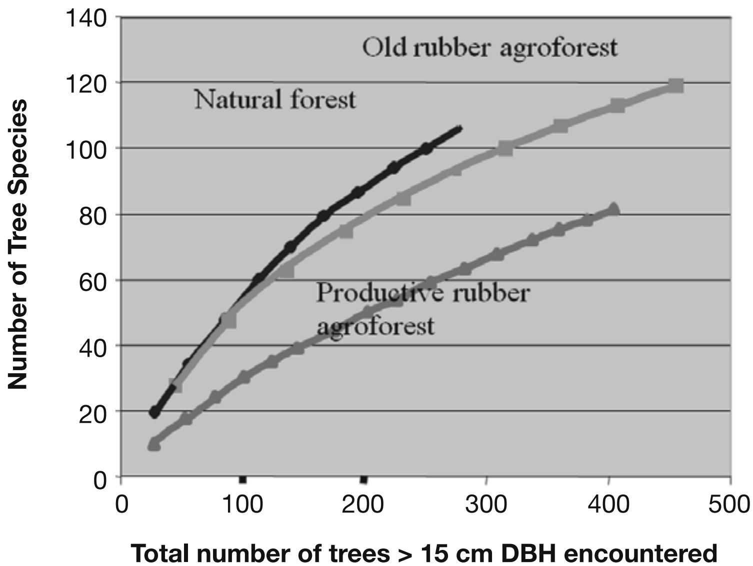

Figure 1. Biodiversity plot measurements in Bungo District, JambiSource: Saida and Gregoir Vincent (in preparation).

Table 3. ASB meta land use systems and representative systems at the study sites

	Indonesia			Peru	Cameroon
ASB meta land use	Jambi	Lampung	East Kalimantan	Ucayali	ASB benchmark site
Forest	Undisturbed forest Logged over forest-high density Logged over forest-low density Logged over mangrove Undisturbed swamp forest Natural regrowth-shrub	Undisturbed forest Logged over forest-high density Logged over forest-low density Logged over mangrove Logged over swamp forest Natural regrowth-shrub	Undisturbed forest Logged over forest-high density Logged over forest-low density Logged over mangrove Logged over swamp forest Natural regrowth-shrub	Residual forest: Previously logged with some selective logging continuing and NTFP extraction Tree canopies of 95, 80, 65, 50%	High forest-relatively intact with some selective logging in the past. Some hunting and the gathering of NTFPs Secondary forest-also important for collection of NTFPs
Tree-crop systems	Home garden Coconut Rubber agroforest Cinnamon agroforest Coffee agroforest Rubber Oil palm Tea plantation	Home garden Coconut Rubber agroforest Cinnamon agroforest Coffee agroforest Rubber Oil palm Damar agroforest Fruit-based agroforest Coffee	Agroforest Rubber agroforest Cinnamon agroforest Coffee agroforest Rubber Small-scale oil palm Large-scale oil palm Plantation	Oil palm	Extensive cacao-low productivity with limited use of fungicides (Akok only) Extensive cacao with fruit-same as above except fruit surpluses are marketed (Awae only) Intensive cacao with fruit-more intensive use of fungicides and labour result in higher yield (500 kg/ha) (Awae only)
Crop/Fallow systems	Agriculture Rice field	Agriculture Rice field Sugarcane	Agriculture Rice field	Shifting cultivation mosaic-combination of forest patches, pasture and annual crops Short fallow-secondary forest converted to 3 years of annual crops (rice, maize, cassava, plantain, bean) followed by 2-6 years of fallow	Mixed food crop/short fallow rotation-groundnuts, cassava, plantain, okra, cocoyams, maize, leafy vegetables Long fallow rotation-melon seed/plantain/long rotation fallow
Other	Settlement Grass Open peat Cleared land	Settlement Grass Open peat Cleared land	Settlement Grass Open peat Cleared land	Native grasses or *Brachiaria*	

Overall, ASB results from across the humid tropics show tradeoffs between biodiversity conservation and contribution to human livelihoods, although there are ways to mitigate the tradeoffs. For example, the upper line in Figure 2 shows more complementarity than the lower lines. The next question is: where and how can we achieve tradeoff scenarios as depicted in the upper line and avoid tradeoff scenarios as depicted in the lower line.

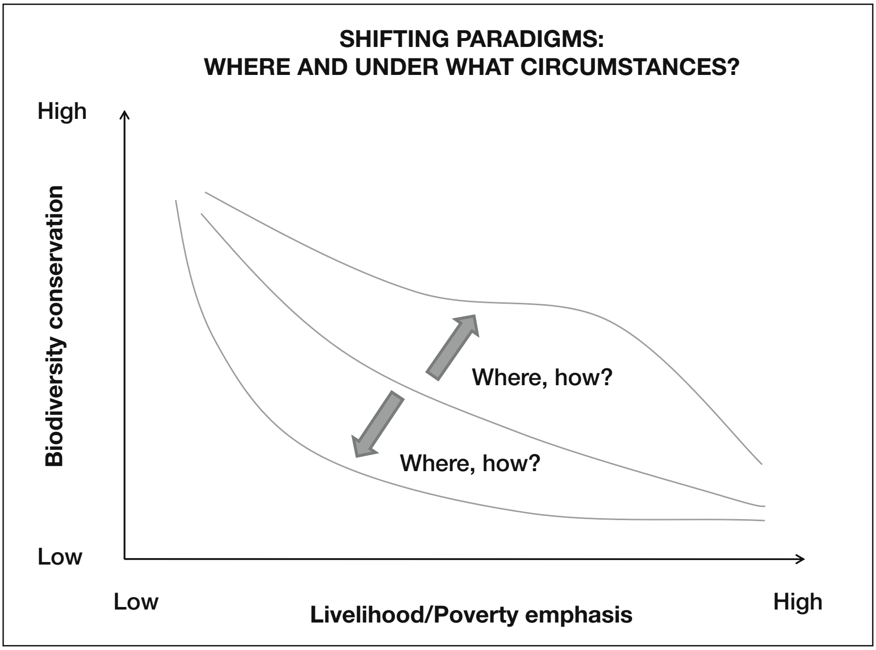

Figure 2. Shifting paradigms of tradeoff/complementarity between biodiversity and livelihood outcomes. Source: ASB.

Responses

Human societies have devised a number of responses to manage the tradeoffs between ecosystem goods and services. The most common response is regulation, the imposition of rules and regulations on human interaction with the ecosystem. Inappropriate rules and weak enforcement of those rules limit the effectiveness of this approach. While thus often insufficient on their own, experience has shown that regulations are usually necessary and can complement other approaches.

Social responses given more emphasis in recent years are recognition, rights and rewards. Recognition and rights go hand in hand. Recognition is the first step. That is, little can be done to effectively manage human impacts on ecosystem services unless those impacts are recognized and the stakeholders and motivations behind those impacts are recognized. Social recognition of stakeholders will often conclude that some stakeholders have more legitimate claims on ecosystem services than others. The next step involves the codification and enforcement of the rights of those with legitimate claims, as well as the duties of other members of society to respect those rights. Research conducted over the last 30 years has shown the advantages and limitations of public property rights (held by the state on behalf of the citizens of a locality), common property rights (in which people have rights through membership in a group) and private property rights.

A public response that has gained increased attention in recent years involves rewards for ecosystem services. That is, individuals or groups are given a monetary or non-monetary reward for stewardship of an ecosystem that provides valuable ecosystem services to other people (FAO, 2007). Over the last ten to fifteen years, the ASB program has shifted its emphasis from regulation, to recognition and rights, to rewards (e.g. Tomich *et al*. 2004).

- Recognition: necessary, problematic
- Regulation: necessary, rarely sufficient
- Rights: necessary, but questions about allocation to the right people
- Rewards: not necessary, but often useful.

Questions/issues raised in consultations:

- What biodiversity goals do 'we' want to achieve?
- Do agro-ecosystems really have low biodiversity value?
- Ecosystem services generated by biodiversity can indeed be important for local people
- Integrated conservation and development projects have had mixed results.

Learning resources and websites

Millenium Ecosystem Assessment: www.millenniumassessment.org/en/index.aspx
ASB: www.asb.cgiar.org
Ecoagriculture Partners landscape measures tools: www.landscapemeasures.org
ICRAF: www.worldagroforestry.org/
TULSEA: www.worldagroforestry.org/sea/
RUPES: www.worldagroforestry.org/sea/networks/rupes
PRESA: www.presa.worldagroforestry.org

Recommended reading

Millennium Ecosystems Assessment (MA) reports: www.millenniumassessment.org/en/index.aspx

Ecology and Society: www.ecologyandsociety.org

FAO, 2007. Farming farmers to protect the environment? State of the World's Food and Agriculture FAO, Rome, Italy.

McNeely J, Scherr S. 2002. Strategies to feed the world and save wild biodiversity. Island Press, Washington DC.

Chomitz K. 2007. At loggerheads? Agricultural expansion, poverty reduction and environment in the tropical forests. World Bank, Washington DC.

Tomich, TP, Thomas, DE, van Noordwijk, M. 2004. Environmental services and land use change in Southeast Asia: from recognition to regulation or reward? *Agric. Ecosyst. Environ*. 104 (1): 229-244.

Pollination

Ian Gordon[1] and Barbara Herren[2]
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Learning points

- Pollination is a frequently forgotten ecosystem service despite a currently estimated global value to agriculture of 153 billion Euros
- Pollination services have been available for free from nature but are increasingly threatened by climate change, local extinctions, pollinator scarcity, habitat destruction, insecticides and bee diseases
- An understanding of pollination must start with the basics of pollination mechanisms and of floral and pollinator morphology and behaviour: not all floral visitors are effective pollinators
- Various simple techniques are available for the practical investigation of pollination
- Indigenous practices do exist that favour effective pollination, but there remains great scope for improved pollinator management on both small and large scale farms
- A greater awareness of the importance of pollination can be fostered by its inclusion in educational curricula at all levels.

Overview of the topic

According to Klein *et al*. (2007), 87 (70%) out of 124 major crops in the world depend partly or wholly on pollinators for sustained production. Even crops such as coffee that were previously regarded as largely self-pollinated benefit from insect pollinators, not only through effects on yields but also on berry quality (Klein, 2003). By taking into account the level of dependence on pollination for 100 crops listed by FAO as direct contributors to human nutrition, Gallai *et al.* (2009) estimate the global value of this ecosystem service to be 153 billion Euros a year.

Pollination is generally an ecosystem service that is nature provides for free, although in many countries (including South Africa and in the past, Zimbabwe) it is deliberately augmented through the management, purchase and/or rental of honeybees, bumblebees and other bee species. Honeybee colonies are moved over hundreds of kilometres on large trucks to pollinate crops ranging from sunflowers to alfalfa and fruit trees. On a landscape and more local scale, pollination may be encouraged by the provision of breeding sites on farms for insect pollinators such as stingless or solitary bees, by reducing the application of pesticides and other agricultural chemicals that may be deleterious and by providing alternative forage plants that encourage pollinators to persist in agro-ecosystems outside of crop flowering periods.

The success of large scale pollinator management over many decades indicates that natural pollinator services may suffer in intensively managed agro-ecosystems. In recent years this pollinator deficit has worsened as a result of global declines in pollinator abundance and diversity. The main driver of these declines has been the destruction of the natural habitats on which pollinators depend, but there are also species-specific drivers such as the colony collapse disorder that decimated honey bee colonies in the US in the winter of 2006-2007. Other factors include the use of insecticides and the emerging and poorly understood impacts of climate change. Climate change may affect pollination services through differential shifts in the distributions and phenologies of pollinators and their dependent plants, leading to trophic and reproductive decoupling. On the other hand the reintroduction of biodiversity, even into intensive systems, may sustain pollination services.

The combination of pollinator declines, increasing intensification of agriculture and our enhanced scientific appreciation of the economic value of pollination makes the inclusion of pollination in educational curricula timely and essential. An understanding of pollination must start with the fundamentals of floral structure, modes of pollination and the means of pollination. Floral structure is covered in most basic biology courses but will need to be revisited as a starting point in the context of a pollination curriculum. Modes of pollination (self and cross pollination) need to be explained in self fertile, self sterile, monoecious and dioecious plants. It also needs to be explained that some crops (phenocarpic crops) develop fruit without any form of pollination whatsoever and are partially or completely seedless. The means of pollination are various (wind, gravity, water, birds, bats and insects) and need to be explained in relation to floral structure. Building on this basic understanding, major pollinators should be identified, and their taxonomy, behaviour and ecology described. The importance of pollination as an ecosystem service to agriculture (including estimates of its economic value,) and threats to pollinators and the global decline in pollinator services, should be covered. The importance of natural habitats and landscape ecology, together with pollinator friendly management techniques are essential components.

A purely theoretical understanding of any topic has limited value and the curriculum needs to include practical exercises. Again these should start with floral dissections, relating the floral structures to pollinator morphology and behaviour in a way that makes clear that not all floral visitors are effective pollinators. The basic taxonomy of important pollinator groups (especially bees) should be covered using keys and specimens. Simple techniques for investigating pollination (e.g. direct observation and recording of floral visitors, pollinator exclusion, hand pollination) should be demonstrated. Farms should be visited and assessed from the perspective of the degree to which they are pollinator friendly (presence of natural habitats, field sizes, monocultures, etc). Breeding sites for pollinators should be identified in the field.

Key issues for further research include the effectiveness of indigenous pollinator-friendly practices, pollinator taxonomy, ecology and behaviour, the influence of natural habitats and refinement of economic valuations.

Learning resources

Eardley C, Roth D, Clarke J, Buchmann S, Gemmil B. editors. 2006. Pollinators and Pollination: A resource book for policy and practice. African Pollinator Initiative, ARC, South Africa.

FAO 2008. Rapid assessment of pollinators' status: a contribution to the international initiative for the conservation and sustainable use of pollinators. Global action on pollination services for sustainable agriculture. FAO, Rome. www.fao.org/uploads/media/raps_2.pdf

Pollination management training curricula study sheets: Available from Global Action on Pollination Services For Sustainable Agriculture, FAO Rome,

Vaughan M, Sheppard M, Kremen C and Hofman Black C (eds). 2007. Farming for bees: Guidelines for providing native habitats on farms. Xerces Society, Portland Oregon.

Bees, Pollination and Climate Change: A Guide to Selected Resources. Science Reference Section, Science, Technology & Business Division, Library of Congress. www.loc.gov/rr/scitech/SciRefGuides/bees.html

Recommended reading

Delaplane KS Mayer DF. 2000. *Crop pollination by bee*. CABI Publishing, CAB International, Wallingford.

Klein AM, Vaissièree BE, Cane JH, Steffan-Dewenter I, Cunningham SA, Kremen C, Tscharnktke T. 2007. Importance of pollinators in changing landscapes for world crops. 2007. *Proc. R. Soc. Biol. Sci.* 274:303-313.

Gallaia N, Sallesc JM, Setteled J, Vaissièrea BE. 2008. Economic valuation of the vulnerability of world agriculture confronted with pollinator decline. Ecological Economics 2009 Vol. 68 No. 3 pp. 810-821 (available at www.sciencedirect.com).

Useful websites

Global Action on Pollination Services For Sustainable Agriculture. fao.org/agriculture/crops/core-themes/theme/biodiversity/pollination/en/

Bees and Pollination: a collection of links from Ohio State University's Ohio Agricultural Research Service (ARS) www.oardc.ohio-state.edu/agnic/bee/

HoneyBeeNet, NASA Goddard Space Flight Center

Wayne Esaias' site for learning about the effects of climate change on bees and ecosystems honeybeenet.gsfc.nasa.gov/

Mid-Atlantic Apiculture: a regional group focused on pest management crisis in beekeeping industry. maarec.cas.psu.edu/

The Pollinator Partnership: learn more and get involved in pollinator protection. www.pollinator.org/

Project Budburst: a national phenology network field campaign for citizen scientists. www.windows.ucar.edu/citizen_science/budburst/

Status of Pollinators in North America, a publication from the Committee on the Status of Pollinators in North America, National Research Council. www.nap.edu/catalog.php?record_id=11761

Genetic resources policy and intellectual property

Robert J. Lewis-Lettington
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Outline

Summarizing issues surrounding genetic resources and intellectual property rights in the African context represents a significant challenge, because of the complexity of the situation and the often confusing or weak regulatory systems. This presentation outlines the basic framework within which the conservation and utilization of genetic resources takes place, and which forms the basis of most national approaches. It is divided into four main sections:

- Ownership and control of genetic resources
- Movement of genetic resources
- Intellectual property rights
- African Union.

Ownership and control of genetic resources

Ownership of and the right to control, genetic resources are the starting point for any consideration of conservation and use.

What is the relevant law?

The Convention on Biological Diversity www.cbd.int applies to most genetic resources and is the default framework for almost all matters relating to their conservation and use. It is important to consider several points when examining genetic resources in the CBD context:

- Country of origin is a key concept in access. The country of origin of a genetic resource is where it is found in *in situ* conditions or, in the case of cultivated species, where the particular varieties developed their distinctive characteristics. There is no definition of distinctive characteristics. Where one is dealing with non-cultivated species the situation can be complicated by multiple points of origin, although the actual country of origin will be the jurisdiction where it is collected, regardless of wherever else it may be found. While, to the best knowledge of the author, it has not been significantly acted upon to date, the provision on the origin of cultivated species could become extremely complex
- The provisions of the CBD are not directly applicable in national law, although they are seen as a framework for good conduct. There must be corresponding national law for them to be directly binding upon other than states
- In developing countries, the genetic resource related provisions of the CBD are usually reflected in national law through access to genetic resources regulations. Some provisions, particularly those relating to conservation, are usually found in general biodiversity or environmental legislation.

The International Treaty on Plant Genetic Resources for Food and Agriculture www.planttreaty.org was developed in harmony with the CBD. It has the intention of providing a framework for the conservation and sustainable use of plant genetic resources for food and agriculture. It also seeks to provide a clear and predictable system for access and benefit sharing relating to plant species of key importance to food security and for which countries are interdependent in terms of access for plant material for research, training and breeding to improve food and feed production. The Multilateral System of Access and Benefit Sharing can be regarded as a means of implementing the framework provisions of Article 15 of the CBD, although the following points must be considered:

- The Multilateral System of access and benefit sharing only applies to material of species listed in Annex I and under the management and control of the state and in the public domain and material in international and other collections placed in the Treaty framework
- To date, the Multilateral System is mostly reflected in national law through administrative practice (rules, contracts etc) but this may change.

In addition to the CBD and the International Treaty, several other initiatives that may have significant impact upon the conservation and sustainable use of genetic resources are at various stages of development, including:

- A more detailed framework for access and benefit sharing is being developed under the CBD. This is expected to be binding in nature, although this has not yet been agreed upon and is currently known as the International Regime. Negotiations are scheduled to be concluded at the meeting of the Conference of the Parties in 2010 but this remains a challenge and any agreed binding instrument would remain subject to some form of accession by states
- With the adoption of the Global Plan of Action for the Conservation and Sustainable Use of Animal Genetic Resources in 2008, discussions on access and benefit sharing are developing in this area, although it is not clear whether this will ultimately lead to any instrument. As things evolve, it appears likely that discussions will probably be confined to domestic livestock but they could also include wild relatives
- The role of microbial genetic resources in agriculture is beginning to be discussed in terms of access and benefit sharing frameworks.

What is your source of material?

The source of material can have significant impacts upon issues of ownership and control. There are two basic sources of material, although each of these can obviously be broken down almost infinitely.

A. Wild material. In considering wild material, the key determining factors are:

- What is the location of the collection? Land tenure or governance, sometimes including customary law and practice, can significantly influence access procedures
- Do you have national access to genetic resources regulations? Regulations are likely to govern access to wild materials regardless of where they are found

- Is the sample native or an alien species? This can have implications for country of origin rights, although even alien species found in *in situ* conditions have, thus far, tended to be managed by the states where they are found.

B. *Ex situ* collection. *Ex situ* collections tend to be more predictable than other sources of material and many are aware of the various international and national regulatory issues and have taken administrative steps to recognize them. In the event that there is any uncertainty, several basic questions should be considered:

- Was the material in question collected pre or post-1992? Material collected pre-1992 is expressly excluded from the scope of the CBD by the Nairobi Declaration that accompanied the adoption of the Convention's text.
- Who holds the collection and what species are you accessing? Some species are covered by the International Treaty on PGRFA, provided they are under the management and control of the state or have been placed within the Treaty framework.
- What country are you accessing material from? Not all countries are parties to the International Treaty on PGRFA, although most are party to the CBD and the country where you are accessing the material may not be the country of origin.

Movement of genetic resources: sanitary and phytosanitary standards

Apart from specific measures for access and benefit sharing, most movements of genetic resources have to comply with sanitary or phytosanitary standards and procedures, which are basically about plant, animal and more recently, general environmental health. The primary umbrella agreement lending force to specific sectoral technical agreements is the World Trade Organisation's Sanitary and Phytosanitary Standards (SPS) Agreement. More information can be found at the International Phytosanitary Portal www.wto.org/english/tratop_e/sps_e/sps_e.htm, but a summary of the scope of the three sectoral technical agreements, known as the 'three sisters' is as follows:

A. Codex Alimentarius Commission (CAC)
   - Food stuffs
   - Includes means of production, preparation, storage, etc.

B. International Plant Protection Convention (IPPC)
   - Regulates plant pests; secures action to prevent the spread and introduction of pests of plants and plant products; and promotes appropriate measures for their control
   - More info: www.ippc.int/IPP/En/default.jsp

C. World Organization for Animal Health (OIE)
   - Technical mandate similar to that of IPPC but animals rather than plants
   - More info: www.oie.int/

In addition to the three sisters, there is the Cartagena Protocol to the CBD, which considers the risk to general environmental health from the movement of living modified organisms. The Cartagena Protocol is not as widely accepted or established as the three sisters. Its basic characteristics are as follows:

- Biosafety: The need to protect human health and environment from the possible adverse effects of the products of modern biotechnology
- Protocol objective: Adequate protection in the safe transfer, handling and use of living modified organisms (LMOs) resulting from modern biotechnology that may have adverse effects on the environment & human health
- Scope: Trans-boundary movement, transit, handling and use of LMOs (Article 4) that can affect sustainable use of biological diversity. Pharmaceuticals are excluded.
- Adopts a precautionary approach.

Intellectual property rights

Intellectual property rights often control many aspects of the ownership and control of genetic resources but are a complex and diverse field at both the national and international levels. However, the key indicative instruments for genetic resources issues are the World Trade Organization's Agreement on Trade Related Intellectual Property Rights (TRIPs), particularly Article 27.3(b) and the Union for the Protection of New Plant Varieties (UPOV) Convention. Under Article 27.3(b) of TRIPs:

- Members may exclude plants and animals from patentability
- Members must protect microorganisms
- Members shall provide for the protection of plant varieties either by patents or by an effective *sui generis* system or by any combination thereof
- Other possibly relevant areas of the TRIPs Agreement include:
    - Protection of undisclosed information (e.g., hybrids)
    - Trademarks (associated with seeds' generic denomination)
    - Geographical indications.

The UPOV Convention is generally considered as linking with Article 27.3(b) of TRIPs by providing a *sui generis* form of intellectual property right for any kind of plant variety. UPOV's basic principles include:

- Commercial novelty
- Distinctness
- Uniformity
- Stability
- Broad exceptions for research and breeding
- Limited, optional, exceptions for small holder use.

This refers to the 1991 text but, in developing a national law, a country could use earlier texts.

Patents vs. Plant Variety Protection (PVP)

Patents	**Plant Variety Protection**
Genes, cells, plants, varieties	Plant varieties
Novelty, inventive step, industrial applicability	Novelty, distinctness, uniformity, stability
Exclusive rights over use, research and breeding	Farmers' privilege Breeders' rights

Various actors, particularly developing countries and NGOs, have raised a number of concerns about intellectual property rights over genetic resources, including:

- How do intellectual property rights, allowing for private monopolies, link with sovereign rights and a state's power to regulate, over genetic resources?
- Third parties can be prevented from producing or selling goods or services using protected information or material without the title-holder's authorization, e.g. a common issue in cut flower exports to Europe
- Another issue that has generated concern is the impact that the appropriation of genetic materials under IPRs may have on the access to such materials for further research and development
- The granting of plant breeders' rights (PBRs) does not limit the use of the protected material as a source for further research and breeding, because of the generally accepted 'breeders' exemption'
- The treatment of traditional knowledge in IPR regimes has been seen as allowing for the appropriation of developments based on such knowledge without recognizing rights to the knowledge itself.

African Union

The African Union has promoted the use of two model instruments relating to genetic resources issues, namely:

- The African Model Law for the Protection of the Rights of Local Communities, Farmers and Breeders and for the Regulation of Access to Biological Resources
- Draft Model National Legislation on Safety in Biotechnology.

The basic characters of each of these models are very similar:

- Not binding – advisory documents adopted by Organization of African Unity/African Union ministerial conferences
- Very useful for identifying principles and key concerns
- Do not replace the need for work at the national level – difficult to implement in a 'cut and paste' approach.

In the specific case of the African Model Law for the Protection of the Rights of Local Communities, Farmers and Breeders and for the Regulation of Access to Biological Resources, one should also consider the following:

- Where UPOV focuses on rights of downstream users of biological materials, i.e. researchers and breeders, Model focuses more on rights of material providers
- Seeks to establish/maintain rights to farmers' varieties and other informally developed or used material
- Balance between role and rights of individuals, communities, government and the private sector can be difficult to achieve and probably needs further analysis at the national level.

Concluding comments: what should a university teach its students?

While universities could seek to develop detailed courses on genetic resources law and policy as part of legal or science and innovation policy training, they may also need to consider several areas for incorporation into courses relating to biological and chemical sciences and into the administration of technology and innovation, in particular:

- How to responsibly and fairly collect and use material
- How to protect the rights of researchers and those of their institutions, as well as those of others
- Focus on promoting research and pre-empting problems
- Universities will need to engage their respective national authorities in policy development.

Threats to agrobiodiversity

Mikkel Grum, Sibonginkosi Khumalo and Julia Ndungu-Skilton
Bioversity International

Learning points

- The main threats to agrobiodiversity
- Differences and similarities between threats to biodiversity in general and threats to agrobiodiversity
- Bridging between the 'conservation' and 'agricultural' worlds and experience
- Creating the right organizational and institutional context for creative interaction between scientific and indigenous knowledge
- Multidisciplinary nature of agrobiodiversity research and practice. Most projects and programmes of work are component specific, i.e. they focus specifically on crops, animals, pests and pathogens of individual species, pollinators or soil biota, etc. (the way components link and interact is not always very clear)
- Because agrobiodiversity is largely managed, there is close interaction of the biophysical sciences with the socio-economic and cultural disciplines. How we effectively adopt partnerships and participatory approaches among researchers, farmers and other stakeholders to integrate ecological and socioeconomic research, which are instrumental in understanding ecosystem services and the tradeoffs of different management scenarios
- Many of the unmanaged components, e.g. wild relatives of crops, habitats for pollinators, pests and diseases, are important factors in the choices that people make. There is currently a lack of scientific knowledge on the totality of ecosystem services provided by agrobiodiversity
- Strengthened capacity among partners to incorporate agricultural biodiversity components in their work and to manage work in ways that reflect agricultural biodiversity needs.

Overview of the topic

Agrobiodiversity has developed and is nurtured within systems manipulated by people. Therefore, it is the choices that people make that drive the continued existence, or extinction, of agrobiodiversity. The initial result has been that there is today many times more agrobiodiversity than existed 10 000 years ago. These hard-won gains for humanity are now threatened by a variety of factors.

The threats generally arise when there are gaps between the private value and public value of changes to production systems. The private and public values of farming activities are very often closely aligned with the development and nurturing of agrobiodiversity. This is how most development of agricultural biodiversity has been driven, in the interest of both the individual and the general public. Yet there are signs that this alignment is in part breaking down.

Agrobiodiversity loss occurs at a range of scales from individual fields to the total loss of species or varieties from the earth. The loss can be viewed from the perspective of the loss of products or ecosystem services in specific locations, or the loss of options for humanity as a whole. Under a broad definition of agrobiodiversity that includes crop wild relatives and gathered plants and animals, its loss occurs in wild habitats as well as in agricultural production systems. However, this presentation will focus on the losses within production ecosystems to highlight the distinctive elements of threats to agrobiodiversity. Markets drive most of these changes.

At one extreme, climate change is probably the biggest future threat to agrobiodiversity and represents the consequences of choices made by societies both within and more importantly, beyond agricultural production systems. With climate change, the trees, crops and varieties that they grow and the animals that they keep will need to alter in whole regions. This will happen at a pace that makes it very unlikely that they will fully master the intricacies of the opportunities offered, or the constraints enforced, by climate change. Since agrobiodiversity will need to be moved around very consciously, it is overwhelmingly likely that much of the diversity will be lost.

In a parallel to habitat change for natural biodiversity, enterprise change is the most dramatic threat to agricultural biodiversity. When farmers replace one plant or animal species with another, or drop species, varieties or races because they focus on fewer enterprises within the farm, the result is a reduction in agrobiodiversity. On a larger scale, loss can also occur when farmers adopt the same varieties across farms, without necessarily resulting in a reduction in diversity on the individual farm. On a global scale the increasing demand for wheat, maize and rice is happening at the expense of diversity of many other crops.

Examples can still be found where taking on new enterprises can increase on-farm diversity, such as when farmers begin cultivating trees or crops that they had previously gathered. The recent introduction of many leafy vegetables into cultivation is one example.

Closely related to enterprise change is industrialization of farming, which often demands significant simplification of production ecosystems and the reduction of diversity. Mechanization is one aspect that encourages the production of fewer crops and varieties. The use of fertilizers, pesticides and medicines all influence production in ways that reduce diversity within the ecosystem through mono-cropping and reduced crop rotations and animal movements. There are also unintended side-effects on other agrobiodiversity by, for example, killing pollinators.

Plant breeding, or even simply selection of one variety over another, results in the loss of large amounts of agrobiodiversity. The replacement of traditional varieties by new varieties is the most talked about effect, but the breeding of one crop, rather than another, favours that crop relative to others.

Weeds, pests and diseases also exert their influence. Some of them add to the diversity of the production system by supplying products that people make use of, such as the weeds consumed as leafy vegetables, grass-cutters and pigeons which provide meat, etc. Pests and diseases have also been primary drivers of the diversification of plants and animals throughout the history of agriculture.

There is currently much talk of 'peak oil', the idea that we have now reached a turning point with respect to the availability of oil and that future supplies will come at a higher cost and at slower rates than previously. Is the same happening with the plants and animals in our production systems? Have we reached 'peak agrobiodiversity'? And if so, how does this prepare us for the challenge of adapting to climate change and other future scenarios?

Recommended reading

Balter M. 2007. Seeking agriculture's ancient roots. Science.316:1830-1835.

Brooks N. 2006. Climate change, drought and pastoralism in the Sahel – Discussion note for the World Initiative on Sustainable Pastoralism. WISP.

Brown O. and Crawford A. 2008. Assessing the security implications of climate change for West Africa: Country case studies of Ghana and Burkina Faso, pp. 51. IISD, Winnipeg, Canada.

Ho, M-W. and Ching LL. 2008. Greening the desert: how farmers in Sahel confound scientists. Institute of Science in Society, London.

Pielke R, Prins G, Rayner S. and Sarewitz D. 2007. Lifting the taboo on adaptation: renewed attention to policies for adapting to climate change cannot come too soon. in Nature, Vol. 445, 8 February 2007: pp. 597.

Useful websites

Platform for Agrobiodiversity Research, www.agrobiodiversityplatform.org

Session 5 – Innovation in higher agricultural education

Chair: Judith C.N. Lungu

Findings from surveys on PGR and agrobiodiversity education in Africa and Latin America

Boudy Van Schagen
Bioversity International

Introduction

Until recently, there has been a critical lack of information on how plant genetic resources (PGR) and agricultural biodiversity are being taught at higher education institutions in the developing world. To redress this, Bioversity International recently commissioned regional university surveys in eastern and southern Africa and in Latin America. The focus of this presentation is on the African survey, with a brief comparison with the Latin American survey results.

Rationale for an African survey on agrobiodiversity/PGR education

A 2007 meeting with the Uganda-based Regional Universities Forum for Capacity Building in Agriculture (RUFORUM) and Bioversity concluded that there was an 'urgent need for capacity strengthening in agrobiodiversity education'. Until this time little was known about how agrobiodiversity was being taught in universities, or the opportunities and constraints to delivering this training.

Methodology

Bioversity commissioned an external consultant to develop and conduct the survey. The consultant visited nine regional universities in eastern and southern Africa to gather in-depth information. In addition, a questionnaire was circulated by email to 50 universities, members of the African Network for Agriculture, Agroforestry and Natural Resources Education (ANAFE).

The survey addressed all levels of university education, from diploma-level through Bachelors and Masters to PhD training. It looked at what was offered at the programme and the individual course level, but did not request information on which topics were covered within courses. Importantly, the study assumed a common understanding of the concepts and approaches defining plant genetic resources and agrobiodiversity.

Results

Of the 50 email questionnaires distributed, only six were returned, five of which were from universities also visited by the consultant. This yielded a total of 10 universities surveyed. There was also a rather heavy and unintended national bias to the results – half of the responding universities are located in Kenya.

In terms of PGR education, the results can largely be organized into four domains: crop science and plant breeding; seed science; biotechnology and; horticulture (Table 1).

Table 1. Programmes of relevance to PGR

Domain	Programme	University
Crop Science and Plant Breeding	MSc Plant breeding	University of Nairobi
	MSc Plant breeding	University of Malawi
	MPhil/PhD Plant breeding	Moi University
	BSc Crop improvement & protection	Kenyatta University
	MSc Plant breeding	University of Zambi
	MSc Crop science (plant breeding option)	University of Zimbabwe
	MSc Crop science (PGR + plant breeding options)	Makerere University
Seed Science	BSc and MPhil Seed science	Moi University
	MSc Seed science and trade	Makerere University
Biotechnology	BSc and MSc Biotechnology	Kenyatta University
	BSc and MSc Biotechnology	Jomo Kenyatta University of Agriculture and Technology
	MSc Crop science (biotechnology option)	Makerere University
Horticulture	MS Horticulture (some also BSc and PhD)	Four Kenyan Universities
	MSc Horticulture	University of Malawi

The survey revealed that there is currently no comprehensive programme on agrobiodiversity offered at any level in any of the responding universities. Nor is there any dedicated course on agrobiodiversity in the surveyed universities. Nonetheless, some agrobiodiversity content is delivered within the context of a few programmes and courses (Table 2).

Table 2. Programmes and courses agrobiodiversity content

Programme with agrobiodiversity content	University
MSc in Ethnobotany	Kenyatta University
BSc Agro-ecosystems and Environment	University of Nairobi
Course on biodiversity conservation in its BSc Agroforestry programme	Copperbelt University, Zambia
Ethnobotany course in its BSc Botany programme	Jomo Kenyatta University of Agriculture and Technology
Course on traditional vegetables production with the BSc Horticulture programme	Egerton University

An important observation is that PGR- and agrobiodiversity-related programmes are often oriented towards specific (and often technical) disciplines, such as seed science, crop protection, agricultural economics, horticulture, microbiology and agronomy. This suggests a reduced scope for teaching more 'holistically' with emphasis on the multidisciplinary elements of agrobiodiversity, including the social sciences.

Somewhat surprisingly, there was widespread dissatisfaction with the way plant genetic resources is currently being taught, with responses ranging from 'inadequate' to 'grossly inadequate'. Only the University of Zambia and Makerere University were comparatively more satisfied with their quality of training.

Job prospects and institutional partnerships

Government ministries (particularly the Ministry of Agriculture) and other public sector institutions (including genebanks, national agricultural research organizations, etc.) are seen as providing the most important career opportunities for graduates. Private sector companies are seen as less enticing, with self-employment and engaging in entrepreneurial activities being the least-favoured career pathway.

Respondents were also asked to give examples of kinds of partnership, collaboration and other forms of external linkages they had established. The responses can be broadly categorized into 3 types:

- Partnership with complimentary organizations
- Linkages with genebanks
- Participation in thematic networks.

Nearly all universities felt that external partners made significant contributions towards the development and sustenance of their programmes. They also confirmed that partnership collectively builds capacity, helps realize common objectives and that it helps in managing and supporting reviews of curricula.

Challenges to teaching and learning agrobiodiversity and PGR

Respondents were asked to identify some of the problems and obstacles in teaching agrobiodiversity and PGR. Their comments were that:

- Teaching and learning is usually not problem-based
- The student/teacher ratio is high
- Excessive emphasis on theory
- There is no e-learning mode of delivery
- A lack of teaching aids, audio-visual equipment, computers etc.
- The system does not expose students to be critical thinkers (there is rote learning).

Some comparisons with Latin America

A similar survey conducted in 2006-2007 in several Latin American countries examined post-graduate level agrobiodiversity/PGR education (undergraduate education was not covered). That aside, the survey revealed that – just as in eastern and southern Africa, no university presently offers an integrated programme on agricultural biodiversity, nor a specific course entitled agrobiodiversity. Programmes and courses are rooted in disciplines of biology and/or agronomy. The survey identified the coverage of some topics that were not picked up in the African survey, such as bio-safety, intellectual property and biodiversity value.

A single extract from the Latin America survey report deftly summarizes the similarity of the problems and opportunities identified in both regions.

The biggest challenge for the future has to do with the relevance of the content to the labour market, not only the national but also the regional market; to harnessing opportunities for collaborative work with other organizations and; to achieve greater inter-disciplinarity within the same university'.

Innovation systems approach: Implications for agricultural education and research

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Learning objectives

- The nature of innovation including innovation triggers and hindrances
- Knowledge, learning and science, technology and innovation policy
- The system of innovation and its relevance to agriculture
- The innovation system approach and its implications for agriculture and agrobiodiversity education and research.

Content

- Knowledge, learning theories, linkages, institutions, organizations and innovation definitions and concepts
- Definition of systems of innovation and innovation systems approach
- Application of the innovation systems approach to agriculture and agrobiodiversity education and research.

Session plan

This module should comprise classroom lectures to introduce the key concepts; a reading assignment on innovation, innovation system, innovation system approach, knowledge and learning; a group assignment in which students compare agricultural innovation system and innovation system in manufacturing sector, e.g. the car industry to identify synergies and differences and present their results orally and; an individual paper identifying and categorizing any innovation(s) for a chosen commodity, the source of the knowledge underpinning the innovation, the innovation triggers and an assessment of the performance.

Background

Technological innovations have been associated with productivity growth and increased material welfare for centuries. Yet, countries in Sub-Saharan Africa (SSA) continue to be challenged in adopting technologies to increase agricultural productivity and competitiveness. The terms innovation, invention and technology development are often used interchangeably but, they are not the same. Innovation is the application of knowledge (including scientific and indigenous knowledge), whether new or old but new in a given context or applied in new ways, to bring new products, processes and services into social and economic use. Innovation as defined in this widest sense is an interactive, cumulative, evolutionary process that is embedded in the political, social, economic, organizational, institutional and cultural context and is driven by science, technology, learning, the policy environment, opportunity and demand. Innovation can also be social, political and organizational. Agriculture in SSA needs innovation.

Scientific discoveries, inventions and technological innovations are not the only factors that underpin socio-economic development. The enabling environment including the policy and legislative framework, the financial system, the physical infrastructure including the communication network, the traditional habits, behaviour and practices and the knowledge and learning competencies of the actors are also important. Institutions, defined as the rules of the game, for example Intellectual Property Rights (IPR) legislation and organizations, defined as the structures created to take advantage of opportunities provided by institutions, for example universities, research institutes and extension services facilitate access to information and knowledge. Collaboration, networking and the information and knowledge flows among key stakeholders and their ability to learn and apply knowledge (codified and tacit; indigenous and scientific; knowledge embedded in technologies etc) within an enabling environment are critical.

The innovation systems approach is a framework that can be used for evaluating and comparing innovation performance within and across sectors and countries. It is conceptually diffuse and is used to describe, understand and explain innovation determinants and processes and the results are used to guide innovation policy. It is holistic and inter-disciplinary in nature and provides a historical perspective. ISA can be applied at various levels and scales (international, national or sectoral) or to a particular technology. The boundaries of the system are generally defined by the aspects to be studied. In developed economies, the approach is used to understand the differences in innovation performance and to explain trends in economic development. Its application to understanding agricultural development in developing countries is limited but is acknowledged to be important.

A system of innovation consists of a network of actors who, together with the institutions that influence their innovative behaviour, create, diffuse and use knowledge within an economic framework. The system actors include: the enterprises, commodity and industry associations, innovation and productivity centres, standard setting bodies, research and development organizations, universities, education and vocational training centres and information and financial services among others. Endogenous science, technology and innovation capacity is important for effective performance of innovation systems. The actors should be able to produce (e.g. through research) or acquire, diffuse, absorb and use scientific and technical knowledge as well as value traditional knowledge.

The role and functions of agriculture have changed over the centuries. Agriculture is a complex inter-related activity with strong forward and backward linkages between producers, intermediaries and markets (highly structured in some countries) and not only provides food (for sustenance, nutrition and health), feed, fibre and fuel but also recreational and eco-system services including conserving agrobiodiversity and safeguarding the environment. This suggests the need for new innovation patterns which rely on collaboration and networking among scientists of several related disciplines and between them and other actors including policy-makers and entrepreneurs. Such system would take advantage of knowledge as needed and create and expand market opportunities for products and services. The emphasis must be on building capacity of the system actors to learn and creating the institutions and organizations that can support the enterprises to continuously innovate. All actors must be able to harness and add value to the rich agrobiodiversity that exists in sub-Saharan Africa for food and wealth creation.

Recommended reading

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ANAFE's experience with curriculum reviews

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Summary

One of the major activities of the African Network for Agriculture, Agroforestry and Natural Resources Education (ANAFE) has been on curriculum review and development. Emphasis has been on agroforestry curriculum review. The method of choice for conducting the curriculum review has been the participatory DACUM (Developing a Curriculum) process.

The process consists of three distinct stages:

- A carefully chosen group of expert workers form the DACUM committee, representing business, industry and the profession of the curriculum under review
- The job is then defined in terms of tasks that successful workers in that job would perform; the result is put together in a 'competency profile'
- The knowledge, skills and attitudes required for students undertaking the course are then clearly laid out.

A facilitator carefully guides the different stages in the DACUM process. ANAFE to date has reviewed 67 curricula covering certificate, diploma, first degree and postgraduate agroforestry courses. Resource persons have been largely drawn from ANAFE member institutions. Stakeholders have included farmers, students, researchers, policy-makers, local leaders, NGOs and educators. From ANAFE experience with the review of agroforestry curricula, seven requirements for an agroforestry curriculum have been identified:

- Analysis of training needs
- Taking into account development and environmental needs
- Assessment of institutional learning
- Estimating the resource requirements
- Focusing on competencies to be developed
- Stakeholder participation
- Capturing multidisciplinary opportunities.

Participants on the past DACUM committees have found the activity to be a professionally stimulating and rewarding experience. The DACUM process has not been a one-off exercise and ANAFE recommends that the process be repeated after two or three student intakes. There is also a need for the DACUM process to be carried out more broadly in various subjects including agriculture and natural resource management courses in tertiary institutions. A significant amount of literature developed by ANAFE is now available both in print and on the Web, to contribute to the growing field of curriculum review.

Introduction

ANAFE was launched in April 1993. ANAFE is one of the largest African networks of educational institutions and comprises 131 member universities and colleges in 35 African countries. The network is hosted at the headquarters of the World Agroforestry Centre (ICRAF) in Nairobi, Kenya.

The initial objectives of ANAFE were to:

- strengthen the capacity of institutions that have interest in advancing agroforestry education
- provide fora for the exchange of information and experiences, especially in the context of south-south collaboration.

Over the years, the ANAFE mandate has been expanded to also include agriculture and natural resources education. ANAFE was registered as an international NGO in June 2007. The mission of ANAFE espoused in its 2008–2012 strategy is '*To improve agricultural education for impact on development*'. The major activities carried out include: policy advocacy, institutional reforms to link education to development, review of curricula, development of learning resources, facilitating knowledge sharing, promoting women and youth in agriculture, HIV/AIDS mitigation, sound environmental practices, mitigation and adaptation to climate change, quality education assurance and risk management in agriculture.

The structure of ANAFE is presented in Figure 1. ANAFE works through four regional chapters known as Regional Agricultural Fora for Training (RAFTs), in eastern and central Africa, southern Africa, the Sahelian countries and the Africa Humid Tropics. ANAFE also has national chapters known as National Agricultural Fora for Training (NAFTs) in 21 member countries.

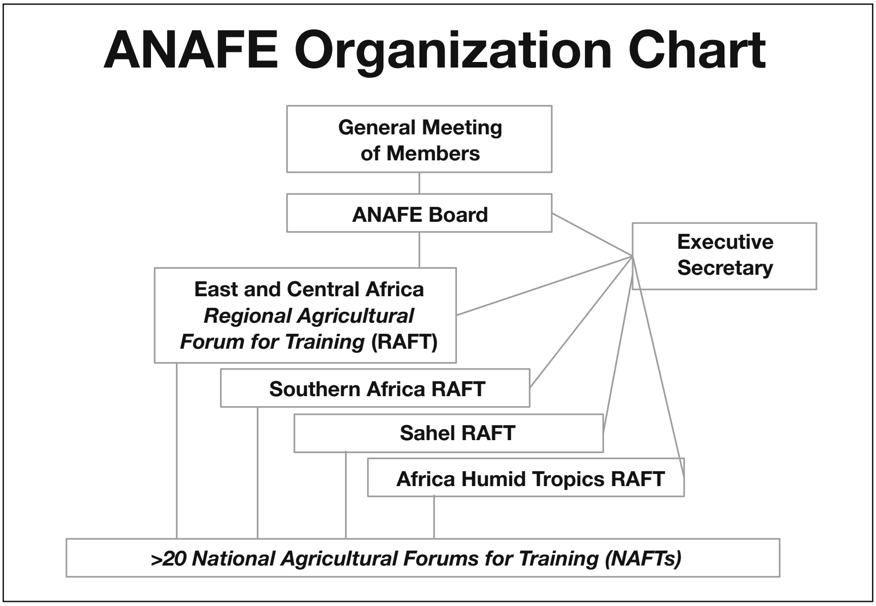

Figure 1. ANAFE organizational structure.

Structurally, RAFTs report to the ANAFE Board, which in turn is accountable to the General Meeting of Members. RAFTs coordinate the work of NAFTs and are supported by the ANAFE Executive Secretary, who is responsible for overall management of the network, liaison with donors and partner organizations, information dissemination and reporting. The Executive Secretary is supported by four Senior Education Fellows, one in each region, who work directly with RAFTs. There is also a Network Manager who works closely with the Executive Secretary at the Secretariat.

Curriculum review: The process

This paper is concerned with the curriculum review activities of the Network and discusses the review process, offers details on curricula reviewed and lessons learnt in the process including the way forward.

Rogers and Taylor (1998) define a curriculum as ‘all the learning that is planned and guided by training or teaching organizations’. Temu and Kasolo (2001) defined curriculum as ‘a logically developed sequence of teaching and learning activities (theoretical and practical) that are undertaken by trainees to achieve a specified level of competence in a given field of study.’

With regards to curriculum development and review, ANAFE sought out methods that were **inclusive**, **integrative** and **affordable** (Temu and Kasolo, 2001). **Inclusive** in the sense that all stakeholder groups were represented in the process; **integrative** in the sense that curriculum aspects of inter- and multi-disciplinarity could be articulated. The process had to be within the **financial** reach of national institutions. This was particularly important especially considering that curricula are dynamic and the review process had to be repeated in the future. The Swedish International Development Cooperation Agency provided resources for ANAFE to carry out curricula development and review exercises.

Curricula review is necessary for a variety of reasons. First, new knowledge on the subject area will be developed. Secondly, we note that jobs are no longer available in the civil service – the traditional employer of graduating students; more and more graduating students are being self-employed. Thirdly, with the advances in information and communication technology, it is clear that new media for delivering education are available.

Curriculum review weighs the effectiveness of an existing curriculum against the developments outside and inside the teaching institution. The objective should be to improve the knowledge, skills and attitudes that can be acquired by students going through the programme.

ANAFE reviewed a number of approaches, including the classical approach; faculty initiated/faculty controlled, hidden process and participatory processes. ANAFE settled on the DACUM - Developing a Curriculum - as the method of choice for curriculum development and review because it incorporates a participatory approach to curriculum review. DACUM is based on three premises.

- Firstly, expert workers are in a better position to describe their job than anyone else. A carefully chosen group of 8-12 expert workers from the job under consideration form the DACUM committee. Committee members are recruited directly from business, industry and the profession. Modified small group brainstorming techniques are used to obtain the collective expertise and consensus of the committee

- Secondly, any job can be effectively described in terms of the tasks that successful workers in that job perform. The analysis usually results in the identification of 6-12 duties involving 50-150 tasks that define what a successful worker in a particular job, or cluster of related jobs, must be able to do. The end product of a DACUM analysis is a complete competency profile
- Thirdly, all tasks, in order to be performed correctly, require certain knowledge, skills and attitudes. Whereas the primary focus of a DACUM process is on the performance aspects of a job, these lists represent other aspects of job analysis; they represent different ways of looking at the requirements of the job.

The DACUM committee is carefully guided by the facilitator through each of the following steps:

- Orientation
- Review of job or description
- Identification of general areas of job responsibility
- Identification of specific tasks performed in each of the general areas of responsibility
- Review and refinement of task statements
- Identification of general knowledge and skill requirements of the occupation, tools, equipment, supplies, materials used, desirable worker traits and attitudes
- Development of the curriculum needed
- Other options, as desired (i.e. identification of entry level tasks).

A summary of the DACUM process as it relates to the development of agroforestry curricula by ANAFE is presented in Table 1.

Table 1: A summary of the DACUM process as adapted for use by ANAFE in the development of an agroforestry curriculum

Activity	Key players	Output
Planning	Policy-makers and educators	Review of existing information; Training area analysis; Workshop fixtures; Identification of a workshop facilitator; Selection of workshop participants
DACUM workshop	Facilitator (stakeholders/ participants)	Knowledgeable participants on the DACUM process; Agreeing on span of positions; Identified duties (general competencies); Identified tasks for each duty; A refined DACUM chart
Analysis of DACUM chart	Educators	Statements of training behavioural objectives for each of the tasks
Course development	Educators	Sequenced topics; Developed syllabi; Time allocation for the training activities
Identification of training resources	Policy-makers Administrators Educators	Resources for teaching; A monitoring and evaluation mechanism

Source: Temu and Kasolo 2001

Curricula reviewed and lessons learnt

The review of curricula is a lengthy process. Normally it takes up to three years to get a change approved. Over a 10-year period, 1992-2003, ANAFE was involved in the review of a total of 67 curricula for Certificate, Diploma, 1st degree and postgraduate levels, as shown in Table 2.

Table 2: Total curricula reviewed by ANAFE from 1992-2003

Discipline\Level	Certificate	Diploma	1st Degree	Postgraduate	Total
Agriculture	2	4	15	2	23
Forestry	7	8	6	2	23
Other (Rural Development, Horticulture)	1	2	3	0	6
New agroforestry programs	0	4	5	6	15
Total	10	18	29	10	67

All curricula were reviewed on cost sharing arrangements between ANAFE and the institutions involved. All reviews and new programme developments were initiated and managed by the colleges and universities involved. Resource persons facilitating the curriculum reviews were drawn from ANAFE member institutions that had developed competence in the process. The DACUM approach was applied in all cases. Stakeholders participating in the process included farmers, students, researchers, policy-makers, local leaders, NGOs and educators.

In the past 3 years, ANAFE has facilitated the development of four curricula:

- A HIV/AIDS curriculum for students of agriculture and natural sciences
- Curriculum for the forestry technician certificate course at the Forestry Training Centre, Kagelu, New Sudan
- Curriculum for MSc in agroforestry and soil management at the Faculty of Agriculture, National University of Rwanda
- A proposed tree seed education curriculum for multipurpose trees on farm land prepared for agricultural and forestry technicians.

From ANAFE's experience, there are seven requirements for a good and relevant agroforestry curriculum development (Rudebjer *et al*., 2005):

- Analyze training needs: where is the expertise in agroforestry needed? What type of expertise? How many people?
- Take account of development and environmental needs: What are those needs? What contribution will the curriculum make to development or environmental management?
- Assess the institutional setting: What adjustments to the curriculum development process are needed to suit the specific situation?
- Estimate the resource requirements: What resources are necessary to develop and implement a good curriculum? Which are actually available?
- Focus on competencies to be developed: What competencies need to be developed? Which competencies are already being provided by existing

courses or programmes? Can desired competencies be achieved by modifying the content and/or delivery of existing subjects, or is a major curriculum revision required?

- Consider stakeholder participation: Who should be involved in the curriculum development process? How?
- Capture the multidisciplinary opportunities: What biophysical and socio-economic issues will be addressed? Which disciplines need to be involved in curriculum development?

As ANAFE's mandate has been expanded to incorporate agriculture in addition to agroforestry and natural resource management, it is important that curriculum development and review reflects the new focus. The DACUM process should now be used to review the curricula in these areas as well. Further support is needed to look at such aspects as quality of delivery, attitudinal changes for staff and students, as well as quality and relevance of programmes.

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Useful websites

African Network for Agriculture, Agroforestry and Natural Resources Education: www.anafeafrica.org

Southeast Asian Network for Agroforestry Education: www.worldagroforestry.org/sea/seanafe

Agroforestry Net: www.agroforestry.net

Higher education in Sub-Saharan Africa: challenges and prospects in agriculture

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Learning points

- The increased interest in higher education presents higher education institutions with an opportunity to move Africa towards a knowledge economy
- Continued capacity strengthening for faculty academic staff, technicians and senior management in African universities is crucial if higher education is to significantly contribute to Africa's development
- Quality assurance and relevance of curricula beyond national aspirations are crucial for Africa's development in a global context
- The labour market has increasingly accused universities of producing technically sound (hard skilled) job seekers rather than competent (soft skilled) graduates with capacity to create jobs
- Higher education institutions face the challenging task of balancing teaching and research
- Capacity strengthening in higher education institutions is crucial for quality assurance
- Africa's higher education institutions could form networks of excellence for maximum impact
- Africa has innovative success stories in higher education that can inform new initiatives.

Introduction

Higher education in agriculture and related fields has a direct impact on agricultural productivity and on the performance of agribusiness. It stimulates implementation of knowledge-driven economic growth and poverty-reduction strategies. The quality of training at higher education institutions is critical because it determines the expertise and competence of scientists, professionals, technicians, civil service and leaders in all aspects of agribusiness and related industries. Their capacity to access knowledge and adapt it to prevailing circumstances, to generate new knowledge and impart it on others is raised. According to the Africa Commission (2009), urgent action must be taken to restore the quality of graduate and postgraduate agricultural education in Africa.

Despite the increased enrolment and number of institutions in the past 15 years, Africa lags behind the rest of the world in investing in its people. The greatest challenge to policy-makers and managers of higher education in Africa today is how to strategically steer higher education institutions to become Africa's drivers for economic development.

Agricultural research has the potential to bring creativity and scientific methods to bear upon the opportunities and problems facing the agricultural sector in Africa. Research leads to generation and adaptation of technological, sociological and economic innovations for use by actors in the agricultural sector, leading to, *inter alia*, increased productivity, incomes and improved, more sustainable livelihoods, as well as food security. Investment in agricultural research is therefore also investment in growth. In the areas of agriculture and rural development the national agricultural research systems (universities, national research organizations, etc.) will continue to be the heart of the research effort. In June 2008, the MDG African Steering Group recommended that investments in agricultural research be significantly scaled up to support research on sustainable agricultural practices to mitigate the anticipated effects of climate change.

Capacity to conceptualize, plan and implement effective research is still limited. Research proposals received by the Regional Universities Forum for Capacity Building in Agriculture (RUFORUM), International Foundation for Science and others in the past 10-15 years highlight the challenge. Development paradigms are also changing and there is need to appropriately adjust, while at the same time building, a critical mass of system thinkers/researchers to address critical issues including food and nutrition insecurity, poverty alleviation in the face of environmental degradation, climate variability and change, high energy and food prices.

Higher education in SSA: Some realities

SSA has the lowest student enrolment rate in the world. Between 1965 and 2005 for example, Gross Enrolment Ratio increased from 1% to 5%. In order for institutions of higher education, particularly universities, to unlock their potential for turning the development wheel in Africa, key capacity gaps have to be addressed. These, *inter alia*, include:

- Curriculum reform and delivery for relevance
- Developing approaches and methodologies that enhance university contribution to national growth and development
- Advocacy and fund raising to increase investment in higher education
- Building managerial and leadership capacity and institutional reform for credible and relevant university training
- Building capacity for Africa-based high quality publications.

National political systems and/or legislation have had a major role in shaping institutions of higher education in SSA. Except for a few countries in the region, higher education is conspicuously absent from Poverty Reduction Strategy Papers (PRSPs), which are Africa’s most recent approach to development.

Renewed emphasis on higher education

Within the past 10 years, Africa has recorded a significant shift towards emphasis on higher education. A number of interventions are currently being implemented at national and regional/continental levels.

National level interventions

At the national level, a number of countries are acting on their commitment to higher education through PRSPs. According to World Bank studies, key examples from Africa include Ethiopia, Mozambique and Ghana (Table 1).

Table 1. Response of some African countries towards higher education

Country	Nature of response
Ethiopia	Parliament's higher education proclamation (2003): Introduced new degree programmes in line with economic needs Established national Quality Assurance and Relevance Agency Launched capacity building of ICTs Increased share of education budget Increased allocation (15 to 23%) of budget to higher education Since 2000, introduced graduate tax to enable graduates to pay back cost of university education
Mozambique	Creation of Ministry of Higher Education, Science and Technology in 2000 In 2000, 10 regional consultations were held with higher education institutions, students, business, regional governments and civic associations. The output was a Strategic Plan for Higher Education in Mozambique 2000-10
Ghana	World Bank 5-year education sector project to improve quality of tertiary education through a teaching and learning innovation fund. Academic units can access fund to introduce new or different higher education delivery approaches Affirmative action policy of lowering admission cut-off points to achieve gender equity. Female enrolment grew by 6% between 1990 and 1999. Similar action in Tanzania's University of Dar es Salaam increased female enrolment from 19.5% to 27% between 1997 and 2000

Regional/continental level interventions

In this section I will highlight some initiatives/interventions by the Regional Universities Forum for capacity building in Agriculture (RUFORUM) during the past last four years.

The Regional Universities Forum for Capacity Building in Agriculture

RUFORUM is a consortium of 25 universities in Eastern and Southern Africa established in 2004. Previously (since 1992) it existed as a programme called Forum funded by the Rockefeller Foundation. RUFORUM has a mandate to oversee graduate training and *networks of specialization* in the Common Market for Eastern and Southern Africa (COMESA) countries. RUFORUM recognizes the untapped potential of universities in contributing to the well-being of small-scale farmers and economic development of the Sub-Saharan Africa region.

RUFORUM derives its agenda largely from the continent-wide policy frameworks especially of the African Union-New Partnership for African Development (NEPAD) Comprehensive African Agricultural Development Programme (CAADP); the NEPAD Science and Technology Framework; the African Union Policy Framework on Revitalising Higher Education in Africa; the Sub-regional Multi-Country Agricultural Productivity Programs; the PRSPs of the member States and Governments and constant review of global trends and foresight planning to ensure Africa has the required capacity for global competitiveness.

RUFORUM Strategic Goals

- Train a critical mass of Masters and PhD graduates, who are responsive to stakeholder needs and national/regional development goals
- Develop collaborative research and training facilities that achieve economies of scope and scale
- Increase in the participation and voice of women in agricultural research, production and marketing
- Improve the adaptive capacities of universities to produce high quality and innovative training, research and outreach activities that can contribute to policy and development practice
- Increase the use technology to support effective, decentralized learning and the sharing of knowledge
- Mainstream new approaches within university teaching and research that emphasizes quality, innovation, impact across the agriculture sector's full value chain
- Create a dynamic regional platform for policy advocacy, coordination and resource mobilization for improved training, research and outreach by universities.

RUFORUM is involved in:

- Masters and doctoral programmes that are responsive to stakeholder needs and national, regional and global development goals
- Shared research and training facilities and capacities that enhance economies of scope and scale
- Mainstreaming operational capacity and approaches for innovative, quality and impact-oriented agricultural research for development and management in universities.
- Policy advocacy, lobbying, coordination and resource mobilization for improved training, research and outreach by universities.

Since 2004, RUFORUM has contributed to higher education through a number of initiatives. They include the following:

Regional PhD programmes

In 2004 RUFORUM commissioned a study for purposes of mapping out the capacity strengths and weaknesses of member universities in terms of expertise, facilities, resource endowment and experience, among others. The outcome was a ‘comparative advantage map’ of member universities.

Through stakeholder consultation nationally, regionally and beyond, the consensus was for RUFORUM to pay particular attention to developing regional PhD programmes with a course work component. The objective is to build capacity for capacity building in agriculture. Six regional programmes were identified:

- PhD in Dryland Resource Management, hosted by the University of Nairobi, Kenya
- PhD in Plant Breeding and Biotechnology, hosted by the Makerere University, Uganda
- PhD in Fisheries and Aquaculture, hosted by the University of Malawi, Malawi
- PhD in Agricultural and Resource Economics, hosted by the University of Malawi, Malawi
- PhD in Food Science and Technology, hosted by the Jomo Kenyatta University of Agriculture and Technology, Kenya
- PhD in Agricultural and Rural Innovation Studies, hosted by the Makerere University, Uganda.

The Drylands Resource Management and Plant Breeding and Biotechnology programmes started in October/November 2008, with 15 and 20 students respectively. The programmes at the University of Malawi are scheduled to start in September 2009. The rest of the programmes are still being developed.

The regional universities have linked up with other knowledge centres to form networks of excellence, within which graduate students receive mentorship/professional development by attachment to specialized institutions and/or senior scientists.

SUCAPRI

Strengthening of University Capacity for Promoting, Facilitating and Teaching Rural Innovation Processes (SUCAPRI) is being implemented as a project by RUFORUM funded by EDULINK - ACP-EU Partnerships in Higher Education. SUCAPRI harnesses south-south and south-north strengths for building both institutional and individual professional capacity needed to promote agricultural and rural innovation. The piloting phase consists of a network of teaching and research staff at Makerere Nairobi, Egerton, Kenyatta and Jomo Kenyatta universities; three national agricultural research organizations are involved, i.e. the Kenya Agricultural Research Institute, the National Agricultural Research Organization in Uganda and the International Centre for Development-Oriented Research in Agriculture in the Netherlands. The Commonwealth of Learning brings the strength of using ICT to enhance communication and partnership.

The project activities aim at:

- Building rapport with managerial and technical staff as well as non-university stakeholders
- Establishing a learning platform for network dialogue on joint curricula, content, delivery methods, student support and research
- Building the capacity of network universities by training trainers of core staff that will in turn train others and by sensitizing university management for the purpose of reviewing policies and institutional arrangements and with other institutions
- Facilitation of participation of multi-stakeholders from the national innovation systems in learning cycles in reflection, planning, action, evaluation cycles of agricultural higher education with focus on needs assessment, priority setting for curricula reorientation and programmes as well as proactively creating a learning enabling environment.

Other initiatives include the following, whose details are available at www.ruforum.org:

SCARDA-ECA: Strengthening Capacity for Research and Development in Africa (SCARDA) is a capacity building programme of FARA, operationalized from sub-regional level to continental level. In East and Central Africa, The programme is being implemented as a project of the Association for Strengthening Agricultural Research in East and Central Africa (ASARECA) called SCARDA-ECA. SCARDA has two components of strengthening: competencies and capacity in agricultural research management and capacity for professional development in agricultural research and development.

PMSS: RUFORUM is piloting the Personal Mastery and Soft Skills development course to enhance quality of training and research in RUFORUM member universities. The objective is to enhance capacity and competencies of the universities for better delivery of services to communities. This will result from enhancing teaching and research competencies of the academic staff, training practical oriented students and having adaptive management to facilitate innovations. The activities involved:

- ***Quality Assurance in Graduate Programmes:*** This project aims at strengthening capacity of universities in eastern, central and southern Africa to offer quality graduate programmes, through building institutional and human resource capacities. RUFORUM is working closely with AGRINATURA www.agrinatura.eu/ in its implementation
- ***Catalyzing Change in African Universities (CCAU):*** This initiative focuses on strengthening leadership, management and cross-cutting professional skills of eastern and southern African universities
- ***Enhancing Research Capacity and Skills in Eastern and Southern Africa (ERESA):*** The goal is to enhance institutional competencies of institutions of higher learning in eastern and southern Africa in impact-oriented research for strengthened development.

Contributing to development

To date RUFORUM graduates are employed in different sectors and are contributing to national and regional development. Summary results of a tracer study on RUFORUM graduates since 1992 are indicated in Table 1.

Table. Employment and service delivery profile of RUFORUM graduates

Employment	%
Research	31
Universities	27
PhD training	15
Industry	10
NGO	8
Extension	6
Policy	3

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Annexes

Annex 1. Workshop programme

Regional workshop on: Learning Agrobiodiversity: Options for Universities in Sub-Saharan Africa. 21-23 January, 2009, ICRAF House, Nairobi, Kenya

DAY 1 – Wednesday 21 January, 2009	
	Step 1: Official opening and setting the scene *Chair: Prof. John Saka, ANAFE Chair person*
09.00	**Opening address** *Prof. John Saka, ANAFE Chair person* Opening remarks *Dr Mikkel Grum, Acting Regional Director, Bioversity International* *Dr Dennis Garrity, Director General, World Agroforestry Centre* *Judith Ann Francis, Senior Programme Coordinator, S&T Strategies, CTA* Overview of workshop objectives, outputs and programme *Aissetou Yayé, Executive Secretary, ANAFE* Introduction to the workshop process and facilitation principles/values *Dr Paul Kibwika, Facilitator*
10.00	**Coffee & group photo**
	Step 2: Creating a common understanding of agrobiodiversity and challenges of teaching agrobiodiversity in universities *Chair: Dr Mikkel Grum, Acting Regional Director, Bioversity International*
10.30	**Introduction of Participants** **Keynote presentation: Agrobiodiversity in food systems, ecosystems and education systems** *Per Rudebjer, Bioversity International* **Keynote presentation: Challenges and approaches to learning and teaching agrobiodiversity** *Prof. Lenah Nakhone Wati, Egerton University, Kenya* **Short plenary discussion** for purposes of clarification **Identifying gaps in agrobiodiversity educatio**n
	Step 3: Sharing experiences and perspectives on agrobiodiversity **a) Agrobiodiversity conservation** Chair: Oudara Souvannavong, FAO
11.20	**Conservation of plant genetic resources, including crop wild relatives** *Dr. Zachary Muthamia, Head of the Kenyan Genebank* **Overview of the state of animal genetic resources** *Dr Julie Ojango ILRI* **Forest genetic resources and farmers tree domestication** *Ramni Jamnadass, World Agroforestry Centre* **Plenary and buzz group discussions**
13.00	**Lunch**
	Buzz group discussions on: **1) glaring gaps in Agrobiodiversity education** **2) conservation of ABD: key issues for teaching and learning**

	b) Use of agrobiodiversity for livelihood services *Chair: Dr. Jacob Mwitwa, Dean, School of Natural Resources, Copperbelt University*
14.00	**Farmer Innovations and Indigenous Knowledge which Promote Agrobiodiversity in Kenya, A Case Study Of Mwingi And Bondo Districts** *Professor Ratemo W. Michieka, University of Nairobi and FAO Consultant* **The impact of biodiversity and bio fortification on nutrition and health for the majority of the poor, through mainstreaming** *Dr Omo Ohiokpehai, CIAT/TSBF* **Plenary and buzz group discussions**
15.30	**Coffee**
15.50-17.00	**Clustering of cards to organize issues identified in buzz group discussions** *Dr Paul Kibwika, Facilitator*
17.30–19.00	**Reception at ICRAF Campus**
DAY 2 – Thursday 22 January, 2009	
	c) Cross-cutting issues: markets, environmental services and policies *Chair: Dr. Gorettie Nabanoga, Dean, Faculty of Forestry and Natural Resources, Makerere University*
08.30	**Review of Day 1 outputs** *Paul Kibwika* **Adding value to agrobiodiversity: developing the value chain for neglected and underutilized species** *Dr. Charity Irungu, Saint Paul University, Kenya* **Ecosystems services in mosaic landscapes** *Brent Swallow, ICRAF* **Pollination** *Ian Gordon, ICIPE and Barbara Herren* **Plenary and buzz group discussions**
10.00	**Coffee**
10.20	**Genetic resources policy and intellectual property** *Robert Lettington, (ex-Bioversity International)* **Major threats to agrobiodiversity** *Mikkel Grum, Bioversity International* **Plenary and buzz group discussions**
	d) Innovation in higher agricultural education *Chair: Dr. Judith C.N. Lungu, Dean, School of Agricultural Sciences, University of Zambia*
11.00	**Higher Education in Sub-Saharan Africa: Challenges and Prospects** *Dr Wellington N. Ekaya, RUFORUM Program Officer, Training* **Innovation systems approach: Implications for agricultural education and research** *Judith Ann Francis, Senior Programme Coordinator, S&T Strategies, CTA* **Findings from surveys on PGR and agrobiodiversity education in Africa and Latin America** *Boudy Van Schagen, Bioversity International* **Plenary and buzz group discussions**

12.15	**Mega-trends and patterns that justify agrobiodiversity education** **Defining the profile and ability of graduates**
13.00-14.00	**Lunch**
14.00	**ANAFE's experience in curriculum reviews** *Professor John Saka, University of Malawi, Malawi* **Plenary and buzz group discussions**
	Step 4: Describing the key elements of agrobiodiversity for mainstreaming into higher agricultural education *Facilitator: Paul Kibwika*
14.40–17.00	**The clusters will be assigned to small working groups** to describe what each of them entails: i.e. the topics of under each module
DAY 3 – Friday 23 January, 2009	
08.30	**Review of Day 2 outputs** *Paul Kibwika*
	Step 5: Options for mainstreaming agrobiodiversity in higher agricultural education Facilitator: Paul Kibwika
09.30	**Integrating agrobiodiversity at different levels of education: options and justifications**
10.30	**Coffee**
10.50	**Strategies for implementation** Working groups to explore what it takes to put each option practice Tools and materials
13.00	**Lunch**
	Step 6: Planning way forward Facilitator: Paul Kibwika
14.00	**Mechanisms for sharing and learning** Platform for knowledge sharing Stakeholders and partnerships **Mapping the way forward: what do we do next?** Action plan Resource mobilization
	Step 7: Workshop evaluation and closure
16.00–17.00	**Evaluation** **Closure**

Annex 2. Draft agrobiodiversity curriculum framework

This draft Agrobiodiversity Curriculum Framework was developed by workshop participants. The Task Force, established at the workshop, will review and expand this framework with the aim of publishing a 'Guide for Developing Agrobiodiversity Curricula' in 2010.

1. Agrobiodiversity valuation

Introduction:
Need to value (in respect to society) agrobiodiversity so as to objectively prioritize conservation and facilitate its utilization.

Main learning points:
- Understanding value chain components and their interactions
- Describe the various processes that lead to final product
- Explain value-adding processes
- Promote agrobiodiversity potential.

Contents:
1. Concepts of agrobiodiversity
2. Economic valuation: agrobiodiversity value chain
   a. Components: roles and functions
   b. Interactions
3. Processing of products
   a. Value-adding
4. Marketing
   a. Searching for new markets
   b. Expanding markets
   c. Segmentation of markets.

2. Agrobiodiversity threats and mitigation

Introduction:
Establish a sense of ownership and protection of agrobiodiversity.

Main learning points:
- Understanding relationship between agrobiodiversity and livelihood
- Identify threats to agrobiodiversity
- Explain influence of threats on agrobiodiversity
- Evaluate and apply appropriate mitigation measures.

Contents:

1. Policy and IPR
2. Community rights
   a. IPR
   b. Legislation issues
3. Sources, scale and trends of threats to agrobiodiversity
   a. Components: roles and functions
   b. Interactions
4. Processing of products
5. Value-adding
6. Marketing
   a. Searching for new markets
   b. Expanding markets
   c. Segmentation of markets
7. Utilization.

3. Agrobiodiversity and livelihood

Introduction:

Show how agrobiodiversity can help humans in their pursuit for livelihoods and the role of socio-economic and cultural aspects in agrobiodiversity management.

Main learning points:

- To appreciate the role of culture and indigenous knowledge in the management of agrobiodiversity
- To be able to detect and harness benefits of agrobiodiversity products towards food and nutritional security
- Detect and mitigate threats to agrobiodiversity
- Guide in value addition and sustainable use of agrobiodiversity
- Utilize indigenous knowledge in agrobiodiversity
- Advocate and communicate agrobiodiversity issues
- Work with farmer and other stakeholders
- Integrate in multidisciplinary/interdisciplinary teams
- Link agrobiodiversity to livelihood
- Create jobs related to ADB
- Facilitate interaction with all stakeholders in an inclusive way.

Contents:

1. Link of agrobiodiversity and livelihood
2. Culture and indigenous knowledge in the management of agrobiodiversity
3. Cost-benefit analysis of agrobiodiversity
4. Financial analysis of agrobiodiversity
5. Socio-economic and cultural threats to agrobiodiversity
6. Agrobiodiversity value chains analysis techniques.

Methods:

1. Participatory assessment of agrobiodiversity products and services
2. Value chain analysis.

4. Agrobiodiversity environmental benefits and services

Introduction:

The role of agrobiodiversity in maintaining and sustaining environmental benefits and services.

Main learning points:

- Undertake a responsive and proactive plan for conservation, rehabilitation and restoration of agrobiodiversity
- Enhance agrobiodiversity contribution through the value chain (e.g. African leafy vegetables)
- Detect and harness environmental benefits of agrobiodiversity
- Detect and mitigate environmental threats to agrobiodiversity
- Coordinate environmentally related activities of all stakeholders in agrobiodiversity
- Advocate and communicate agrobiodiversity environmental issues
- Apply environmental management principles in agrobiodiversity conservation
- Establish competency in environmental accounting.

Contents:

1. Principles of agrobiodiversity conservation and management
2. Cost-benefit analysis of agrobiodiversity
3. Mitigation strategies for agrobiodiversity threats
4. Advocacy and communication of agrobiodiversity environmental issues
5. Environmental accounting.

5. Diversity, domestication and pollination

Introduction:

The module will cover types, characteristics, value and importance of biological diversity (including plant and other underutilized species, animal, aquatic); aims at providing the graduate with knowledge and skills on reproductive biology for greater diversity; and aims to equip the students with knowledge and skills in improvement and domestication of genetic and species diversity (including breeding and biofortification) leading to sustainable utilization of genetic resources.

Main learning points:

- Analyze the differences in biological diversity
- To discuss socio, economic, cultural and ecological values of biological value
- To use diagnostic tools for identification
- Describe the reproductive system of biological resources
- Analyze reproductive systems in different biological resources
- To provide options for improvement
- To compare different strategies for improvement and domestication of genetic diversity
- To analyze different options for sustainable utilization.

Contents:

1. Types and characteristics of biological diversity
   a. Plant
   b. Aquatic
   c. Animal
   d. microbial
2. Value and importance of biological diversity
   a. Ecosystem service
   b. Food and nutrition
   c. Economic e.g. ecotourism
   d. Socio-cultural value
3. Phenology
4. Mating systems
5. Reproductive systems
6. Dissemination
   a. Plants
   b. Animals
   c. Fish
   d. Microbes
7. Domestication
8. Biotechnology
9. Breeding.

6. Agrobiodiversity extension and the public-private sector dynamic

Introduction:

Awareness and promotion of agrobiodiversity potential, public-private partnerships and optimization of private sector interests.

Main learning points:
- Various PRA approaches
- Development and utilization of dissemination techniques
- PRA design for stakeholder engagement

7. Agrobiodiversity conservation and management policy

Introduction:
The purpose of this course is to understand national, international policies related to agrobiodiversity conservation and management. It should equip the student with knowledge on legal frameworks related to agrobiodiversity and apply the same.

Main learning points:
- All treaties and conventions related to agrobiodiversity
- Benefits and consequences of
- Enforce the relevant national policy/legal frameworks related to agrobiodiversity
- Contribute to the improvement of agrobiodiversity policies.

Contents:
1. International treaties (CBD, ITPGRFA, IPPC, EOAC, Codex Alimentarius)
2. National policies/regulations on agrobiodiversity
3. Land tenure and management of agrobiodiversity
4. International property rights in relation to agrobiodiversity.

8. Principles of agrobiodiversity conservation and management

Introduction:
To impart skills for agrobiodiversity conservation.

Main learning points:
- Scientific and local knowledge on agrobiodiversity conservation
- The rationale of agrobiodiversity conservation and management
- Methods of agrobiodiversity conservation and management.

Contents:
1. Rationale for agrobiodiversity conservation and management (underutilized species, etc.)
2. Ecosystem functions
3. Inter- and intra-species diversity
4. Conservation strategies (conventional and traditional)
5. Conservation through use.

9. Agrobiodiversity and traditional knowledge

Introduction:

Traditional knowledge has been sidelined by science. Yet for centuries communities have managed their agro-ecosystems using traditional knowledge systems. Tradition and culture is therefore an integrated part of agricultural biodiversity. This course will define and explore traditional knowledge and cultural practices associated with the conservation and management of agrobiodiversity.

Main learning points:

- Acknowledge, recognize and appreciate all elements of traditional knowledge systems
- Explore and identify traditional knowledge and practices
- Integrate traditional and scientific knowledge systems
- Appreciate gender relations regarding agrobiodiversity knowledge
- Appreciate and support traditional innovation related to agrobiodiversity.

Contents:

1. Theory and concepts regarding traditional knowledge
2. Evolution of traditional knowledge
3. Traditional knowledge in the modern society
4. Local conservation strategies
5. Culture and agricultural biodiversity
6. Traditional knowledge vs. modern science
7. Traditional value systems on agrobiodiversity
8. Traditional germplasm management and conservation methods.
9. Impact of modern agriculture on use of traditional varieties
10. Informal seed systems
11. Case studies/success stories on application of traditional knowledge to agrobiodiversity
    conservation
12. Policies and traditional knowledge in agrobiodiversity conservation and management.
13. Bio-prospecting/IPR issues
14. Strengthening the market chain for traditional species.

10. Agrobiodiversity conservation

Introduction:

Rapid genetic erosion is threatening the future adaptability and evolution of agricultural biodiversity. This course will define approaches and methodologies for implementing agrobiodiversity conservation in an integrated and interdisciplinary way, in mosaic landscapes.

Main learning points:

- Apply methods for assessing diversity at ecosystems, species and within-species level
- Design appropriate conservation strategies, in collaboration with multiple stakeholders
- Apply conservation strategies across mosaic landscapes.

Contents:

1. Structure and function of agro-ecosystems
2. Ecosystems assessment methodologies
3. Population genetics
4. Systems approaches
5. Mosaic landscape approach to conservation
6. Connectivity and geneflow in mosaic landscapes
7. Species traditionally used
8. Conservation through use of neglected and underutilized species
9. Wild relatives of domesticated species
10. Assessing status of threats
11. Conservation strategies (ex situ, in situ, on farm)
12. Trade-offs and conflicts over natural resources
13. Conflict prevention and management in conservation
14. Multi-stakeholder planning
15. Traditional conservation strategies
16. Information and communication skills
17. Use of GIS and modelling for landscape analysis and conservation planning.

Annex 3. List of participants

Regional workshop on learning agrobiodiversity: options for universities in Sub-Saharan Africa, 21-23 January, 2009, ICRAF House, Nairobi, Kenya

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