SCARDA briefing papers

Strengthening Capacity for Agricultural Research and Development in Africa

Volume 3

Forum for Agricultural Research in Africa

PMB CT 173 Cantonments
2 Gowa Close, Roman Ridge
Accra, Ghana

2008

FARA (Forum for Agricultural Research in Africa), 2008. *SCARDA (Strengthening Capacity for Agicultural Research and Development in Africa). Volume 3. Briefing papers.* Accra, Ghana. 64 pp.

Acknowledgement

FARA gratefully acknowledges the support provided by the United Kingdom Department for International Development (DFID) for the programme on Strengthening Capacity for Agricultural Research and Development in Africa (SCARDA).

FARA Secretariat

PMB CT 173 Cantonments
2 Gowa Close, Accra, Ghana

Tel.: +233 21 772823 / 779421

Fax: +233 21 773676

E-mail: info@fara-africa.org

Web site: http://www.fara-africa.org

ISBN: 978-9988-1-1063-4 (print)

Printed at Pragati Offset Pvt. Ltd., Hyderabad, India. www.pragati.com

Preface

The briefing papers in this volume were commissioned by the Conseil Ouest et Centre Africain pour la Recherche et le Développement Agricoles / The West and Central African Council for Agricultural Research and Development (CORAF/WECARD) during the SCARDA Inception phase. They are the products of consultation on five of the most important issues that African agricultural research and development institutions will have to address during the SCARDA Implementation Phase.

The paper on *Agricultural Innovation Systems* by Barry Pound and George Essegbey sets out the general concepts and principles of the Agricultural Innovation Systems approach, and its application to agricultural research and development, particularly in sub-Saharan Africa. It is not meant to be a comprehensive treatment of the topic, and suggestions for further reading are given at the end of the paper. It is intended for those interested in applying new approaches to research with farmers, NGOs and the private sector that led to developmental outcomes.

The paper *Gender and diversity in sustainable agricultural research and innovation: Issues, challenges and the way forward* by Valerie Nelson, Adrienne Martin and Aissétou Dramé Yayé discusses the patterns of change in gender relations in the context of rural livelihoods. These patterns are of critical importance in agricultural research: in the framing of research agendas and influencing research priorities; in selecting methods, approaches and collaborative partners for research implementation; and in the assessment of the impact of new technologies, knowledge and innovation. It raises important issues in relation to gender, diversity and the processes of agricultural innovation, summarizes lessons from existing mainstreaming initiatives and suggests ways forward.

The paper on *Agricultural Information Management* by N. Nathaniels, R.I. Lamboll, M.A.C. Conroy and A. Youdeowei aims to begin a debate about agricultural information management in the CORAF region. It poses questions as to what agricultural information and management is and highlights some key dilemmas and promising initiatives to provide inspiration for debate about information in development.

The paper on *Climate change and agricultural development* by Tim Chancellor, John Morton, Ramadjita Tabo and Ralph von Kaufmann discusses the influence of climate change on smallholder agriculture, with a special focus on West and Central Africa. The likely impacts of climate change on smallholder farmers are assessed and farmers' strategies for adapting to these impacts are examined. Key research and capacity-strengthening priorities are identified that will help minimize adverse impacts and identify new opportunities.

The paper on *Crop biotechnology and biosafety* by S.Seal, A. Sangare, M. Makinde focuses on crop biotechnology issues of relevance to West and Central Africa and specifically the application of molecular biology techniques to generate higher crop yields or plant varieties that can be grown under adverse conditions. Increased crop yields are necessary to assist Africa meet its increasing food security needs; the continent's estimated annual rate of population growth of 2.8% will lead to a doubling of the population in 25 years.

FARA is grateful to the United Kingdom Department for International Development (DFID) for its support for SCARDA and to CORAF/WECARD for its initiative in commissioning these papers.

Ralph von Kaufmann
Director, Capacity Strengthening
FARA

1
Agricultural Information Management

Nathaniels, Nick., Lamboll, Richard.I, Conroy, Martin A.C. and Youdeowei, Anthony

Introduction

This briefing paper aims to raise debate about agricultural information management (AIM) in the CORAF region. It draws attention to initiatives concerned with AIM and sub-Saharan Africa (SSA) from global to local levels. Using these examples, we pose questions as to what AIM is, highlight some key dilemmas, and some promising initiatives that may provide inspiration for debate about information in development.

What is Agricultural Information Management and why is it important?

Agricultural information management (AIM) is concerned with all actvities and resources necessary for acquisition, storage, updating, and making agricultural information and data of all kinds and formats—scientific research reports, growers' testimonies, market information, details of practical crop production technologies, machinery, weather forecasts, sources of credit, production, education and training and other instructional manuals, 'grey zone' literature—accessible to agricultural stakeholders at all levels. AIM considers not only information resources and technologies, but also development of the human resources needed for efficient use of these technologies.

Agriculture, in the medium term at least, is seen as key to reversing worsening poverty in many countries in SSA. If this strategy is to succeed, the relevance, quality and accessibility of information for all agricultural stakeholders must be assured on a wider scale than ever before. Agricultural information and AIM are therefore attracting intensified focus as a critical component of projects, programmes and agreements concerned with economic development and poverty reduction in Sub-Saharan Africa. But isolated approaches to AIM for development may have little chance of success. Several resources need to be in place before information can be acted upon and lead to the changes desired by the individuals, communities, organisations, states (Figure 1). These resources include:

- Data Resources: availability of relevant data.
- Economic Resources: the money, the skills, and the technology in order to access the data.
- Social Resources: the motivation, confidence and knowledge to access, assess and apply the data, and to be able to trust the source.
- Action Resources: the ability to act on the decisions made with the information. This may be hard resources eg money, technology, raw materials or soft resources eg skills and empowerment. This implies a high degree of integration between AIM services and other services, together with policy.

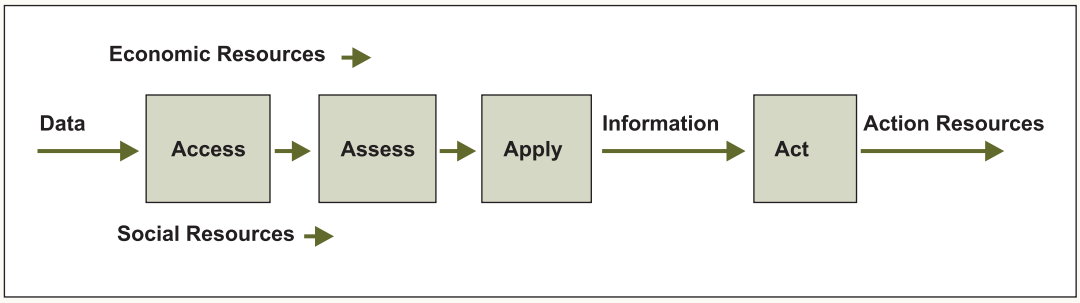


Figure 1. The Information Chain in Development ***Source: Heeks, R. (2005)***

Due to the considerable overlap of use of the terms data, information and knowledge in different sources, some further explanation of terms is provided in Box 1.

Box 1. Explanation of terms

As used in the Information Chain above, data are considered to be simple facts such as measurements or statistics that can be used by a recipient as a basis for reasoning, discussion or calculation. When organised and placed in a specific context that has relevance for the recipient, data acquires meaning from the perspective of the recipient and is termed **information**. Information may take various forms, such as spoken, written and graphic messages, gestures and even body language. Collections of information messages organised in for example email messages, letters, books, videos, papers in journals and so on, may be considered as information resources. Data, information and information resources can exist outside of the mind, and can be manipulated, stored, shared or transferred between individuals and organisations. The process of transferring information from one source to a recipient is technically known as **communication;** and communication of information serves as the mechanism for information sharing

By contrast, **knowledge** is what we know and can take place only in the mind as the result of mental processes. The knowing mind can use data and information, assimilate and understand these, incorporate them in its own knowledge structures, and use the new knowledge to predict and /or guide action. This process cannot be managed externally, nor shared with others except through uttering new messages.

Information Management involves identification of information needs, acquisition, organisation, storage, distribution and use of information defined as above. Wilson (1997) has put it succinctly: "Information management deals with the value, quality, ownership, use and security of information in the context of organizational performance."

The term **Knowledge Management (KM**), which was developed mainly within the corporate sector, has initially been widely used essentially as a synonym for Information Management. However, a second generation of KM has emerged with a wider and different perspective. Focusing much more on learning processes than on data or information management per se, the goal of these KM strategies is to enhance the capacity of an organisation to think and act creatively.

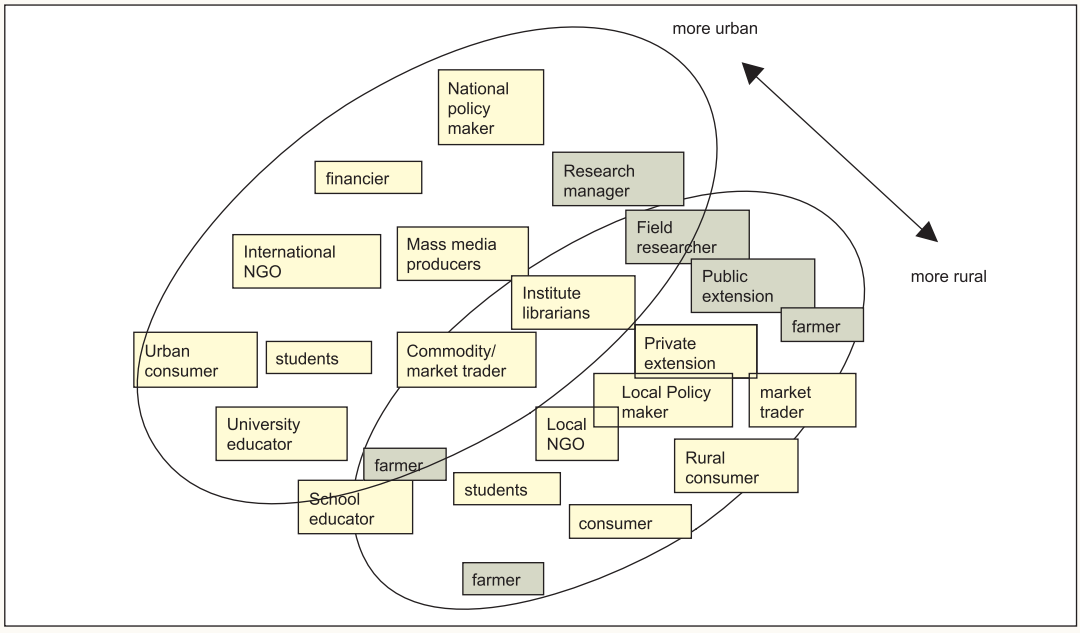
Adapted from, Wilson 1997, 2002; Bouthillier and Shearer 2002.

AIM in the context of broad agricultural R&D trends

Notions of agricultural development have changed from earlier concepts of one-way supply driven technology transfer to the more inclusive current concepts of innovation systems, synergies, ownership, and the importance of demand. This trend is mirrored by an increasing realisation that although agriculture has global and universal elements, farmers' ability to use and maintain a beneficial agro-ecological environment is linked to local knowledge and biodiversity.

In AIM, a rather comparable development is apparent. There is a trend away from centralized services providing information from Western based information banks to African institutions (the '*communication by dissemination'* model, Rangi et al, 2006). Instead, decentralized information management, south-south and south-north information flow are emphasized. This increased focus on local content and capacity is extending to include not only the traditional academic information producers and users in universities and research institutes, but also farmers, development partners including policy makers, schools, traders and ordinary citizens (see figure 2). It is being increasingly recognized that these diverse stakeholders facing very different information issues and needs have an important role in access, creation and sharing of information. Across these developments, modern electronic ICTs are seen by some as offering immense new opportunities both for capturing and storing information and for rapid sharing and dissemination. They point to the rapid spread of mobile phone use and internet kiosks in many parts of Africa. However, others argue that ICT-based projects have a poor track record and that the technologies promoted have not lived up to expectations (Beardon, 2005) due to a range of factors— accessibility, affordability, inadequate physical infrastructure, non-sustainability (in social and financial terms) and limited relevance of the information supplied. In the case of telecentres, for example, it has been noted that "stories abound of government or NGO sponsored telecentres lying empty, equipment abandoned or stolen" (Beardon, 2005).

Figure 2. From 'communication as dissemination' (research to farmer - coloured boxes) to communication in the innovation process.



Faced with this complexity it is clear that enhancing the efficiency and effectiveness of AIM in sub-Saharan Africa presents many challenges. These are being addressed through global, regional, sub-regional and national and local actors involved in capacity strengthening services, promoting establishment of communities of practice, networking activities, and managing information resources.

Global level

African scientists have for decades suffered from limited access to international scientific literature, whilst barriers to their own contributions both within SSA and globally, have been significant. This has been so both for conventional hardcopy scientific journals and electronic journals despite the promise of accessibility offered by the internet. Costs of accessing commercially published literature have exceeded the budgets of African libraries and research institutes.

Internationally, FAO with other global partners such as GFAR and CTA, and with sub regional organizations, is a major player in promoting and supporting global initiatives to manage and exchange information more effectively. Major initiatives to improve African scholars' access to global information include: Access to Global Online Research in Agriculture (AGORA) and the Programme for Enhancement of Research Information (PERI, in association with INASP, especially the AJOL project of INASP). Both provide either free or reduced cost online access to a range of full-text scientific journals on agriculture to developing countries. Intensifying capacity building activities, FAO and partners have developed the new AGRIS strategy (2002) which includes a range of services from: training on new methods of information management, focus on full text documents and promotion of an Open Access (see Box 2) publishing model, and a set of web-enabled standards and tools. Exploiting e-learning opportunities, FAO's Information Management Resource Kit (IMARK), as well as the RAILS programme of FARA are recent initiatives for training individuals in effective management of agricultural information (www.imarkgroup.org). The goal is to empower individual research organizations to directly contribute and share information with the international community (Chisenga et al, 2006; FAO 2004).

Box 2. Open Access

Open standards and open-source software present many possibilities for reducing and even eliminating entirely the cost barriers to scientific publications faced by African scientists and research institutes. Open Access is information which is digital, online, free of charge, and free from most copyright and licensing restrictions. Users of Open source software are permitted to run the program for any purpose, to study and modify the programme, and to redistribute freely copies of the original or modified programme. The best-known and most widely used open source software for document management are Eprints, DSpace and CDSware. All recent versions of this software are easy to install and allow further re-development according to the user's requirements. Two basic strategies may be used to achieve open access document management:

- Self-archiving: making electronic pre-prints and post-prints available on author home pages or depositing them in digital archives and repositories)
- OA journals: these do not charge readers or their institutions for access. Authors meet the publishing costs and in return retain copyright to their articles.

Lwoga and Chilimo 2006: other sources: Dspace (2006), EPrints.org (2005), CERN (2005)

Challenges faced by these initiatives are: awareness of the existence of these initiatives, limited ICT skills, insufficient facilities and financial support to ensure uptake and use of these electronic systems even after training such as that provided by FAO, CTA and partners through the IMARK initiative; a limited range of journals that are free of charge (AGORA); wide lack of awareness of OA and its possibilities amongst libraries, and hence fear by authors and libraries that if they deposit papers already published in international journals in OA archives, they will be in breech of copyright.

Regional/Sub-regional level

In SSA as a whole, there are several programmes focusing on information generation and delivery. A major issue being addressed capacity building. NEPAD through its Comprehensive Africa Agricultural Development Programme (CAAADP) Pillar IV, is seeking to intensify agricultural research, technology dissemination and adoption, and capacity building across service providers. NEPAD has designated the Forum for Agricultural Research in Africa (FARA) as its technical arm for advancing these objectives. FARA, aware that national partners (NARS) face inadequate infrastructure, institutional support and human resource capacity, has established the Regional Agricultural Information and Learning Systems (RAILS) to address these issues in close collaboration with the SROs, NARS and international service providers. An important component is Advocacy for improved policies and Capacity building on ICT/ICM Skills, infrastructure and leadership. RAIN is an example of a Sub-regional initiative organised by an SRO (see Box 3).

CORAF/WECARD is also in the process of establishing an agricultural information programme to address these issues in West and Central African countries. Adding impetus to regional efforts to improve agricultural information management, African agricultural information specialists were responsible for an important meeting in 2006 in Nairobi under the aegis of the International Association for Agricultural Information Professionals (IAALD — see Box 4). The meeting "*Managing Agricultural Information for Sustainable Food Security and Improved Livelihoods in Africa*" led to the launching of an African chapter of the IAALD. The Chapter provides a collective lobbying platform on agricultural information and can furnish inputs to NEPAD and other organisations. The IAALD African Chapter will provide a forum for generating African solutions to the many challenges facing effective management of agricultural information, for priority setting, and constitutes an informal networking base. The meeting drew attention to many challenges connected with information management in

Box 3. The Regional Agricultural Information Network (RAIN)

RAIN is a project of the Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA). Starting in 2003, RAIN is a new network of agricultural information organizations and professionals in 10 countries in eastern and central Africa – Burundi, Democratic Republic of Congo, Eritrea, Ethiopia, Kenya, Madagascar, Rwanda, Sudan, Tanzania and Uganda.

RAIN collaborates with other regional organizations and the Forum for Agricultural Research in Africa (FARA) to promote client-oriented agricultural information throughout the region and assist NARS institutes to obtain IT hardware and software. The network supports new initiatives aimed at enhancing information and communication management (ICM)/ICT skills; improving access to existing agricultural information; generating new content; and harmonizing agricultural information policies. RAIN has public relations materials in English and French, and a bilingual website.

SSA, including infrastructure, policies, computer and ICT skills, awareness of standards. Major recommendations point to keen interest and willingness to exploit global opportunities such as AGORA and Open Source AIM solutions, and to intensify focus on information needs of users.

Box 4. The International Association for Agricultural Information Specialists

IAALD was established in 1955 in Gand, Belgium and is committed to ensuring creation, capture, access and dissemination of information to achieve a more productive and sustainable use of the world's land, water, and renewable natural resources. IAALD's guiding principles are to:

- Connect agricultural information specialists world wide;
- Convene meetings and catalyse dialogue among stakeholders;
- Communicate and advocate the value of knowledge and information;
- Collaborate with members and other partner organisations, facilitating educational and other opportunities.

IAALD provides a platform for agricultural information specialists worldwide for information dissemination, exchange, dialogue among agricultural information stakeholders, improving the status and practice of agricultural information management and dissemination, and facilitating educational and other opportunities across agricultural information communities.

National and local level

National researchers, public and private extension services and other stakeholders in the agricultural sector continue to suffer wholly inadequate access to information.

The new information and communication technologies (ICTs) such as the Internet appear to offer unimagined opportunities and hope to countries and citizens in SSA at last to gain access to sources of expertise, information and markets necessary for development. ICTs and the internet have rapidly become core elements in training programmes and information systems development supported by international, regional, sub-regional, and national organisation in Africa.

African initiatives that are taking up the challenge of developing ICTs with a special African focus include the CILSS RESADOC facility at the Institute de Sahel, (INNSAH) in Bamako for the Sahelian countries, the CSIR/INSTI (Council for Scientific and Industrial Research Institute of Scientific and Technological Information) of Ghana as well as the recently established Ghana-India Kofi Annan Centre of Excellence in ICT (AITI-KACE). This Centre works with other institutions located in six continents, Africa, Asia, Australia, Latin America, Europe and the United States. With a special focus on nurturing ICT competence and development, AITI-KACE's Technology Transformation Seminars (TTS) give stakeholders a platform to share experiences and technical know-how. Bi-monthly stakeholder meetings equip participants with knowledge on recent innovative IT technologies and create the forum for clients and the public to effectively discuss cutting-edge issues on ICT. Outreach and training includes specialized training for decision-makers and parliamentarians, and other courses to demystify ICT with students and other important groups in Ghana such market women, taxi drivers.

A model for which there have been great hopes is the telecentre. Telecentrex generally combine phone and preferably also internet access and range from small privately run internet cafés common in

African countries to larger networks of telecentres set up by government, parastatal, university, NGOs and other donor supported initiatives. A major problem is establishment and running costs and the level of end-user costs that can be acceptable. Small family-run individual telecentres are for this reason virtually all in urban centres where paying customers are assured.

Some of Africa's first telecentres were in Uganda, with donors such as IDRC working in collaboration with the government and local NGOs to supply information to farmers. Experience from these showed that low patronage was linked to lack of awareness about the centres and their potential, and a lack of information on critical areas of interest to farmers such as markets, prices, inputs, weather and credit. Interest in internet and email was low.

This experience has led to testing of more innovative ICT solutions with a firm basis in potential users needs and with a view to some degree of commercial sustainability. In Kenya, for example, one promising telecentre's (or rural knowledge centre) idea is to offer a range of other services in addition to internet/email in order to generate sufficient revenue (Box 5).

Box 5. Piloting sustainable information services - Kenya

A pilot agricultural knowledge centre was established in Machakos town, Kenya. The centre has both traditional and modern ICTs including computers with internet and email, telephone, fax, scanner, digital camera, TV, VRC, DVD and satellite radio. The information provided covers mainly agricultural production and marketing, natural resources but also public health and other topics.

Information is obtained mainly from Kenya-based institutions such as NGOs, national and international research institutions and extension agencies and targets smallholder farmers and traders, intermediary organizations e.g. extension workers. The centre is an access point for the Open Knowledge Network (OKN) which promotes use of ICTs to enable communities share local content to support development.

Sustainability of the centre has been the driving force behind the introduction of many services namely, the trading floor for agricultural commodities, outreach programmes and the provision of demand driven services such as photocopying and typing which generate income for the centre. Income generated currently from the centre remains low but has shown a steady increase.

The centre is working to increase the participation of the partners in the activities through contributions in terms of membership fees, content development and management, in ways which will promote sustainability. Decentralization of activities is high on the agenda and it is hoped that this will increase access to remote areas in the region and increase the number of users and revenue generated.

The centre is sensitizing and training its users on ICTs through partnerships with NGOs, research institutes, government ministries, training institutions and CBOs. This has enhanced the community's involvement in identifying and prioritizing developmental activities and needs, and wide publicity has been achieved. Usage is monitored and shows increasing use by women since its establishment.

Adapted from Asaba J et al., (2006) .

The experience of the Kenyan agricultural knowledge centre provides some useful ideas about how to improve local level access to information. These include: supportive communication policy, technical solutions to the problem of distance and costs, partnership between different stakeholders, and most importantly, dialogue with information users, to ensure a range of valued services are provided.

The mobile phone is one form of ICT that has already achieved a large measure of success and commercial viability in SSA. This has resulted from a mix of supportive policy and commercial entrepreneurship on the one hand, whilst rural development programmes and farmers themselves have been quick to see the benefits of rapid access to information such as market prices. In Uganda, the telecommunications company MTN through a licensing agreement with the government has provided coverage even in remote areas. Farmers now have access to price information provided via amongst others the Foodnet project, since this kind of information can easily be sent as text messages.

Local content and context

Related to the discussion on ICTs, minimal local content (language, themes, news, information connected to and relevant for particular communities where they live), and also in some places lack of traditions for information seeking, are major issues for AIM. This has enormous bearing on the interest in and use to which information services, from university/library based information systems to near-rural or rural telecentres/kiosks are put. ICTs, particularly the internet, have the potential to open a gateway to a huge wealth of information, but this may be of little relevance, nor even accessible, if there are few local messages and little local information in accessible languages.

Several information services are recognising this and setting in motion a move away from serving only traditional academic information users (see Box 6).

Box 6. Ghana Agricultural Information Service

GAINS was established in 2000 as part of a decentralisation trend from a CTA supported Q & A system designed to increase ACP member countries' access to world scientific literature, supported by advice, training, networking and information handling skills. The service is run from the Institute for Scientific and Technological Information (INSTI). It became popular with researchers and students making requests for information, but surveys showed minimal use by extension services and farmers.

Recognising a falling off of traditional users by 2005 and continuing low use by farmers and others, GAINS shifted tactics towards a more proactive role and initiatives using radio and the Algona Swedru agricultural information centre as intermediaries to spread information to farmers. Since 2006, Radio Peace of Winneba has been used to broadcast agricultural programmes with indications that many more people have been served through the radio. Documentaries shown from village to village by the Agona Swedru Agricultural Information Centre have led to demands from farmers for field based training. GAINS has also been distributing posters as part of its promotional strategy. During the pilot phase two national dailies were used to raise awareness about how to contact and use the service.

GAINS has a dedicated website www.gains.org.gh which contains information on the service and its partners, contacts and links to agricultural websites, how to use the service, the GAINS newsletter,

an online information request form, and three databases—Ghana Agricultural Research Information (GHAGRI), Ghana Science Abstract (GHASAB) and Agricultural Experts in Ghana (AGRIEX). The website promotes the service, with 4184 people visiting the site between May 2004 and March 2005.

Source: Sam and Verster, 2006. For another experience form Kenya see Juma, Esther Kahinga (2006).

Encouraging though these examples are, the challenge to increasing local content in new ICT mediated information flow is substantial. Furthermore, the notion of communication as dissemination (meaning essentially an information flow from recognised professionals and centres to farmers) is likely to be more firmly entrenched than the view that people at the most local level, for example farmers', own expressions of knowledge can have immense value. Local content faces immense competition from foreign sources. As Peter Ballantyne (2002) puts it, "*With a few exceptions (phones, community radio, or indigenous knowledge systems), most formal content and communication 'channels' in developing countries help to push 'external' content into local communities. Counter efforts to push local content on to global stages, such as African film, African research publications, 'southern voices' in the media, or the e-trading of crafts face an uphill struggle."* Some interesting recommendations in support of local content that resulted from a consultative process funded by DfID to explore action point 8 under the DOT Force Plan of Action are shown in Box 7.

As costs and complexity decrease, it is becoming increasingly possible for local people, including farmers, who are not professional media persons, to make their own media and tell their own stories and experiences through use of modern digital ICTs such as digital video. These media, in contrast to media made by professional outsiders, can have major advantages in that they capture farmers' own perspectives and experiences within a context and in a language that other farmers can recognise. For a discussion on the topic of participatory video see for example CTA's webbased newsletter ICTUpdate issue no. 34.

Box 7. Some recommendation for promoting local content in ICTs.

Invest resources in a wide spectrum of local initiatives, using a variety of media, that create or communicate genuine local content, clustered around high priority sectors like health, education, rural livelihoods and the environment, and involving a wide range of actors.

Work with existing eContent, networking producers and intermediaries to exchange and deliver development-oriented content.

Provide incentive financing for local content. An example is the 'script pitching' notions in the African television and film sector that can link owners of local content with content producers and financiers. Organised in a series of workshops at the local, regional, and continental level, local content project proposals can be 'pitched' and winners selected for financing or to receive other prizes. In a simple form, such an initiative might simply provide prizes and funding for digital content development ideas.

Source: Ballantyne 2002

Market for information

The liberalisation agenda prevailing in the reform of services in many SSA countries is likely to influence the attitudes and knowledge sharing strategies of the main actors, shaping elements of the "rules of the game" for knowledge innovation and sharing. Conversely, the other elements of the rules of the game influence the implementation of liberalization policies.

Most agricultural research undertaken in East Africa is in the public domain and has public-good characteristics. Information—whether derived from formal R&D systems or from local knowledge—is in principle a public good once it is in the public domain, making it difficult for the providers to make a profit from this information to pay for future knowledge generation. However, information products (books, brochures, training materials) and tailored advice have private-good characteristics. They are commodities that can be sold, thus excluding those who cannot afford to purchase them. Information access can be skewed by both wealth and gender and some forms of extension service delivery can effectively exclude some potential users. Currently, information on agricultural technologies and services is, in principle, available free of charge from research institutes funded by the national governments and donors. However, these organisations are under increasing pressure to commercialise their operations. From the service user perspective, even if no charges are made, accessing information involves transaction costs.

Where publicly funded extension services have been out-sourced to private sector providers, farmers are expected to become more skilled and experienced in quality control so that service providers will need to regularly update their knowledge in order to secure future advisory contracts. This should result in an emerging market for information, training and specialist advisory services. However, despite the increasing number and range of service providers, there is little to suggest that a functioning "agricultural information market" exists. At field level, many of the advisory service providers are also poor, working for low salaries, as volunteers and in the case of Uganda competing for short-term contracts. Recent research in Uganda (Mubangizi et al. 2005) showed that private service providers generally rely on course notes and information obtained from colleagues as a basis for advisory services provided to farmers, rather than more up-to-date sources (journals, Internet, research organizations).

Moreover, a market model presumes that incentives to "trade" information and advice exist. Service providers' willingness to pay for information will also depend on their ability to pass on information costs to their service users, whose willingness to pay will depend on the perceived benefit from the information, and the likeliness of obtaining it elsewhere), for example through informal channels. Another issue is the quality of information for distribution, influenced by policies on quality assurance for privatized delivery. How information should be packaged, disseminated, presented, and differentiated needs to be considered, including the cost implication of different alternatives and accessibility to the different user categories.

Some concluding points

A whole host of conditions need to be in place along the information 'chain' if information is to be acted on.

Diversity of stakeholders and perceptions of AIM— 'Communication as dissemination' is still a prevalent view based on policies of regional organizations and programmes (eg NEPAD's pillar IV on dissemination and transfer). FAO and others are enthusiastic about the internet as the main ICT to

break the AIM deadlock, and are investing in training of academic cadres. On the ground, it's clear that there are a wide range of AIM needs and practitioners are finding out that farmers and other stakeholders may need a lot of other services before really taking an interest in the internet. Rural people are accustomed to accessing information in specific ways - farmers tend to attach high value to the experiential information from other people like themselves. Trust and relevance are key.

There is a need to break away from the top-down, technology-centred and supply-led approach to information-related projects that are supposed to benefit farmers and rural people in general. Instead, what is needed is a people-centred, demand-led approach that focuses on developing the capacity of disadvantaged groups to identify and articulate their information needs and preferred media, access the required information, through whatever media and sources are most appropriate, and then manage and use it effectively to improve their livelihoods. Experience has highlighted the need for a wide range of media in managing and supplying information, and the importance of traditional as well as modern media. Radio is a popular and widely accessed medium in rural Africa that could receive higher priority from development agencies; and mobile phones have considerable potential.

Capacity strengthening—there are a host of capacity strengthening issues associated with AIM. These need to be identified with stakeholders at all levels. This ranges from how African scientists can more effectively contribute to "content" (eg effective writing of agricultural research information to various audiences, contributing to the information database and management of agricultural journals and other publications, including electronic publishing and capacities in editing, etc.) to opening up new approaches to two-communication and sharing information eg participatory video.

Enabling environments—effective national agricultural information policies need to be in place and acted upon. These include eg stable power supply and introduction of ICT in primary secondary and tertiary educational programmes. Some countries have progressive enabling policies (eg in Tanzania computer equipment is imported duty free)—with Ghana appearing to be a lead player in the CORAF region. However, it's still expensive to get bandwidth in Africa, and technically difficult to take electronic ICTs out to people (mobile phones are an important exception, e.g., Space Phone in Ghana, MTN in Uganda).

Information management, organisational change and the rules of the game—how information is managed has a major influence on organizations and their associated institutional environment (rules of the game). Information management, organizations and the institutional environment co-evolve. An effective and efficient AIM system should improve the performance of organizations and influence the 'rules of the game'. Conversely, AIM systems needs organizations and institutions which operate transparently, motivate people, offer appropriate incentives, encourage trust and commitment. This co-evolution is key to rural development and poverty reduction.

References and further reading

Information Management

Bouthillier, F. and Shearer, K. (2002). "Understanding knowledge management and information management: the need for an empirical perspective" Information Research, 8(1), paper no. 141 http://InformationR.net/ir/8-1/paper141.html

Macevičiűtë, Elena and Wilson, T.D. (2002) "The development of the information management research area" Information Research, 7 (3) http://InformationR.net/ir/7-3/paper133.html

Wilson, T.D (1997) "Information management", in International Encyclopedia of Information and Library Science, pp. 187–196. London: Routledge.

Wilson, T.D. (2002) "The nonsense of 'knowledge management'" Information Research, 8(1), paper no. 144. http://InformationR.net/ir/8-1/paper144.html

Organisational learning

Hovland, I (2003) Knowledge Management and Organisational Learning: An International Development Perspective. ODI Working Paper 224. ODI London

Agricultural Information Management – summaries and cases

Beardon, H. (2005) *ICT for Development: Empowerment or Exploitation?* Action Aid: UK.

Asaba J F, Musebe R, Kimani M, Day R, Nkonu N, Mukhebi A, Wesonga A, Mbula R, Balaba P and Nakagwa A (2006). Bridging the Information and Knowledge Gap between Urban and Rural communities through Rural Knowledge Centres: Case Studies from Kenya and Uganda. Paper presented at the IAALD meeting "Managing Agricultural Information for Sustainable Food Security and Improved Livelihoods in Africa", 21–26, May 2006, Nairobi Kenya.

Ballantyne P (2002). Collecting and Propagating Local Development Content: Synthesis and Conclusions. Report of a project carried out by IICD in association with the Tanzania

Commission for Science and Technology and funded by the UK Department for International Development (DFID) May 2002.

Chisenga, J., Keizer,J. , Rudgard, S., Onyancha, I, and Zwart, R. P. (2006) FAO's Capacity-Building Initiatives in Accessing, Documenting, Communicating and Managing Agricultural Information. Paper presented at the IAALD meeting "Managing Agricultural Information for Sustainable Food Security and Improved Livelihoods in Africa" 21–26, May 2006, Nairobi Kenya.

Easdown W and Starasts A (2004) Constructing useful information for farmers– the role of IT. Proceedings of the 4th International Crop Science Congress, Brisbane, Australia, 26 Sep – 1 Oct 2004. http://www.cropscience.org.au/icsc2004/symposia/4/3/238_easdownwj.htm

Ferris S (2004). FOODNET. Information is Changing Things in the Marketplace. http://www.comminit.com/strategicthinking/st2004/thinking-579.html

Lwoga, E T and Chilimo W (2006) Open Access and Open Source: Considerations for Agricultural Academic Libraries in Promoting Collaboration and Sharing of Information and Knowledge. Paper presented at the IAALD meeting "Managing Agricultural Information for Sustainable Food Security and Improved Livelihoods in Africa", 21–26, May 2006, Nairobi Kenya.

Juma D and Kahinga E (2006). Rural Development Networks Online: A Web-based Agricultural Information System. Paper presented at the IAALD meeting "Managing Agricultural Information for Sustainable Food Security and Improved Livelihoods in Africa", 21–26, May 2006, Nairobi Kenya.

Ofir Z (2003) Acacia: The Case of Uganda. IDRC. http://www.idrc.ca/ev.php?ID=31661_201&ID2=DO_TOPIC

Mubangizi, N., Mangheni, M.N. and Garforth, C. Challenges and opportunities of private agricultural extension service providers in accessing and utilising information under the National Agricultural

Advisory Services (NAADS) system in Uganda: a case study of Arua and Tororo districts. In: The globalisation of information: agriculture at the crossroads XIth IAALD World Congress, Lexington, Ky, USA, 2005.

Rangi D, Day R and Asaba J F (2006). Knowledge Sharing, Information and Innovation. Paper presented at the IAALD meeting "Managing Agricultural Information for Sustainable Food Security and Improved Livelihoods in Africa", 21–26, May 2006, Nairobi Kenya.

Sam J and Verster E (2006) Developing and managing question-and-answer services: challenges and lessons from PRAIS and GAINS. Paper presented at the IAALD meeting "Managing Agricultural Information for Sustainable Food Security and Improved Livelihoods in Africa", 21–26, May 2006, Nairobi Kenya.

Sarah Parkinson (2005) Telecentres, Access and Development. Experience and Lessons from Uganda and South Africa. Practical Action Publishing/Fountain/IDRC 2005.

IC Technology and Open Source

Caspary G and O'Connor D (2003) Providing low-cost information technology access to rural communities in developing countries: What works? What pays? OECD Development Centre. Working Paper No. 229.

DSpace: an open-source digital archiving system designed by MIT Libraries and Hewlett Packard to capture, manage and share research in digital formats. http://www.dspace.org

EPrints for digital repositories. http://www.eprints.org

CERN Action on Open Access http://open-access.web.cern.ch/Open-Access

SSA AIM Websites

African Journals Online http://www.ajol.info/.

AGORA –Access to Global Online Research in Agriculture http://www.aginternetwork.org/en/ .

Ghana Agricultural Information Network System http://www.gains.org.gh/ .

Ghana India Kofi Anan Centre of Excellence in ICT http://www.aiti-kace.com.gh/ .

Information Management Resource Kit (IMARK) www.imarkgroup.org .

International Association of Agricultural Information Specialists. http://www.iaald.org/.

International Network for the Availability of Scientific Publications. http://www.inasp.info/ .

Networking in Africa: using ICTs to exchange research and policy knowledge. http://www.id21.org/id21ext/s8bpb1g1.html .

Regional Agricultural Information Network http://www.asareca.org/rain/ .

Reseau Sahelien De Documentation Et D'information Scientifiques Et Techniques. http://doc.intercooperation.net/authors1/reseau-sahelien-de-documentation-et-d-information-scientifiques-et-techniques-resadoc.

Système d'Information Scientifiques et Technique. http://www.sist-sciencesdev.net/rubrique.php3?id_rubrique=2&lang=fr .

2

Climate change and agricultural development

Tim Chancellor, John Morton, Ramadjita Tabo and Ralph von Kaufmann

Introduction

This paper discusses the influence of climate change on smallholder agriculture, with a special focus on West and Central Africa (WCA). The likely impacts of climate change on smallholder farmers are assessed and farmers' strategies for adapting to these impacts are examined, drawing on examples from the WCA region. Key research and capacity strengthening priorities are identified, that will help to minimize adverse impacts and identify new opportunities. The paper is aimed at all stakeholders in agricultural research for development, because climate change will be one of the central challenges facing agriculture in Africa. References are made to publications that deal with specific topics in more detail and a glossary of terms is provided at the end of the paper.

Agriculture and climate

Although an increasing number of people in sub-Saharan Africa live in urban areas, the majority of people still depend on agriculture as their main livelihood source. Agricultural crop production is largely determined by patterns of temperature and rainfall and changes in these patterns influence water availability in specific locations (Nkomo *et al*., 2006). Available moisture and the range of temperature affect the period during which conditions are suitable for crop growth. These factors also have a significant effect on livestock production, especially through impacts on vegetation in rangelands, on water availability for animals, on disease incidence and on the production of fodder crops.

Much of the agricultural production in sub-Saharan Africa takes place in arid and semi-arid areas where rainfall distribution is highly variable. More than 180 million people live in these fragile environments and they are highly vulnerable to conditions that lead to lower productivity. In West Africa, the Sahelian region is a particularly vulnerable environment and has become increasingly dry during the last 100 years. As a result, there has been a significant reduction in the length of the growing period for crops and a continuation of this trend would have very damaging consequences (Thornton *et al*., 2006).

Is the climate changing?

There is a growing body of evidence that global climate is changing (see Box 1). It is also becoming increasingly clear that this change is strongly associated with the increased emissions of greenhouse gases. Scientists from the Intergovernmental Panel on Climate Change (IPCC) have shown that global atmospheric concentrations of carbon dioxide, methane and nitrous oxide have increased substantially as a result of human activities since 1750. The use of fossil fuel and land use change are mainly responsible for the increase in carbon dioxide. Agriculture is the prime contributor to the increases in

methane and nitrous oxide. The IPCC strongly believes that there is a link between human-induced activity and global climate change. It now states that *most of the observed increase in global average temperatures since the mid-20th century is* very likely *due to the observed increase in anthropogenic greenhouse gas concentrations*.

The IPCC projects that an average increase in global temperatures of about 0.2°C per decade will occur, taking into account a range of emission scenarios. For West Africa, warming by 2080-2099 will be higher than this, with an average across models of 3.3°C, and higher, above 4°C, in the far north of the Sahel countries. It also states that even if the concentrations of all greenhouse gases and aerosols were kept constant at year 2000 levels, temperature increases of about 0.1°C per decade are probable. This means that it will be essential to develop suitable adaptation strategies as well as to find ways to reduce future emissions.

West Africa is one of the regions of the world that presents most uncertainty as regards future trends in precipitation. An average of the major models suggests a modest increase in rainfall for the Sahel with little change on the Guinean coast, although there are models which project either strong drying

Box 1. What is the evidence for climate change?

Is global climate really changing in the way that many scientists are claiming? Critics point out that there are gaps in our scientific understanding of climate trends. They also maintain that there have been large changes in global climate in the past and that these cannot be attributed to human activity. Scientists who believe that climate change is occurring state that this is happening more rapidly than ever before. A recent report of the Intergovernmental Panel on Climate Change (IPCC) concluded that *warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global average sea level*.

- Eleven of the twelve years from 1995 to 2006 are amongst the warmest years since 1850.
- Based on historical records, a warming of approximately 0.7°C over most of Africa during the 20th century is reported in the IPCC TAR . Observational records show that this warming occurred at the rate of about 0.05°C per decade with slightly larger warming in the June-November seasons than in December-May. Very high temperatures records have also been indexed e.g. the 5 warmest years have all occurred since 1988.
- Between 1961 and 2003, global average sea level rose at an average rate of 1.8 [1.3 to 2.3] mm per year.

Furthermore, in recent decades variability in climate and the frequency of extreme events have increased significantly.

- Droughts have become more intense and of longer duration since the 1970s, especially in the tropics and subtropics.
- Heavy precipitation events have occurred more often over most land areas.
- There have been fewer cold days, cold nights and less frost.
- The frequency of hot days, hot nights and heat waves has increased.

Source: IPCC (2007)

or strong moistening. Models suggest an increase in the number of extremely wet years and seasons, with much weaker projections of drought, except in the far north of the region.

Other effects of climate change that will have direct or indirect consequences on agriculture are rises in sea levels which will lead to flooding in coastal areas. Coastal West Africa has been identified as a highly vulnerable area with both urban and rural communities at risk. Adverse impacts are likely to occur on coastal marine fisheries and populations will be exposed to an increased risk of infectious diseases as a result of flooding. Declining human health will have a negative effect on labor productivity in agriculture.

Vulnerability of smallholder farmers

The negative impacts of climate change will be felt most severely by people in poor countries, many of them in sub-Saharan Africa (Stern *et al*., 2006). Most of these people live in rural areas and have access to only limited areas of land for cultivation or livestock production. Smallholders cultivate more than 70 percent of crop land in West Africa but produce a large proportion of food and cash crops. For example, in Nigeria smallholders produce over 90 percent of several food crops, including rice and wheat, and cash crops such as cocoa and cotton (Jazairy *et al*., 1992). These farmers live in diverse and risk-prone environments, with very limited access to agricultural inputs like fertilizers and good quality seeds and are seriously affected by climate variability and increases in levels of crop and animal disease. Because of their limited livelihood options and scarce resources they are also highly susceptible to market and governance shocks.

It is widely believed that unless the livelihoods of these smallholder farmers and the resource base upon which they depend can be made more resilient through a better understanding and management of current climatic variability, the challenge of adapting to future climate change will be daunting for most and perhaps impossible for many.

Impacts of climate change on agriculture

Most of the research on the likely effects of climate change on crop productivity has been done on the major world cereals and cotton with little attention given to root crops, sorghum and millet, legumes, oilseeds, tropical fruits and other commodities that are important in the WCA region. The available evidence suggests that overall impacts on rainfed agriculture will be strongly negative, with crop yields reduced by up to 50 percent (IPCC, 2007). In tropical areas, adaptation measures may prevent yield losses in cereals where only limited warming occurs and there may be some benefits from the so-called *fertilization effect* of enhanced levels of CO_2 (see Box 4). Once mean temperature increases reach about 2^0C, significant yield losses will result even with adaptation (see Figure 1 for tropical maize).

Effects on crop tolerance are not only caused by changes in mean temperatures. Short term variations in temperature can have limiting effects on key developmental stages even in the absence of mean temperature rises (Porter and Semenov, 2005). For example, it has been shown that grain fertilization and grain set in wheat is very sensitive to the maximum temperature at mid-anthesis and that grain yield declines at accumulated temperatures above 31^0C (Ferris *et al*., 2000). As current projections show an increased frequency of extreme events, including high temperatures, the implications for crop productivity are potentially serious. Similarly, the increased temperatures will increase heat stress on livestock, which may lead to higher levels of mortality, especially in taurine cattle.

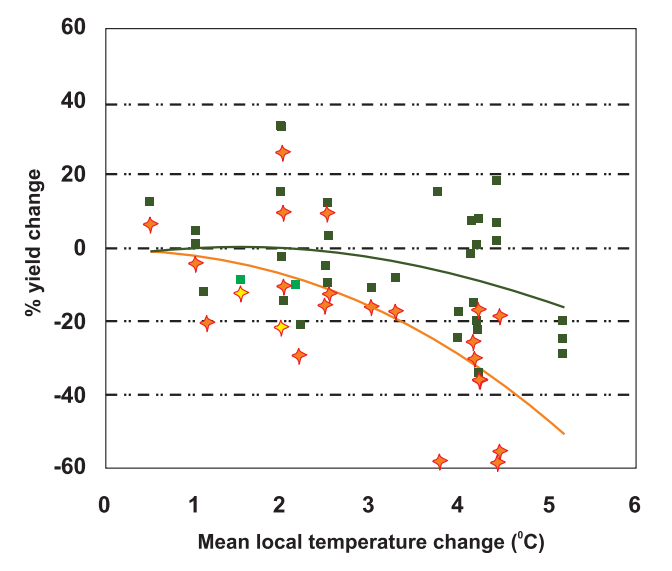


Figure 1. Sensitivity of tropical maize to mean local temperature change without adaptation (red dots) and with adaptation (dark green dots). Modified from Easterling et al., 2007.

Even given the uncertainty about rainfall regimes discussed above, increased water requirements for crop growth, from increased warming, are likely to be widespread within the WCA region. Where rainfall is reduced and/or more variable the production and the quality of forage for livestock in rangelands may be adversely affected.

Climate change will have consequences for pests and diseases of both crops and livestock. Increased abundance of some insect vectors is likely in areas where temperature rises and moisture is not limiting (Chancellor and Kubiriba, 2005). This may lead to an increased risk of cassava mosaic disease and maize leaf streak disease which are transmitted by whiteflies and leafhoppers, respectively. Hotter and drier conditions are likely to favour Sorghum head smut, an important soil-borne pathogen. By contrast, some other fungal diseases such as leaf blights of sorghum and maize may decline in importance under these conditions. For livestock, a major concern (though not currently in WCA) is the risk of increased incidence of rift valley fever.

Another important potential adverse impact of climate change is the loss of biodiversity as some plants and animal breeds are unable to adapt to the new conditions. This includes fish species in inland and marine fisheries where increased water temperatures will affect fish and their habitats.

Farmers' adaptation to climate change

Over long periods of time farmers in sub-Saharan Africa have demonstrated resilience to unfavourable environments by evolving short-term 'coping' strategies to manage specific hazards, and longer-term adaptations to address variability in environmental conditions; for example, by changing the way they manage labour inputs. Farmers modify crop planting dates to adjust to changes in the onset and cessation of rainfall. Similarly, they utilize early maturing varieties or more drought-tolerant crops where moisture becomes limiting and they practice intercropping or mixed farming to reduce the risk

of total crop failure. Farmers harvest water or, where this is feasible, they adopt irrigation practices such as the drip irrigation system developed for vegetable production in parts of Senegal.

Adaptation or coping strategies can be broadly grouped into activities aimed at (a) diversification (risk spreading) of both farming and other associated livelihood enterprises *prior to the onset of the season* and (b) activities which *respond to specific seasons as they evolve*. Matlon and Kristjanson (1998) provide an example of such a matrix to describe such coping/adaptation strategies in the semi-arid tropics of West Africa and also consider the 'spatial scale' at which the various strategies operate (Box 2).

Farmers' ability to adapt to climate change will build on adaptation to climate variability, but will be influenced by a range of factors including the extent to which they are affected by other constraints. Where population is increasing rapidly and land degradation has reached a critical level, farmers will be less able to manage the impacts. Similarly, high incidences of HIV/AIDS and of vector-borne diseases will reduce their ability to cope. In some cases, where farmers have little previous experience of adapting to climate variability they may be more susceptible to the effects of climate change even though they may live in relatively favourable environments. This appears to be true of some livestock keepers in relatively wet areas as they have not had to cope with the effects of drought in the past. Consequently, farmers' adaptation strategies should be seen in the context of their overall situation. In many cases, adaptation strategies are likely to involve maximizing the generation of income from non-agricultural sources.

Box 2. Coping/adaptation strategies used by farmers in semi-arid West Africa.

Scale	Time Frame		
	Before the season	**During the season**	**After the season**
Plant	Varietal selection for stress tolerance / resistance	Replanting with earlier maturing varieties	
Plot	Staggered planting dates Low density planting Intercropping Run-off management Delayed fertilizer use	Changing crops when re-planting Increasing or decreasing plant density at re-planting or by thinning	Grazing of failed plots for animal maintenance
Farm	Diversified cropping Land type diversification Plot fragmentation	Shifting crops between land types	Late planting for forage
Household, village, region	Cereal stocks Livestock / assets Social and off-farm employment networks	Matching weeding labour inputs to expectations of the season	Asset sales for cereal purchases Food transfers Migration for employment

Source: Matlon and Kristjanson (1998)

Climate information

Farmers may be better able to make informed decisions about how to manage their farming enterprise if they have more reliable climate information. Projections about changes in climate are largely derived from global circulation models which are becoming increasingly complex and sophisticated. These models do not provide information at local scales but regional models are now also being developed, such as the PRECIS model of the United Kingdom Meteorological Office. Climate prediction is extremely challenging in the WCA region because of the wide variation in vegetation, the role of land-use changes, the possible affects of atmospheric dust, and the influence of the oceanic jet stream. In addition, there are considerable barriers to smallholder farmers receiving, understanding, trusting and having the capacity to act upon, climate information.

Nevertheless, there are examples of where improved climate information has helped farmers to improve their decision-making (see Box 3), and further examples where government or other agencies working on behalf of smallholders have used climate information. In southern Africa climate information is being used to underpin crop insurance schemes (Malawi and South Africa) and to assist with flood management (Mozambique).

Box 3. Farmers' use of climate information in decision-making in Mali

Rainfed agriculture is the basis of the livelihoods of most people in rural communities in Mali. Managing the risks associated with variability in rainfall is one of their main concerns. In 1982, an innovative project was started which involved several different organizations led by the national meteorological service. The aim was to deliver agrometeorological information to rural communities and authorities in order to help them improve their decision-making in farming activities and food security. Technical support was provided by the Centre Régional de Formation et d'Application en Agrométéorologie et Hydrologie Opérationelle (AGRHYMET) and the World Meteorological Office. The project established a multidisciplinary working group whose main function was to act as a 'boundary institution' that bridges the gap between the climate and agricultural communities. The working group sought to achieve this by providing climate information and advice in ways that could be easily understood and used by farmers. The project is still continuing and a recent review has shown that it has resulted in several positive outcomes. These included:

- Some evidence for increases in yields of crops such as maize, sorghum and pearl millet by farmers using climate information compared with traditionally managed plots.
- A willingness by farmers to take more risks by investing in new technologies that can increase crops yields and income.
- Additional financial resources provided by the Malian government to the meteorological service for new weather stations and equipment.

However, a recent review of the project also acknowledged that the project's crop focus was narrow and the needs of livestock owners were largely neglected. There were difficulties in providing reliable local-scale information to farmers and it was not always easy to reconcile the different perspectives of different stakeholders. In spite of these constraints, the project is considered to have been successful and to provide useful lessons for other similar initiatives.

Source: Hellmuth *et al*. (2006)

Crop modelling

A further step is the use of simulation models that integrate the impact of variable weather with a range of soil, water and crop management choices. Such simulation models, driven by daily climatic data, can be used to predict the impact of existing climate variability and change on the *probability of success* of a range of crop, water and soil management strategies. The use of such models, with long runs (30 years or more) of daily climatic data thus provides a quick and much less costly opportunity of 'accelerated learning' compared with the more traditional multi-location, multi-seasonal and multi-factorial field trails. One such model that is becoming increasingly used by ICRISAT and her partners is the Agricultural Productions Systems Simulator (APSIM). APSIM can simulate various soil and water management practices together with the growth and yield of a range of crops amongst which maize, sorghum, pearl millet, chickpea, pigeon pea, soybean, groundnut, sunflower, cotton and trees are of importance in ICRISAT's mandated regions. (Dimes, 2005).

Research and capacity development needs

Most of the current research on the likely impacts of climate change on agriculture is targeted at the main cereal crops and cotton, with relatively little attention being given to other crops or to livestock and fisheries. With regard to crops, more research is needed on millet and sorghum and on tropical root crops, particularly cassava, yams and sweetpotato. Greater efforts are needed to identify opportunities for capturing potential benefits of climate change; for example, through increased productivity of certain beverage crops. Understanding of the impact of climate change on pests and diseases remains limited and more research is needed to improve knowledge in this area. Until now, research has focused on production aspects and more resources are required to address post-harvest issues, including storage, transport and marketing.

Action research is needed on the effects of climate change on farmer behaviour; on the feedbacks between short-term coping, long-term adaptation and the economic and policy context; and on how information flow between stakeholders can be optimized. There is also a need to assess current and expected future impacts and vulnerabilities, and the future adaptation options and pathways that may arise from the interaction of multiple stressors on the coping capacities of African communities (Boko et al. 2007). Farmers will require more support than before, particularly where their indigenous knowledge cannot be applied to new situations; for example, where new crops and cropping patterns are introduced. There is considerable scope to develop intercrops which maximize the use of available moisture without incurring a significant yield penalty. Farmer participatory research will become increasingly important and tools such as participatory plant breeding offer real opportunities to develop varieties that are adapted to local conditions.

Agricultural graduates will need a wider set of skills in order to enable them to work with farmers to develop appropriate solutions to new problems. In addition to the latest technical information, graduates will need to be able to analyse complex multi-faceted problems and develop suitable recommendations. They will also need to be able to interact effectively with different stakeholders and this will require good communication and facilitation skills. In a rapidly changing environment it will be important to keep up to date with new developments in agriculture and related fields. These emerging needs mean that new ways of teaching and learning are required to equip graduates with suitable skills. Provision also needs to be made for continuous learning through participation in initiatives such as the Forum for Agricultural Research in Africa's Regional Agricultural Information and Learning System.

Box 4. Glossary of terms

Climate
Climate is the statistical description of the weather in terms of the mean and variability of key variables such as temperature, precipitation, and wind relevant quantities over three decades. In a wider sense the "climate" is the description of the state of the climate system.

Climate change
A change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods.

Climate sensitivity
The long-term (equilibrium) change in global mean surface temperature following a doubling of atmospheric CO_2 (or equivalent CO_2) concentration.

CO_2 fertilization
The enhancement of plant growth as a result of elevated atmospheric CO_2 concentration.

Feedback
When one variable in a system triggers changes in a second variable that in turn ultimately affects the original variable; a positive feedback intensifies the effect, and a negative feedback reduces the effect.

Greenhouse gas
A gas that absorbs infrared radiation and traps the heat in the atmosphere. Water vapour (H_2O), carbon dioxide (CO_2), nitrous oxide (N_2O), methane (CH_4) and ozone (O_3) are the primary greenhouse gases in the Earth's atmosphere.

There is a need for improvements in how data are collected and information gathered as well as in the analysis, interpretation and dissemination of such data and information to end-users. In-country capacity needs to strengthened for generating, managing, processing and analysing data sets, for improving the quality of analytical tools, and for disseminating the results of these efforts in sectors that can contribute to climate change impact analysis. One way to do this is through the establishment of 'hubs' or centres of excellence established by Africans and developed by African scientists. This will help to also enhance institutional 'absorptive capacity' in the various regions, providing opportunities for young scientists to improve research in the fields of climate-change impacts, vulnerability and adaptation. (Boko *et al*. 2007).

References

Boko, M., I. Niang, A. Nyong, C. Vogel, A. Githeko, M. Medany, B. Osman-Elasha, R. Tabo and P. Yanda, 2007: Africa. *Climate Change 2007 (forthcoming): Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson, Eds., Cambridge University Press, Cambridge

Chancellor, T.C.B. and Kubiriba, J. (2005). The effects of climate change on infectious diseases of plants. In: Infectious Diseases: Preparing for the Future. Office of Science and Innovation, United Kingdom.

Christensen, J.H., Hewitson, B., Busuioc, A., Chen, A., Gao, X., Held, I., Jones, R., Kolli, R.K. Kwon, W-T., Laprise, R., Magaña Rueda, V., Mearns, L., Menéndez, C.G., Räisänen, J. Rinke, A. Sarr, A. and Whetton, P. Regional Climate Projections. In: *Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* [Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Avery, M.Tignor and H.L. Miller (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Dimes, J.P. (2005). *Application of APSIM to evaluate crop improvement technologies for enhanced water use efficiency in Zimbabwe's SAT.* In Pala M, Beukes DJ, Dimes JP and Myers RJK (eds). Management for improved water use efficiency in the dry areas of Africa and West Asia: Proceedings of a workshop organized by the Optimizing Soils Water Use (OSWU) Consortium. April 2002, Ankara, Turkey. Aleppo Syria; ICARDA and Patancheru, India: ICRISAT. pp288

Easterling, W., Aggarwal, P., Batima, P., Brander, K., Erda, L., Howden, M., Kirilenko, A., Morton, J., Soussana, J-F., Schmidhuber, J. and Tubiello, F. (forthcoming) Food, Fibre and Forest Products. In *Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*

Ferris, R., Ellis, R.H., Wheeler, T.R., and Hadley, P. (1998). Effect of high temperature stress at anthesis on grain yield and biomass of field-grown crops of wheat. Annals of Botany 82 (5): 631–639.

Hellmuth, M.E. Moorhead, A., Thomson, M.C. and Williams, J. (2006). *Climate Risk Management in Africa: Learning from Practice*. International Research Institute for Climate and Society (IRI), Columbia University, New York, USA.

Hulme, M., Doherty, R., Ngara, T. and New, N. (2005). Global warming and African climate change: a reassessment. In : *Climate Change and Africa* [Pak Sum Low (ed)]. Cambridge University Press, Cambridge.

IPCC, 2007: Summary for Policymakers. In: *Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* [Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Avery, M.Tignor and H.L. Miller (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Jazairy, I. Alamgir, M. and Pannuccio, T. (1992). The State of World Rural Poverty: an Inquiry into its Causes and Consequences (NY University Press for IFAD)

Matlon, P. and Kristjanson, P. (1998) *Farmer's Strategies to Manage Crop Risk in the West African Semi-arid Tropics.* In "Challenges in Dryland Agriculture: a Global Perspective." Proceedings of the International Conference on Dryland Farming, August 15–19, 1988, Bushland Texas, USA pp 604 –606.

Nkomo, J.C., Nyong, A.O. and Kulindwa, K. (2006). The impacts of climate change in Africa. In: *The Stern Review on the Economics of Climate Change*.

Porter, J.R. and Semenov, M.A. (2005) Philosophical Transactions of the Royal Society B. 360: 2021–2035.

Pradeep Kurukulasuriya, Robert Mendelsohn, Rashid Hassan, James Benkin, Temesgen Deressa, Mbaye Diop, Helmy Mohamed Eid, K. Yerfi Fosu, Glwadys Gbtibouo, Suman Jain, Ali Mahamadou, Renneth Mano, Jane Kabubo-Mariara, Samia El-Marsafawy, Ernest Molua, Samiha Ouda, Mathieu Ouedraogo, Isidor Sene, David Maddison, S. Niggol Seo, and Ariel Dinar. 2006. The World Bank Economic Review, Vol. 20, No. 3, pp. 367–388

Thornton P.K., *et al*., (2006). *Mapping Climate Vulnerability and Poverty in Africa*. Report to the Department for International Development.

3
Crop biotechnology and biosafety

Susan Seal, A. Sangare, M. Makinde

Introduction

Biotechnology refers to any technique that uses living organisms, or substances derived thereof, to make or modify a product or to improve plants, animals or micro-organisms. This discussion paper will focus on crop biotechnology issues of relevance to West and Central Africa (WCA) and specifically the application of molecular biology techniques to generate higher crop yields or plant varieties that can be grown under adverse conditions. Increased crop yields are necessary to assist Africa to meet its increasing food security needs; the continent's estimated annual rate of population growth of 2.8% will lead to a doubling of the population in 25 years (see Eicher et al., 2006). In West Africa, agriculture contributes to more than 35% of the region's GDP (CORAF/WECARD, 2004) and estimates show that a 10% increase in the level of agricultural productivity is associated with a 7.2% reduction in poverty (IFPRI, 2004).

One particular technique referred to as genetic modification (GM) enables new crop varieties to be developed rapidly, which is particularly useful for crops that rarely or never set seed or are difficult to cross-breed (e.g. banana, sweet potato, yam). GM allows isolated genes of interest to be inserted into a plant genome such that this 'transformation' event is stable and inherited by the plant's progeny. The most common GM traits introduced to date have generally been ones of value to farmers in Northern America that are encoded for by single genes for which the metabolic pathways are well understood, e.g. herbicide resistance, insect pest resistance. Transgenic crops resistant to other biotic (plant pathogens) and abiotic stresses (drought, saline soils, etc) have also been produced. Genetic engineering has also made it possible to grow pharmaceuticals and industrial products in plants, such as biodegradable plastics, adhesives, antibodies and vaccines, e.g. a GM rice producing a vaccine for cholera has recently been produced and has the advantage that the rice can be stored at room temperature for over a year and the vaccine remain effective. Moreover, purification of the vaccine from the rice is not necessary reducing production costs.

GM crops were first grown commercially in 1995 in the United States, Mexico and Australia. Over a decade later, the only African country growing GM crops commercially is South Africa in the form of insect resistant and herbicide tolerant varieties of cotton, maize and soybean (Eicher et al, 2006, James, 2006). However, worldwide GM technology represents the fastest adopted crop technology in recent history, with the area planted to such crops rising 60-fold between 1996 and 2006, when 102 million hectares of approved GM crops were grown (James, 2006). Of the over 10 million farmers growing GM crops in 2006, around 90% were smallholders from developing countries mainly China and India.

In South Africa, insect-resistant (Bt) cotton was the first GM crop to be grown commercially in 1997 and has shown a high adoption rate with 92% of the 2006 cotton crop being GM (James, 2006).

Similarly GM soybeans have been adopted rapidly by South African farmers rising from 5% of the 2001 crops to 75% of 2006 soybean cultivation. The high adoption rates reflect that growth of these crops has offered benefits to the farmers, not only in providing more convenient crop management practices, but also increased return through higher productivity, lower input costs, and health benefits through less pesticide use (James, 2006). Questions have therefore been raised as to the main underlying reasons for adoption not having been wider in Africa. A wealth of literature exists on this subject (e.g. Alhassan, 2002, CORAD/WECARD 2004, Eicher et al., 2006) with delays primarily attributed to investment in this field primarily targeting crops of importance to Western countries as well as a lack of capacity and suitable political and institutional frameworks in Africa to address concerns raised over GM crops. It is feared by some that GM crops will have the following risks:

- Transfer of the GM genes to other crops or wild species through cross pollination. This is of particular concern where crop plants are grown near their centre of origin as cross pollination is more probable as highlighted in Mexico in 2001 by the contamination of wild maize varieties by the unauthorised cultivation of GM maize (see www.scidev.net). The risk of gene flow will also be higher for open-pollinated crops such as maize, than self-pollinated crops, such as rice. Organic farmers fear that GM genes may contaminate their crop resulting in them losing their organic certification. Management measures to isolate crops need to be applied, such as spatial isolation or installing physical or temporal barriers against pollen drift. Such methods for preventing cross-fertilisation pose particular difficulties for WCA where small-scale farms with diverse cropping systems dominate the agricultural land.
- It is also feared that gene flow could transfer aspect such as herbicide resistance to weeds/wild relatives leading to superweeds which would be hard to eradicate.

Research is being carried out to develop mechanisms to impede transgene movement, driven by the above concerns and particularly from the cultivation of transgenic crops that produce pharmaceutical or other harmful industrial products. Mechanisms that impede transgene movement generally are effective by making the plant not develop properly, or produce functional pollen or seed, or by preventing the transmission of the transgene. More information on such genetic use restriction technologies (GURTs) can be found in a recent review by Hills et al (2007). To date, no GURT has been applied to GM crops grown commercially.

- A loss in biodiversity will result from the widescale cultivation of a few GM varieties. Similar effects have been found for conventional agriculture where the adoption of varieties on a wide scale can lead to a decrease in local crop diversity.
- Pests will develop resistance to pest-resistant GM crops such as Bt-crops. This has been shown to occur in conventional agriculture systems where applications of the Bt bacteria (*Bacillus thuringiensis*) have been used as biopesticide for over 70 years by farmers. It is probable that over time resistance will build up to single 'Bt' genes but management practices are recommended by seed suppliers to minimise this. GM varieties with multiple Bt-genes have been developed to reduce this risk further.
- GM crops will affect non-target organisms. The toxins produced by Bt bacteria only kill certain insects, and have been shown not to be toxic to human, animals or some other insects. Although there may be some effects on non-target insects, recent studies suggests that fields planted with Bt crops contain more invertebrates than fields sprayed with insecticide (see Eicher et al., 2006).

- Risk of food allergy or toxicity. GM food plants do not inherently present more toxic properties than those presented by conventional breeding practices (Crop Biotechnology Update, 2002) and plants existing in nature; toxic substances are present in many crops (e.g. cassava, potato) although usually in low concentrations.
- Loss of farmer sovereignty and overdependence of farmers on seed and chemical companies, but such concerns apply equally to the use of hybrid seeds.
- Loss of foreign markets. The GMO moratorium in some countries together with the need for accurate labelling pose problems as it is essential that there is minimal mixing of GM with non-GM products. Contamination can occur from material left in a field at the end of one growing season, as well as from farm machinery and storage bins, or get mixed during produce handling or transportation.

Constraints to adoption of GM crops in West and Central Africa

The wide diversity of potential risks mean that biosafety risk assessment and management systems need to be put in place in WCA countries to deal with requests for the field testing and commercial release of GM organisms. To date, this has been one of the principal constraints. International treaties exist on biodiversity and biosafety (the Cartagena Protocol of Biosafety), plant variety diffusion (UPOV: Union for the Protection of New Varieties of Plants) and intellectual property rights (TRIPS: Trade Related Aspects of Intellectual Property Rights, World Trade Organization). The United Nations Environmental Program/Global Environmental Facility (UNEP/GEF) Biosafety Project is currently assisting WCA countries to develop and implement their national biosafety frameworks. It is important that biosafety systems are set up using a regional approach as not only are existing capacities in countries often insufficient (CORAF, 2004), but also to deal with expected trans-border movements. Almost all African states plan to have draft policies by the end of 2007, when the UNEP project comes to an end (www.scidev.net). Currently only Burkina Faso has an operational Biosecurity Law (Chetaille, 2006). The African Union (AU) Commission and NEPAD have established a panel of 14 African scientists and policy analysts to prepare a common African biotech strategy to deal with issues such as transboundary movement.

Other problems that have slowed down adoption of GM crops are:

- Low biotechnology capacity
- High technology and regulatory approval costs
- Patents covering the use of most GM technologies
- A lack of efficient input delivery and smallholder credit systems
- Requirements to consider labelling and coexistence issues

Low biotechnology capacity

Biosafety implementation requires a wide range of technical expertise and studies carried out by Prof Walter Alhassan (Alhassan 2002, CORAF/WECARD, 2004) identified that in the agricultural biotechnology field that in general individual research institutes in WCA countries possessed insufficient funding and human capacity to undertake research independently for launching major biotechnology products.

High technology and regulatory approval costs

The development costs for a GM variety are higher than at first thought in part due to the cost of lengthy field trials and regulatory approval, and this has been a major factor hindering the commercialisation of GM crops developed by the public sector worldwide (Eicher et al., 2006). For example, the total cost of Bt potato research in Egypt and South Africa is US$3 million to date. Similar amounts (US$2–$4 million) have been spent by private companies developing Bt cotton hybrids in India. It is considered that the financial cost will be lower (ca. US$50,000–$100,000 per event) for GM crops developed through Indian government funding (Eicher et al., 2006). Such high costs restrict the suitability of using GM traits for some crops and mean that it would be best for GM varieties developed by WCA countries to be approached through regional/international public and private partnerships. It is worth noting that the Indian agricultural biotech sector grew from US$26.82 million in 2002–03 to US$225.85 million in 2006-07 and hence the investments made have been financially worthwhile (ISAAA, 2007).

Patents covering the use of most GM technologies

The tools of genetic engineering are mostly proprietary and held by the private sector in industrial countries, but these have little to gain financially from investing in the majority of crops of importance to WCA countries. Where there are mutual crops of interest (e.g. Bt cotton) the private sector remain cautious due to a lack of regulatory systems to ensure they receive a return on their investment in GM crop development. This together with a relative lack of GM research capacity in WCA and the extensive regulatory and commercial expertise of multinational companies, means that it would be beneficial to develop public-private as well as 'North-South' partnerships. Access by developing countries to proprietary genetic resources has been extremely limited with Cohen (2005) estimating in his studies that only 6% of publicly developed GM crops at that time had used private genetic materials.

The African Agricultural Technology Foundation (AATF) was founded in 2004 to facilitate smallholder access to GM technologies with funding from DFID, DANIDA, USAID, Rockefeller and OCDE. To date efforts have focused on brokering royalty-free proprietary technologies for use in GM improvement of banana, cowpea and especially maize (Striga and insect resistance as well as vitamin A enhancement) (Eicher et al, 2006).

A lack of efficient input delivery and smallholder credit systems

Consideration needs to be given to how best to access to seed, credit and markets by smallholders (Rukuni et al., 1998). Lessons can be learnt from studying why hybrid crops and other high yielding varieties have not been grown extensively in WCA. Cohen (2005) found that of the publicly developed GM crops studied, for many there had been insufficient time set up for partnerships required for acceptance, engaging farmers at all stages and to set up appropriate seed distribution mechanisms.

This point is best illustrated by the case study of the rise and decline in smallholder production of Bt cotton in South Africa described by Eicher et al. (2006). Higher yields and lower chemical costs outweighed seed costs and led to rapid wide-scale adoption of the Bt cotton by smallholders in the KwaZula Natal region of South Africa. However, just 3-4 years after the commercial introduction of Bt-cotton, problems arose due to the establishment of a new gin to which some farmers sold their

cotton. This led to financial problems being experienced by the original gin, which as a result stopped providing credit to smallholders leading to a decline in Bt cotton adoption.

Requirements to consider labelling and coexistence issues

Legislation needs to be put in place that enables purchasers to know the GM status of the product they are buying (e.g., see South Africa's labelling legislation at www.doh.gov.za). Moreover for export of food exports labelling is required if GM material exceeds particular thresholds (EU: 0.9%, Australia 1%, Japan 5%). The infrastructure to enable accurate labelling is lacking in much of the developing world as are coexistence strategies for conventional, organic and GM crop systems (see www.scidev.net). Of particular concern is how to ensure that pharmaceuticals or toxic compounds produced in GM crops do not get into human or animal food supplies. Seed companies and organic production system are likely to have useful expertise.

Demand for GM research in West and Central Africa

It becomes clear from the above described issues that crop improvement by GM methods is only worthwhile where it is able to overcome problems that have not been solved effectively by conventional breeding methods. The priority constraints affecting plant production in WCA have already been drawn up (Alhassan, 2002; CORAF/WECARD 2004). They centre around the low production potential of plant genetic material, as well as susceptibility to both biotic and abiotic stresses:

- Sorghum and cowpea: resistance to the weed Striga
- Maintenance and evaluation of genetic resources (all crops)
- Pre- and post-harvest insect resistance (cowpea, sorghum, groundnut)
- Resistance to a range of viruses (groundnut, tomatoes, rice, banana and cassava)
- Resistance to fungi (groundnut, cacao, rice)

Eicher et al. (2006) considered that increasing the yields of cereal is the greatest challenge facing Africa and there are a number of pipeline GM research products that could be of great interest to WCA (maize resistant to stem borer, fungal and virus infections and drought tolerance, and salt and drought resistant wheat). Partnerships are essential to build on research carried out to date on GM crop traits relevant to WCA. For example, the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) has a regional hub in Nigeria working on transgenic varieties of pigeon pea, groundnut and pearl millet. There has also been considerable public GM research in some other African countries such as South Africa, Kenya, Zimbabwe where experience has been gained in crops of interest (e.g. maize, sweet potatoes, cowpeas, coffee, pearl millet, rice, sorghum).

Capacity in West and Central Africa

Expertise in a range of biotechnology areas is relevant to the selection of improved plant varieties. A basic understanding of the **genetic diversity** of germplasm collections underlies many applications and DNA fingerprinting is useful for determination of seed purity, parentage and for diagnostic purposes. The determination of molecular markers (identifiable DNA sequences transmitted from one generation to the next) tightly linked to a useful gene can speed up selection of breeding lines and enable germplasm collections to be rationalised.

However, although **marker assisted selection** has been available for ca. 15 years, there are very few reports of varieties released through its use and the reasons for this need to be studied. Attributed reasons are similar to that found for many biotechnological techniques, namely inadequate links between breeders and molecular biologists with a global decline in academic plant breeding training (Eicher et al., 2006; Reece and Haribabu, 2007).

Nucleic acid based diagnostic techniques allow pathogens to be detected at very low levels which is useful for screening latently infected export or planting material. Such methods also enable the assessment of the genetic diversity of pathogen populations and the efficacy of crop protection measures.

Plant tissue and cell culture refers to the growing of plant tissues or cell suspensions in artificial media. Capacity in this field is a pre-requisite for the genetic transformation of plants. It is more widely used for the rapid multiplication of plants. The technique also enables pathogens to be eliminated from plant material, easier maintenance of germplasm collections or producing homozygous lines rapidly facilitating the production of new varieties by plant breeders.

Currently much of agricultural biotechnology research in WCA is on crop improvement but much of this centres around non-GM biotechnology; plant tissue culture is currently used extensively in WCA, especially in CG centres (IITA, WARDA and ICRISAT) for mass propagation of many crops, fundamental research to assist genetic transformation studies and the cleaning of vegetative planting material (cassava, yam, sweet potato, etc). Although good tissue culture labs exist in many WCA countries (Alhassan, 2002; Chetaille 2006, Eicher et al., 2006), well-equipped molecular biology labs are more scarce. Nevertheless WCA possess some excellent biotechnology labs in addition to the facilities present in CG centres. Some of the best examples include:

- Laboratoire de biologie moleculaire de L'Universite Cheikh anta Diop (Senegal)
- Le centre d'Etude regional pour amelioration et L'adaptation a la secheresse (CERAAS, Senegal)
- Laboratoire biologie moleculaire appliqué, Faculte des Sciences et Techniques (Mali)
- Institute of Environment and Agricultural Research (INERA, Burkina Faso)
- L'Institut National de Recherche Agronomique (INRAB, Benin)
- Centre National de Recherche Agronomique (Cote D'Ivoire)
- University of Legon (Ghana)

With regard to human capacity in WCA, it was determined that in 2004 242 persons had received degrees in biotechnology in comparison to only 19 in biosecurity (Alhassan, 2004).

Capacity required

The CORAF/WECARD Biotechnology and Biosafety project proposal (2004) highlights that the ability to apply agricultural biotechnology in WCA requires increased capacity both at national and sub-regional levels. It suggests that capacity would be built most effectively by concentrating on three areas:

1. Product-driven capacity building activities in agricultural biotechnology and biosafety. Specific case experience for stakeholders will be more productive than discussions centering around a generalised debate. The trials of Bt-cotton in Burkina Faso illustrate that rapid action can occur for real products tackling real problems.

2. Creation of a competitive grant system to foster consortium building between and within WCA countries.
3. Development of a biosafety framework that builds commonalities in regulatory processes across WCA countries.

Specific objectives for capacity building would be

- Develop national centres for containment and regional GM safety centres. It would be of benefit to set up regional cooperation to assist with determining scientific and regulatory data, and carrying out expensive environmental and food safety risk assessments using centralised resources.
- Provide long-term training in agricultural biotechnology for scientists in national and regional centres of excellence, with emphasis on genetic engineering, molecular diagnostics, genomics, bioinformatics and biosafety testing.
- Training of policy makers in diverse fields related to agricultural biotechnology to assist effective communication at national and regional levels. Much debate is centered around a lack of understanding of the issues concerned.
- Intellectual property management capacity needs to be strengthened to assist scientists to access the tools/techniques needed to develop a new biotech product as well as ensure that such a product can be used without infringing IPR issues.
- Strengthen institutional capacities and human resources for biosafety implementation. It will be necessary to build commonalities in biosafety procedures and establish a regional regulatory framework. This could be assisted by reviewing existing risk assessment, management and policy instruments material developed by international organisations and countries with longer experience in biotechnology such as South Africa, Australia, Canada and the USA. It will also be necessary to decide upon which protocols to use for testing the safety of GMOs and for selected protocols to be pre-tested by selected WCA institutions in relation to GMOs of highest priority to the region.
- Develop mechanisms to improve communication and information to all stakeholders ensuring an input mechanism of stakeholders views in the decision process of GMOs. This could be carried out by e.g. web pages for information and inviting views, meetings, video documentaries. The material would need to be available in the languages spoken in the region (English, French, Portuguese and Arabic).
- Build effective methods for access to the products by end-users. Assessments need to be made throughout the region to gain accurate insight into how seeds move from producers to end-users in each country, and evaluate whether such systems could operate effectively for GM seed. Consideration also needs to be given about how to ensure that the new products are used correctly.

Training required

Although quite a number of scientists in the region have received biotechnology-related training, to date there have not been significant outputs from such training. Some of the setbacks experienced have been due to a high turnover of biotech scientists (Eicher et al., 2006) and mechanisms need to be put in place to minimise this. Another problem has been that donors have invested relatively

heavily in workshops and networks, with much less emphasis on long-term (MSc and PhD training in biotechnology and biosafety) training.

Another reason for the low uptake is probably that closer interactions need to be established between biotechnology and plant breeding programmes. Eicher et al (2006) have noticed an increasing trend for donors to support GM crop research rather than conventional plant breeding and as a result it is harder to attract African students to pursue postgraduate training in crop science and plant breeding in African universities. Special attention does need to be paid to strengthening the plant breeding programmes in the National Agricultural Research Systems (NARS), local universities and the CGIAR centres (Eicher et al 2006; Reese and Haribabu, 2007). An excellent molecular plant breeding course targeting 'African' crops does exist at the University of Free State, South Africa.

Biosafety legislation is being built up effectively with UNEP-GEF programme, but it would be beneficial to build up science-based biosafety training to ensure that policy makers participate effectively in negotiations regarding important international agreements.

Much of the training to date has been at universities in industrialised nations. Efforts now need to concentrate on expanding biotechnology curricula in WCA universities at various education levels. An effective way of doing this would be through setting up collaborative training courses with US/ European Universities. This has worked very well for project RIBios (Switzerland) and the University of Greenwich is in discussions regarding BSc- and MSc-level training courses e.g. in molecular diagnostics, GM crops, sustainable agriculture and markets.

References

AfricaBio (www.africabio.com)

Chetaille A. 2006. Evaluation des besoins en renforcement de capacities sur la biosecurite en Afrique de l'Ouest. Etude pour le ministere des Affares etrangeres. Groupe de recherche et d'echanges technologiques, France.

Cohen J.I. 2005. Poorer nations turn to publicly developed GM crops. Nature Biotechnology 23 : 27–33.

CORAF/WECARD, 2004. CORAF/WECARD Biotechnology and Biosafety Project Proposal: CORAF/ WECARD, December, Dakar.

Crop Biotechnology Update, 2002 (www.isaaa.org)

Eicher C.K., Maredia K, Sithole-Niang, I. 2006. Crop biotechnology and the African farmer. Food Policy 31: 504–527

Hills M.J., Hall L., Arnison P.G., Good A.G. 2007. Genetic use restriction technologies (GURTs): strategies to impede transgene movement. Trends in Plant Science

http://dx.doi.org/10.1016/j.tplants.2007.02.002.

IFPRI. 2002. Ending Hunger in Africa: Only the small farmer can do it (see Cohen 2005?).

IFPRI, 2004. Agriculture, Food Security, Nutrition and the Millenium Development Goals. (see Cohen, 2005).

ISAAA 2007. CropBiotech update 29 June 2007

James, C. 2006. Global Status of commercialised biotech/GM crops: 2006. ISAAA brief 35, New York. http://www.isaaa.org/Resources/publications/briefs/default.html

Reece D.J., Haribabu E. 2007. Egenis briefing note based on paper 'Genes to feed the world: The weakest link?' Food Policy 32: 459–479.

Rukuni, M., Blackie, M.J., Eicher, C.K. 1998. Crafting smallholder-driven agricultural research systems in Southern Africa. World Development 26: 1073–1087.

Sithole-Niang, I., Cohen, J., Zambrano, P. 2004. Putting GM technologies to work: public research piplines in selected African countries. African Journal of Biotechnology 3: 564–571.

Tollens, E., Demont, M., Swennen, R. 2004. Agrobiotechnology in developing countries North-South partnerships are the key. Outlook on Agriculture 33: 231–238.

4

Gender and diversity in sustainable agricultural research and innovation: Issues, challenges and the way forward

Valerie Nelson[1], Adrienne Martin[1] and Aissétou Dramé Yayé [2]

Introduction

Inequality varies across countries and cultures, but women are usually more disadvantaged than men. Gender inequality has huge costs and represents many lost opportunities, not only for women, but for society as a whole. CTA (2000) defines Gender as socially constructed relations between women and men in a particular society. These relations and roles that women and men assume are culturally and institutionally embedded. Society ascribes different roles to men and women and what is considered socially acceptable behaviour is learned by boys and girls as they grow up and is internalised psychologically. Other forms of social difference are also the basis of disadvantage.

Whilst both men and women have roles in production and public life (although these also vary by gender), most of the work of maintaining and sustaining the household falls on women. Access to and control over resources is gendered—i.e., men and women have different levels of access to resources and differentiated control over the use and benefits from those resources. These '*social reproduction'* tasks are generally undervalued. In public spheres, men tend to hold higher status positions compared to women and often have greater decision-making power (Williams, 1994).

However, relationships are not fixed—men and women negotiate over resources and gender relations are dynamic and changing (Cleaver, 2000).

Understanding these patterns of change in gender relations in the context of rural livelihoods is of critical importance in agricultural research: in the framing of research agendas and influencing research priorities; in selecting methods, approaches and collaborative partners for research implementation; and in the assessment of the impact of new technologies, knowledge and innovation. However, gender analysis is not usually given adequate attention and a gender perspective is still neglected in agricultural innovation.

This paper raises some of the important issues in relation to gender, diversity and the processes of agricultural innovation. It summarises lessons from existing mainstreaming initiatives and suggests ways forward.

1. Natural Resources Institute (NRI), University of Greenwich. 2 FARA, Accra.

Why do we need to tackle gender inequality?

Tackling gender inequality is necessary because women are most affected by poverty, and because women's empowerment is a precondition for the eradication of poverty. In the past, women-in-development (WID) approaches focused specifically on women, but often left them worse off, as they led to increased workloads and often further entrenched gender disparities. Gender and development (GAD) approaches aim to be more transformative, considering not only men's and women's *practical needs*, but also their *strategic interests*. GAD initiatives seek to empower women so that they improve their relative position in society so that society as a whole benefits. Transforming gender relations can benefit men as well as women (e.g. in increasing overall family income), but it is more than reallocating economic resources. It is critically important to recognise that it is fundamentally about *redistributing power* (Kabeer, 1992) and men may have to surrender some economic, political and social power (Williams, 1994). Achieving gender equality and women's empowerment is thus a complex, long-term project—one which requires sustained, concerted action and integration of a gender perspective across all activities, plans and programmes.

Intersecting with gender—other kinds of social differentiation

Gender is not the only form of social differentiation. People are ascribed different roles and characteristics according to their gender, but also along other lines of difference: e.g., age, ethnic background, religion, caste, class, occupation, disability, illness etc. One kind of social differentiation can overlap and intersect with others. This creates multiple layers of deprivation and the exclusion of social groups from participation in decision-making and in social, economic and political processes.

Gender and social exclusion

People can be excluded because of: a) *what they have* (or what they do not have in the way of resources, also termed economic deprivation); b) *where they live* (spatial deprivation, such as the stigma from living in the 'wrong part of town' which may prevent otherwise good candidates from getting a job); and, c) simply because of *who they are* (identity-based discrimination). More accurately put, it is who people are perceived to be by others in society. Groups that are discriminated against on the basis of identity in this way are culturally devalued and this can cause poverty (although social exclusion and poverty are not necessarily synonymous) (Kabeer, undated). Exclusion can operate through public institutions, such as laws, education, health services which can reflected prevailing prejudices in society, as well as through social institutions (e.g., the household) (DFID, 2006). It is important to understand how processes of exclusion either change or persist over time; for example, how the degree of poverty and deprivation of one generation compares to the next and how multiple stresses (e.g. drought, HIV/AIDS, decline in state provision of input and extension services, etc.) can accumulate over time to have a negative impact on the livelihoods of excluded groups.

Gender underpins social discrimination—it is often the most significant factor in disadvantage and discrimination - and gender inequality intersects with economic deprivation. Gender inequality is increasingly part of extreme poverty in many parts of the world. Understanding social differentiation and exclusion—its causes, complexities and manifestations—should be an integral part of gender and social analyses in participatory research and in analysing organisations and institutions.

Gender and agriculture

In agriculture, gender issues have been widely analysed and documented. Key (inter-related) topics include: The *gendered division of labour*, with specific gender constraints on access to labour; *Gendered access to, control of and inheritance of resources*, with disparities between men and women in relation to land, water, livestock, finance; In countries like Burkina Faso, Niger, Mali, Gambia and Senegal where women can hardly inherit the land, it is usually the husband who gives a portion of land to the wife to grow the family crops. But with the increasing poverty, exacerbated since 1990 by periodical famines, land is becoming a marketable product that is sold to less vulnerable farmers and rich urban people. As a result, the lands given to women are even poorer than before. *Women also play a crucial role in rural agricultural production*, and are involved in other livelihood activities and enterprises, including gathering wild foods, marketing, agro-processing, and food storage. The *feminisation of labour* in some areas, coupled with demographic changes (e.g., changes in age profiles) in rural populations, the impact of social, economic, political and environmental factors, such as *macro-economic policies* (e.g. current neo-liberal policies are said to be leading to deepening gender inequalities, UNRISD, 2005).

Box 1 illustrates the significance of understanding and working with gender roles to address practical needs.

Box 1. Gender roles and village level reafforestation in Senegal

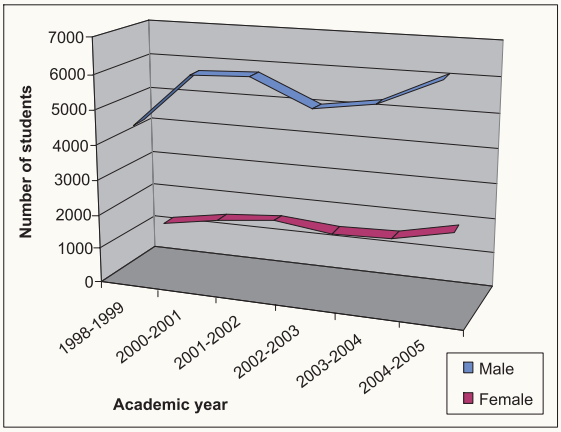
From its outset the PREVINOBA project in Senegal had a strategy of 'popular involvement' to deal with deforestation and erosion. However, large numbers of rural men were absent as seasonal migrants, while women traditionally only had access to land through men. This meant that women's participation was essential to the design and set-up of land management plans. The project began by building a partnership with village organizations and women's groups and became involved in activities responding to the needs of women (e.g. improved ovens to reduce demand for firewood, access to water, millet mills, oil presses, improvement of family nutrition, etc.). Planning and organization of activities took account of the different tasks, responsibilities and concerns of men and women. Women's groups were involved in reafforestation and cultivation of land and in planting fruit trees, shrubs and shade trees in family plots. Some modifications were made to project activities on the basis of gender differentiated interests. The project did not set out to focus on women's participation in an explicit manner, but the context forced gender issues to be taken into account to allow practical progress. Benefits were:

- land was more easily accessible for women;
- technical training (tree nurseries, plantations, market gardening), training in management and functional literacy were open equally to women;
- significant incomes which were reinvested in the group or used individually;
- social recognition of women thanks to their know-how and their active participation in problem-solving and financial contributions to village projects
- satisfaction of women's practical needs.

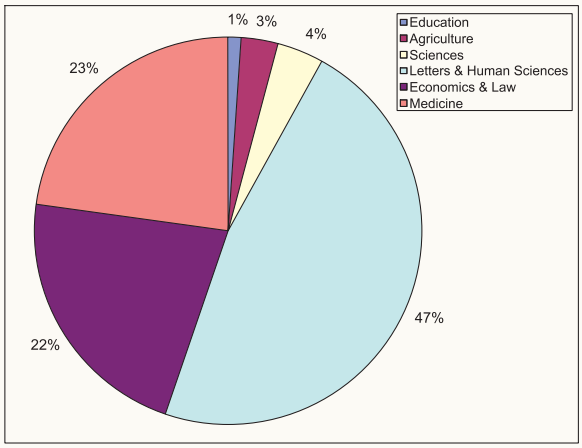
The approach advanced women's integration in development, although the changes did not challenge the village hierarchy or the balance of power between men and women. (Source: adapted from FAO 1997a & b).

Gender and tertiary agricultural education

The examples from the Abdou Moumouni University of Niamey in Niger show evident disparities between female and male enrolment:



Total male and female students enrolled at the Abdou Moumouni University (Niger) within the past 9 years.



Overall percentage of women enrolment in the various Faculties of the AMU.

Gender and vulnerability

Conflicts, such as internal or civil wars and conflicts carried over from the post-colonial era have increased since the end of the Cold War, but gender is not yet mainstreamed in many post-conflict institution-building processes and negotiations (UNRISD, op cit); yet there is evidence that gender roles often change in conflict situations (UNDP, 2001).

The accumulative and systemic impact of *HIV/AIDS* – a study in Zambia found that social networks bolster resilience, but the combined effects of the AIDS epidemic, livestock disease, economic and policy environment changes is negatively affecting even wealthier households. There are multiple effects of this disease on rural households, such as the loss of local knowledge and decreased access to labour (Samuels, et al, 2006).

Climate change represents an enormous challenge for developing countries in terms of their mitigation and adaptation strategies. More research and empirical evidence is urgently needed to clarify the gender dynamics and impacts (Nelson et al, 2003). This is because climate variability and change will, in a sense, add to the multiple layers of stress upon poorer households—of which gender inequality is a key element. It is now widely thought that climate change will hit the poorest hardest. More sustainable development pathways will reduce the negative impacts of climate change. Adaptation and mitigation strategies must not exacerbate inequalities based on gender or other forms of diversity. For example, the expansion of biofuel cultivation—a valuable cash crop—could have positive gender implications if tailored to the needs of rural women, but otherwise potentially negative consequences for women's labour, family food supply and child nutrition.

Participatory, gender and difference-responsive research

Participatory approaches have now had several decades in which to be implemented in agricultural research and extension, although the extent of transformation varies from place to place, and from organisation to organisation, in terms of approaches to research management, the framing of research agendas, and in research implementation. Unfortunately, many participatory research processes have not always succeeded in moving beyond fairly simplistic notions of gender roles, social differentiation and what constitutes empowerment (Cleaver, 2000).

It is important to learn the lessons from successful examples of institutionalisation of such approaches. It is now commonly recognised that as well as capacity building in participatory methods (including analysis of gender and social difference), it is important to look at the overall organisation managing the research—its culture, structure and practices, and to consider the roles of other actors in the innovation process (again integrating a gender/social difference perspective). A recent FARA study focusing on how to strengthen agricultural research found a number of weaknesses in current practice and skills in national agricultural research systems (see box 2 below).

Box 2. Improving agricultural research – FARA study lessons

A FARA commissioned study on improving agricultural research delivery identifies a number of weaknesses in current practice and skills in:

- priority setting, programme planning, monitoring and evaluation
- make-up of management boards and programme committees with under-representation by farmer based organisations, NGOs and processors.
- commitment, interest and relevance of some members of these boards, especially of some politicians

Gender issues were not raised systematically in this study, but a number of issues were raised with relevance to gender equality and diversity, e.g.:

- balance of male and female scientists
- PhDs held by men and women
- Gender and difference issues at the grassroots – with calls for greater engagement of diverse rural groups in framing research agendas

FARA (2006)

Agricultural Innovation systems and gender

An innovation systems approach aims to offer a means of looking at research as part of a larger dynamic whole—which involves a *network* of actors involved in innovating. This involves not only science and technology, but also applying knowledge to institutional arrangements, attitudes and roles to achieve desired social and economic outcomes (World Bank, 2006). Theoretically, innovation systems promote the integration of research and education systems, encourage public-private sector partnerships and strengthen organisational mechanisms such as farmer and community based organisations.

Ideally, an innovation systems approach focuses on creatively supporting new linkages, activities and roles to achieve those goals (such as linking research with markets). With an emphasis on collaboration and partnerships, patterns of trust and creating a culture of innovation, it aims to *transform the attitudes and practices* of the main actors. It offers opportunities to tackle gender inequalities and social discrimination, and to promote specifically the empowerment of women, because a wider network of actors is engaged than has traditionally been the case. It provides opportunities to build up the involvement of farmer organisations and representation by women in agricultural innovation. The *linking up of research based capacity with community based capacity*— networks of rural actors around development themes (World Bank, 2006) is said to be a central element. All of these foci represent opportunities, but there are also risks that gender inequalities and social exclusion will be further entrenched if programmes and activities are gender blind in planning and implementation.

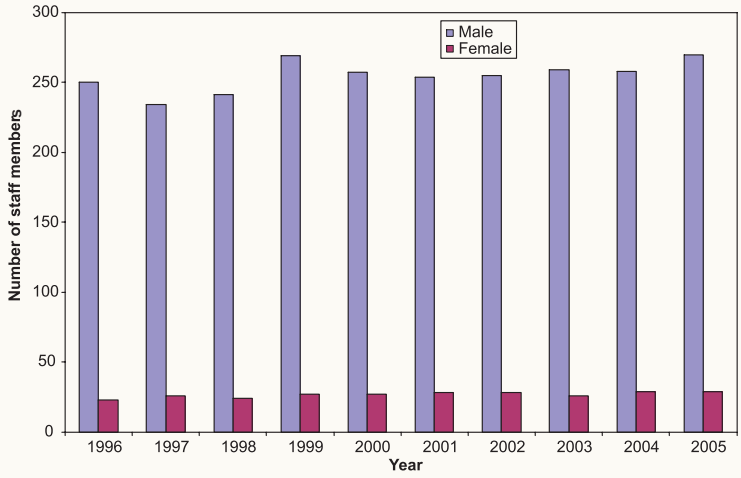
In relation to research implementation, what is needed is '*gender and difference responsive, participatory agricultural planning*'. This involves two key elements (FAO, 1997a, p9): firstly, 'policy planning that responds to the different constraints, needs and priorities of different groups of farmers, where these differences are based on gender, socio-economic situation, age, ethnicity, religion etc'. Secondly, 'policy-makers and planners are aware of these differences and of how best to respond to them because men and women farmers from different socio-economic, age, and ethnic groups have taken an *active* part in planning agricultural development activities' (FAO, op cit). These perspectives need to be at the forefront of agricultural research for development informing not only theoretical understanding, but practical orientation.

Research management, gender and social difference

However a gender and difference perspective must also be embedded in research management, to provide the appropriate environment to nurture the right kind of research practice and agenda setting - an environment in which research is truly demand-led and positive in outcome for women as well as men. Research managers need to ensure that the 'priorities, ideas and voice of people at the grassroots are able to inform and shape the research agenda' (CGIAR, 2007). The values and principles that underpin the 'participatory paradigm' must be integrated into organisational principles, structure and culture - with gender and diversity considerations taken seriously.

Gender mainstreaming strategies

The recognition of the need to look at both research practice and organisational culture simultaneously, led to the strategy of '*mainstreaming*' — i.e. integrating women's as well as men's concerns into the design, implementation, monitoring and evaluation of all legislation, policies and programmes, so that women and men benefit equally and inequality is not perpetuated. The ultimate goal is achieving gender equality. It concerns staffing, procedures, and culture of development organisations, as well



Female staff member enrolment since 1996 at the Abdou Moumouni University of Niamey, Niger.

as their programmes, and it is the responsibility of all staff (Derbyshire, 2002, p9). It is intended as a *transformative process* and involves: identifying gaps in gender equality through the use of gender analysis and sex-disaggregated data; raising awareness of the gaps; building support for change through advocacy and coalition building; developing strategies to close those gaps, such as targeted training and capacity building programmes; putting adequate resources and the necessary expertise into place; monitoring implementation; and holding individuals and institutions accountable for the results' (UNDP, 1997, p4).

Development organisations often reflect gender inequalities in wider society. These widely prevalent external gender disparities affect: who is qualified and available to work; patterns of staffing; training; promotion; career development opportunities etc. There have been successes in gender mainstreaming, but it is also important to analyse why there has sometimes been less success than expected.

A CGIAR programme has been supporting gender mainstreaming in CG centres on the basis that gender issues should be integrated into organisational culture and work ethics. This CGIAR programme has already promoted gender-mainstreaming with eight NARS of East and Southern Africa, NARS and NGOs in South and Southeast Asia, and two CG Centres (CIP and ILRI). Following a successful external review a new strategic platform for action 2007 has been set out (see box 3 below).

Box 3. New Strategic Platform: CGIAR Systemwide Programme on Participatory Research and gender analysis for technology development and institutional innovation

The New Strategic Platform (2007) comprises three core themes and five supporting actions for mainstreaming gender research. The core themes are:

- Promoting risk reduction in participatory plant breeding.
- Institutions in Africa's seed and seedling (planting material) revolution, including support for women entrepreneurs.

- Integrating the diversity of soils and farmers' variety preferences with systems to supply planting materials.

Impact assessment is a cross-cutting theme. The five supporting actions for gender mainstreaming, (in the CG system), are:

- Support for an annual gender research prize.
- Develop a series of policy briefs on the main lessons to date.
- Develop a series of short manuals on participatory research and gender analysis for key research areas.
- Re-inventory past and ongoing gender research within the CG and distil lessons, and look at impact on research agenda of women scientists.
- Work with CIAT (as a model) to establish gender indicators for performance evaluation across the board, and mentor one of its research themes.

It was recently announced that the gender prize is being established, and that a gender audit will be conducted of CIAT to feed into mainstreaming initiatives.

CGIAR (2007)

The challenge of overcoming 'gender fatigue'

Various development agencies have evaluated their gender mainstreaming activities in recent years and have found limited progress. Indeed, Jones (2007) argues that there has been a loss of momentum by global women's movements, limited achievement in mainstreaming, a lack of achievement relating to the Millennium Development Goal on gender empowerment – and declining or stagnant funding for work on gender equality. Overcoming this gender fatigue represents a significant challenge to those concerned with equity in development.

Learning lessons from existing mainstreaming initiatives

One of the places to start is in identifying some of the reasons for this under-performance. These are as follows:

- Treatment of women in isolation, rather than focusing on gender relationships. The role of men in relation to gender and development has been neglected until recently – men have been left out of the analysis and of implementation. The importance of understanding different *conceptions of masculinity* is only now gaining greater attention. For women's and girl's empowerment it is necessary to tackle internalised attitudes of gender based inferiority. At the same time it is necessary to work with boys and men, and to also address harmful understandings of masculinity (Jones, 2007). A more *male inclusive* approach is needed (the World Bank promotes a concept of 'menstreaming'), although some feminist scholars are wary of approaches that might distract from or 'inadvertently blunt the significance of the larger issue of female subordination' (UNRISD, 2005, p12).
- Women scientists are allocated to what are perceived to be projects about women. 'The involvement of women scientists in on-farm research should encourage higher rates of rural women's participation in research activities….., but the risk is that gender analysis becomes confined to the realm of women scientists rather than being an integral part of research planning and implementation' (Meadows and Sutherland, 2000, p1). People who are given specific responsibility for gender mainstreaming

in organisations, can also face constraints if they do not have personal commitment, are too junior in position to effect change, or are not allocated extra time or resources to carry out new tasks etc (Derbyshire, 2002).

- Organisational and national policies can evaporate, remain invisible or be actively resisted when it comes to implementation, documentation, and designing specific monitoring or evaluation indicators.
- Under-estimation of the depth of change required, as gender and other lines of social difference are deeply embedded in people's daily beliefs and practices
- Organisations in both the north and the south have not yet built significant staff capacity in gender mainstreaming and many staff lack the right skills, resources, confidence, support and organisational position (Derbyshire, 2002).
- Lack of recognition and acceptance of the political dimensions of the process.

Mainstreaming as a strategy itself is being questioned — does it blunt the political edge to the process and too easily lend itself to becoming a tick-box, technocratic exercise? Or is it a strategy that has perhaps not been properly implemented?

Lessons are emerging as to what might be done better to achieve the goal of gender equality. Some of the factors for success in gender mainstreaming include:

- Appointing champions of change at the national policy-making level within key organisations (governmental, NGO, politicians, civil society, donors, private sector etc). Government staff needs

Box 4. Gender equality in Cameroon – whose agenda?

The Cameroonian gender-activist movement is largely concerned with ensuring that women and men have equal opportunities in the workplace. However, the distribution of such benefits in practice depends on factors such as social, economic, and educational background. In general, middle-class or white-collar women in the urban sector have gained more than their rural and grassroots sisters. This is because the campaign for gender equality is most effective among the increasingly gender-sensitive institutions and bureaucracies in the public and private sectors. African women who can 'prove their worth' within their workplaces are beginning to benefit from the growing commitment to equal opportunities in the formal sector. In much of Africa there are deepening inequalities of opportunity along gender and class lines, since gender equality for ordinary women, including rural women and those who work outside the formal sector, is basically ignored. How men and women perceive equality or inequality (discrimination) relates to differences in social status. The agenda of gender equality has not penetrated the grassroots and in agriculture related occupations in the same way as has happened among professional women in Cameroon. For this situation to change in such a way that the benefits of gender equality reach women in all social sectors in Cameroon, there needs to be a renewed commitment from these 'higher' women to promoting gender-equality practices among their grassroots sisters, on the basis of their shared interests. This will permit more ordinary women to grasp, absorb, and begin to practise greater gender equality in a wider range of social and working roles, even the most culturally prohibited ones that are currently the preserve of men.

(Source: adapted from Orock, 2007)

facilitation skills in participatory stakeholder processes, and engaging women and disadvantaged groups. Support is needed for women's organisations and gender equality proponents.

- Progress has been strongest where the political will is there to ensure that laws, regulations and policies are followed through with real action. High level responsibility for change is essential and accountability mechanisms need to be clarified.
- Innovative mechanisms for interaction and increased stakeholder representation, especially of women and excluded groups at all levels of research and innovation – particularly in framing research agendas.
- Availability of appropriate, high quality information and analysis, including context-specific, sex-disaggregated data and qualitative gender studies.
- Capacity building should include training that is learner oriented, and has follow-up and supportive organisational culture, policies, and structures, otherwise trainees will find it hard to put their new skills and knowledge into practice.

Some ways forward

Achieving gender equality and women's empowerment requires support from research managers, policy-makers and those in authority, and recognition that this is a complex, long-term project – one which requires sustained, concerted action and integration of a gender perspective across all activities, plans and programmes. Specific actions could encompass the following:

1) Appoint gender focal staff and champions of change - as catalysts for action. These people have designated responsibility and a strategic role in mobilising and targeting resources, identifying entry points, providing training and mentoring, developing alliances etc.

2) Use gender specialists strategically. Specific applications of gender expertise include:

- Ensure women's participation by working with representative women's organisations, female planners/research and extension staff.
- Use well-developed social and gender analytical skills to provide focused studies of complex, changing gender relations and the mechanisms and impacts of exclusion.
- Promote gender equality at the community level using specialist skills in participatory negotiation processes, working with local communities and in providing support/guidance to frontline staff.

3) Build social networks amongst rural farmers, especially women and disadvantaged groups experiencing poverty, to enhance their ability to advocate, lobby and negotiate. This is important to increase their voice in policy-making, in influencing agricultural innovation and research agenda-setting and in demanding access to and better quality services from government.

4) Promote gender equality within organisations through organisational capacity building and change strategies, including

- Equal opportunities processes; including gender issues in staff job descriptions, interviews, appraisals; develop gender policies and plans; checklists and guidelines; and develop appropriate information systems.
- Developing staff understanding of and skills in gender mainstreaming, carry out training for staff on gender and difference issues; use of facilitation, participatory training and adult learning skills.

sharing applied and practical understanding of gender analysis and mainstreaming (Derbyshire, 2002).

- Creating internal and external networks.
- Commissioning gender research.
- Integrating these concerns into monitoring and evaluation (Derbyshire, 2002).

5) Encourage organisational learning: promote 'unlearning' of existing paradigms and practices, to encourage more deep-seated change. (Engel, *et al,* 2007).

6) Build senior management support —an absolutely critical element, because this provides the signals to other staff of the relative priority assigned to the goal. Specific training for senior management is recommended as is encouragement of their involvement in gender policy development, with clear responsibilities set out etc (Derbyshire, 2002).

7) Monitoring, impact assessment, accountability and reporting*:*

   - Gather better evidence about the impact of gender equality and women's empowerment issues and use to pressure for change. Routine monitoring should collect sex-disaggregated data and gender analytical information at the client or beneficiary and organisational levels.
   - Involve key external partners in accountability flows—rather than carrying out planning, activity, and reporting in isolation of key stakeholders (Engel, *et al,* 2007). These need to be representative of local social groups in poverty, who are clients of agricultural research by NARS.
   - Use monitoring tools and approaches which involve multiple actors. Outcome mapping is a useful monitoring tool which involves multiple actors required for social change in collectively identifying the desired outcomes (in behaviour, relationships and action (Earl et al, 2001). The ActionAid Learning and Planning System (ALPS), moves from standardised reporting to a system which involves intensive dialogue between staff and intended beneficiaries, frees staff to determine how to generate/systematize reports and what to prioritize in reporting (removing formalised formatting requirements), and promotes local adaptation so that it is relevant to all its users (including investing in translating and adapting to the many different 'languages' spoken within it (Engel, *et al,* 2007, p3). This kind of approach may provide important lessons for integrating gender and diversity perspectives.

8) Learn from lessons from experience elsewhere on institutionalising participation in research and ensuring that participatory research and innovation is properly sensitive to gender and differentiation and exclusion along other lines (age, ethnicity, religion etc).

Conclusion

In the global context, new challenges are emerging in agriculture and rural development, including climate change, the impact of HIV/AIDS, conflict and post-conflict situations, an increase in urban agriculture and the continued deepening of inequality resulting from neo-liberal market economic policies. Despite the gloom of the reported increases in inequality and a detected gender fatigue with mainstreaming in some quarters, there are also many positive examples of women's empowerment and of successful interventions aimed at empowering other disadvantaged groups. It is clear that agricultural research system organisations need to be transformed so that they reflect the same principles that guide and underpin participatory, gender sensitive research, learning and action. Although, success to date may have been mixed, evaluations by development agencies and researchers are highlighting

some of the pieces of the puzzle that might need to be in place to achieve more rapid, far-reaching change in the position of women and those suffering discrimination.

A renewed effort is required to tackle gender disparities and social discrimination— something that needs to be addressed if agricultural innovation is to be socially and economically sustainable, as well as effective.

References

CGIAR (2007) 'Systemwide Program on Participatory Research and Gender Analysis for Technology Development and Institutional Innovation: New Strategic Platform. http://www.prgaprogram.org/modules/DownloadsPlus/uploads/PRGA_Publications/General/Flyer_-_New_Strategy-s.pdf

Cleaver, F., (2000) 'Analysing gender roles in community natural resource management: negotiation, lifecourses and social inclusion'. IDS Bulletin 31(2). Available at: www.ids.ac.uk.

CTA, (2002). Gender and agriculture in the information society. A special report. 98 p.

Dahl-Østergaard, T., Unsworth.S., Robinson.R, Ingrid Jensen, R. (2005). 'Lessons learned on the use of Power and Drivers of Change Analyses in development cooperation'. Review commissioned by the OECD DAC Network on Governance. Govnet. Final report

Derbyshire, H. (2002) 'Gender Manual: A practical guide for Development Policy Makers and Practitioners'. DFID. Available at: www.dfid.gov.uk.

DFID (2007) 'Gender Equality Action Plan 2007-2009 Making faster progress to gender equality' DFID practice paper Briefing. Available at: www.dfid.gov.uk

DFID (2005) 'Reducing poverty by tackling social exclusion: A briefing paper'. DFID, London.

Earl, Sarah, Fred Carden, and Terry Smutylo, 2001, OUTCOME MAPPING Building Learning and Reflection into Development Programs IDRC. 120 pp.

Engel, P., Keijzer, N., and Ørnemark, C. (2007) 'Responding to change: Learning to adapt in development cooperation'

FAO. (1997a) 'Gender and participation in agricultural development planning: Key issues

from ten case studies'. Women in Development Service, Rome.

FAO. (1997b) 'Gender and participation in agricultural development planning: Lessons from Senegal. Women in Development Service, Dakar.

FARA. (2006) 'Agricultural research delivery in Africa: An assessment of the requirements for efficient, effective and productive national agricultural research systems in Africa'. Main report and strategic recommendations.

Feldstein, H.S., and Jiggins, J. (1994) Tools for the Field: Methodologies handbook for gender analysis in agriculture. West Hartford, Conn: Kumarian Press.

Goldey, Patricia, Shelley Le Breton, Adrienne Martin and Rachel Marcus (1997), Approaches to Address Gender Specific needs in relation to access to technological change, Agricultural Systems, Vol 55 no2 pp 155–172.

Jones, N. (2007) 'Gender fatigue: What can we do to overcome it?' ODI weblog, Wednesday March 07, 2007. Accessed at: http://blogs.odi.org.uk/blogs/main/archive/2007/03/07/1760.aspx

Kabeer, N. 1992 Triple roles, gender roles, social relations: the political sub text of gender training IDA discussion paper 313. IDS Brighton.

Kabeer, N. (undated) 'Social exclusion: concepts, findings and implications for the MDGs'. Available at: www.ids.ac.uk

Lang, J. and Smith, S (date) 'Evolving the gender agenda: the responsibilities and challenges for development organisations' in Chant, S., and Guttman, M. (date) 'Gender Equality and Men'.

Meadows, Kate and Alistair Sutherland, (2000) Addressing gender in renewable natural resources knowledge strategies. Socioeconomic methodologies for Natural Resources Research Best Practice Guidelines. Chatham UK Natural Resources Institute. www.dfid.gov.uk/pub/files/BPG07.pdf

Moser, C., M'Chaju-Liwewe, O., Moser, Annalise, M., Ngwira, N. (2004) 'DFID Malawi Gender Audit: Evaporated, invisibilized or resisted?' DFID, UK.

Nelson, V., Meadows, K., Cannon, T., Morton, J. and Martin, A. (2002) Uncertain predictions, invisible impacts, and the need to mainstream gender in climate change adaptations", *Gender and Development*, **10**, 51–59 (also appearing in R Masika (ed.) *Gender, Development and Climate Change*, Oxfam (2002).

Orock, Rogers Tabe Egbe 2007, Gender equality – whose agenda? Observations from Cameroon, *Development in Practice*, Volume 17, Number 1, February 2007

Samuels, F., Drinkwater, M., McEwan, M (2006) 'Understanding HIV/AIDS and livelihoods: the contribution of longitudinal data and cluster analysis'. ODI briefing paper 8, Overseas Development Institute, UK.

Williams, S. (2004) 'The Oxfam Gender Training Manual'. An Oxfam Publication.

World Bank (2005) 'Gender, Conflict and Development'. Gender and Development Briefing Notes, Washington D.C.

World Bank. (2006) 'Enhancing agricultural innovation: How to go beyond the strengthening of research systems', WB, Washington. Available at: www.worldbank.org/rural.

UNDP. (2006) 'Taking gender equality seriously: Making progress, meeting new challenges', Gender Unit, UNDP, New York. Available at: www.undp.org/gender/

UNDP BCPR 2001 Gender approaches in conflict and post situations. UNDP BCPR www.undp.org/women/docs/gendermanualfinalBCPR.pdf

UNRISD (2005) 'Gender equality: Striving for Justice in an Unequal World'.

5
Agricultural Innovation Systems

Barry Pound [1] ***and George Essegbey*** [2]

Introduction

This briefing paper sets out the general concepts and principles of the Agricultural Innovation Systems approach, and its application to agricultural research and development, particularly in sub-Saharan Africa. It is not meant to be a comprehensive treatment of the topic, and suggestions for further reading are given at the end of the paper. It is intended for those interested in applying new approaches to research with farmers, NGOs and the private sector that lead to developmental outcomes.

Key issues: why is the innovations systems approach important and necessary?

Conventional approaches to agricultural development have tended to regard innovation as the product of research, and have viewed its dissemination as a largely linear process from researchers to extension staff and then to farmers. Quite often the research community is enclosed with only minimal opportunities for farmers and other stakeholders to make inputs to the research. The conventional approach typifies a paradigm of the scientist having a monopoly of knowledge in the research context. The impact of this type of research on rural people's livelihoods in sub-Saharan Africa has remained limited, particularly in relation to other continents (FARA, 2006), and an alternative approach is needed.

The rapidly changing context for agricultural development in SSA offers new challenges (IAC, 2004) that require the re-orientation of research to approaches that emphasise development outcomes, not academic ones. Some of the changes that particularly affect Africa are:

- The globalization of agricultural production and trade.
- Agricultural development is increasingly being driven by markets.
- The private sector is driving innovation, and also increasingly the generation, diffusion and application of knowledge, information and technology.
- Information and communication technology provides new opportunities.
- Biotechnology is making impact on agricultural production and processing systems.
- National development strategies increasingly emphasise support to the commercialisation of agriculture (e.g. the Ugandan "Plan for the Modernisation of Agriculture" and the Horticultural

1. Natural Resources Institute, Chatham, Kent ME4 4TB, UK; b.pound@gre.ac.uk
2. Science and Technology Research Institute, Council for Scientific and Industrial Research, Ghana; goesseg-bey@hotmail.com

Exports Industry Initiative of Ghana) and the increasing role of markets and the private sector in agricultural development.

- Environmental changes coming with climate change, degradation of ecosystems, genetic erosion, water shortages, social conflicts and upheavals pose new challenges in agricultural development.

The rapid environmental, economic and social changes occurring at global, national and local levels require a research and development approach that is able to support adaptation to those changes, while the complex, risk-prone and diverse nature of rural areas of sub-Saharan African requires a flexible, de-centralised type of research that builds on the involvement of farmers and other actors in developing and disseminating technologies and processes. Donors and programmes are increasingly turning to agricultural innovation approaches to provide that adaptability and the required developmental outcomes.

The transformational nature of technological innovation involves a shift in traditional relationships in society *(Juma and Yee-Cheong, 2005)*

Diversity requires locally-specific technologies and practices (*Waters-Bayer et al, 2006)*

The evolution of the agricultural innovation systems approach

Since the 1970s, alternatives to top-down, linear approaches to research and extension have been evolving. They include farming systems approaches, and a host of participatory approaches, from Participatory Rural Appraisal, Participatory Technology Development, Participatory Learning and Action, Action Research, Sustainable Livelihoods and farmer empowerment approaches. Each one of these stresses different aspects or different stakeholders in the innovation and utilisation continuum. During the same period there have been major shifts towards the decentralisation of extension, the liberalisation of input supply and the empowerment of farmers to demand services relevant to their needs. The innovation systems approach brings these different components and actors together by emphasising the linkages between actors, covering the spectrum from producers through processing and marketing to consumers (Triomphe et al, 2007).

The Agricultural Innovation Systems approach arose from innovation approaches in commerce (Arnold and Bell, 2001). The World Bank looked at its applicability to the agricultural sector of developing countries in 2004 (World Bank, 2007), and again in March 2007. A major conference on Integrated Agricultural Research for Development (IAR4D) in Kampala (www.innovationafrica.net)[3] also explored the characteristics of innovation systems and how these are applied to the identification and use of innovation by farmers and other researchers.

The approach is still evolving, and there is no blue-print for how to apply it. Rather it is a set of principles and best practices that together add up to a way of conducting research for development.

Definitions

Two definitions for innovation systems are given in Box 1. The applied nature of the approach is clear in these definitions. It places innovation at the centre rather than technology or research itself. It is an evolving concept, which needs flexibility in its application to different situations.

3. Innovation Africa Symposium, Kampala, 20–23 November 2006.

Box 1. Definitions

An **innovation system** can be defined as a network of organizations, enterprises, and individuals focused on bringing new products, new processes, and new forms of organization into economic use, together with the institutions and policies that affect their behaviour and performance.

Source: World Bank, 2007

A simpler definition of an **innovation system** is "a dynamic, multi-stakeholder partnership working together to develop and use technologies and processes to improve livelihoods".

An **innovation** is defined here as the application of technical or organisational knowledge to a new situation.

Principles and characteristics of innovation systems

The main principles and characteristics are provided below, and summarised in Table One.

1. The most striking characteristic of the innovation systems approach is its emphasis on bringing **multi-stakeholder partnerships** together to address a need or opportunity. Interaction between stakeholders is essential in order to learn from each other and negotiate the terms of the partnership. Thus the concept embraces not only the science suppliers (traditionally researchers in government stations and Universities) but the totality of actors involved in production and marketing. Stakeholders that can form part of an innovation partnership include: farmers (of different types); market traders; processors; exporters; researchers; extension staff; input suppliers and others. The mix of stakeholders depends on the problem or opportunity to be addressed, and the composition of the partnership changes over time as the situation changes.
2. Forming, maintaining and managing partnerships require **facilitation/coordination skills** and resources. Trust is an essential ingredient of success, and any partnership has the potential for asymmetry (power, voice, benefit…) and conflict. Local institutions may need empowerment through building their capacity and the development of links to input supplies, markets and technical assistance.
3. A major difference with conventional research is that the Innovation Systems approach recognises that **innovation can arise anywhere** (Box 2). It is not the preserve of formal research organisations. Farmers, CBOs, NGOs and private enterprises can be the source of the innovation, and in many cases can develop the innovation independently of formal government structures (see the Case Studies on the development of the "gari" processing industry in Nigeria and the flower industry in Kenya). In other cases, innovation is stimulated and coordinated by government initiatives that bring the relevant stakeholders together and support them through the innovation process (see the Case Study on cassava processing in Ghana). In other situations the innovation process can be coordinated by an NGO or extension programme that provides capacity building and empowerment for farmer groups, and links them to local government, research and private agencies that can support production and marketing (see the Case Study from Tanzania).
4. Research is important, but not always central – and one needs to consider other **bottlenecks to the use of innovations**. The livelihoods framework is useful in analysing where these constraints

Box 2. Local innovation

Innovation is a social process that can be enhanced by creating possibilities for actors to interact.

Normally, the term "innovation" at farmers' level has been used to refer to farmers' adoption of new technologies coming from outside, rather than the new technologies, management practices and institutions that farmers and their communities have developed themselves. Many local innovations are not of a technical nature but rather are socio-economic and institutional innovations such as new ways of gaining access to resources or new ways of organizing marketing activities.

Waters-Bayer et al, 2006 (also see www.prolinnova.net*)*

might be through consideration of the social, human, financial, natural and physical assets available to communities, and the legal, institutional and political influences on them.

5. The innovations systems approach is related to some previous approaches, such as the commodity systems approach and the analysis of value chains, both of which, like the agricultural innovation systems approach, consider the whole chain from **producer through to consumer** (see the Case study from Uganda on potato production and marketing).
6. It also has a lot in common with **IAR4D** (Integrated Agricultural Research for Development). The term IAR4D was first used in 2003 by the Forum for Agricultural Research in Africa (FARA, 2004), and follows similar principles and objectives as approaches such as ICRA's Agricultural Research for Development (ARD) approach, DFID's Sustainable Livelihoods approach, and the Integrated Natural Resources Management (INRM) approach developed by the CGIAR.
7. The approach requires that organizations must **act in new ways** (flexibly, in partnership…) and with **new skills** (facilitation, conflict management, participation…) – see Table 2.
8. The **public sector** has a central role to play through developing legal and regulatory frameworks and providing an enabling policy, trade, infrastructural and support environment that encourages innovation.
9. The innovations systems approach is **not inherently pro-poor**. As with other approaches, real impact on poverty and gender imbalances will only result if special attention is given meeting those challenges.
10. A change in mindset of some researchers can be brought about through **competitive grant research** funds that insist that the applicants work together with private and civil society elements to test new technology in the real world of markets and inputs.

Table 1. Defining features of agricultural innovation systems.

Defining feature	Agricultural Innovation System
Purpose	Strengthening the capacity to innovate throughout the agricultural production and marketing system.
Actors	Potentially all actors in the public and private sectors involved in the creation, diffusion, adaptation and use of all types of knowledge relevant to agricultural production and marketing.
Outcome	Combinations of technical and institutional innovations throughout the production, marketing, policy research and enterprise domains.
Organising principle	New uses of knowledge for social and economic change.
Mechanism for innovation	Interactive learning
Degree of market integration	High
Role of policy	Integrated component of the approach, providing an enabling environment.
Nature of capacity strengthening	Strengthening interaction between actors; institutional development and change to support interaction, learning and innovation.

Source: World Bank, 2006

Capacity development needs for Agricultural Innovation Systems

While there is no consensus on the precise nature of innovation capacity, its broad features include a combination of: a) scientific, entrepreneurial, managerial and other skills and knowledge, b) partnerships, alliances and networks linking different sources of knowledge and different areas of social, economic and policy activity, c) routines, organisational culture and traditional practices that pattern the propensity to innovate, d) clusters of supportive policies and other incentives, governance structures and the nature of the policy process, and e) the ability to continuously learn and use knowledge more effectively (http://www.innovationstudies.org).

Implications for national researcher and advisory services include the need to re-skill in the areas of facilitation, communication, entrepreneurship, conflict management, value chain analysis and market research. Reward systems will also need to change to reflect the changed emphasis from academic papers to developmental outcomes. In addition it also implies much closer working between research and extension on the one hand, and government, civil society and private sectors on the other. The

Box 3. Capacity Development recommendations from World Bank, 2007

- Research capacity should be developed in such a way that from the beginning it nurtures interactions between research, private and civil society organisations
- An effective IAS requires a cadre of professionals with a new skill set and mind set (markets, agribusiness, intellectual property law, rural institutions, rural microfinance, facilitation, system analysis, conflict management…)

stakeholders need behavioural change and a re-configuration of their roles and relationships to ensure a more proactive and interactive engagement for innovation. These sentiments are echoed by World Bank in their book on Enhancing Agricultural Innovation (World Bank, 2007—see Box 3), and in calls for the reform of University curricula to include innovation systems principles and case studies.

Risks and benefits of adopting an innovation systems approach

There is a risk that organisations will adopt this approach ***in favour*** of previous approaches, such as farming systems, livelihoods, agricultural knowledge systems and participatory approaches. This would be a shame as each of those approaches is still valid, and their concepts should still be brought to bear when considering rural development situations. Rather the innovation systems approach should be ***complementary*** to these other, still valid, approaches.

Table 2. Human capacity needs for implementing Agricultural Innovation Systems approaches, and some mechanisms for developing that capacity.

Human capacity needs for the implementation of innovation systems	Some mechanisms for enhancing human resource capacity
• Management of dynamic partnerships • Governance of partnerships • Facilitation • Negotiation and conflict management • Communication • Sourcing, managing, interpretation and "packaging" of information • Entrepreneurship and business skills • Systems thinking • Value chain analysis • Market evaluation • Research methods, including participatory and impact-oriented methods (action research) • Research leadership • M&E, impact assessment and learning • Mobilization and local organisation development • Rural finance • Demand identification/articulation and priority setting **+ technical expertise and curriculum reform** *Adapted from Kibwika et al, 2007*	• Partnerships (e.g. through competitive grant schemes) • Exchanges (N-S, S-S) attachments and internships • Undergraduate and post-graduate degree studies • Vocational training • On-the-job learning • Short courses • Distance learning (e.g. professional PhDs) • Conferences and workshops • Reflection and learning events • Job rotation • Mentoring and coaching • Joint activities (e.g. joint monitoring visits, PRAs etc) • Curriculum reform and the adoption of course delivery methods that stimulate problem solving abilities *Adapted from Pound and Adolph, 2005*

A further risk is that the need for technical specialists will be disregarded in favour of those with soft skills. Again that would be a mistake, as technical specialists are still needed to investigate and provide understanding of complex technical aspects of innovations.

In contrast, the benefits include greater efficiency due to the "joined up" thinking in the production to consumption cycle as people work together to address opportunities, and the emergence of creative solutions to problems facing rural communities from a range of sources.

Implications for Agricultural Development in Africa

Already major donors such as the World Bank and DFID are advocating the adoption of the approach, and sub-regional organisations such as ASARECA are incorporating Integrated Agricultural Research for Development as the underlying research paradigm for their programmes. In addition there will be a reform of University curricula in sub-Saharan Africa to include Innovation Systems approaches, including a shift towards more client-oriented, vocational courses.

The implications of the innovation systems approach for donor support are clear. Formulation of intervention programmes should be done in the specific context of the respective countries and localities. There are no one-fit-all solutions to the developmental problems in Africa.

The intervention programmes must emphasise strong linkages among the critical stakeholders and detail the respective roles and expected outcomes. The investments in such programmes must not only be in producing the tangible outputs such as improved planting materials, technologies and products, but also the intangibles such as enhanced skills, knowledge and mutual trust.

References and further reading

Arnold, E and Bell, M 2001. Some new ideas about research for development. In: *Partnerships at the leading edge: a Danish vision for knowledge, research and development.* Report of the Commission on development-related research funded by Danida, 279–319. Copenhagen: Ministry of Foreign Affairs/Danida.

ASARECA IAR4D CB team, 2007. Review Paper on Integrated Agricultural Research for Development: Towards enhancing IAR4D Capacity at ASARECA. The Hague: KIT

Ekwe KC and Ike, N. 2006. *Sustaining Gari Marketing Enterprise for Rural Livelihood: Farmers Indigenous Innovations in South Eastern Nigeria.*. Paper presented at the Innovation Africa Symposium, Kampala, 21–23 Nov 2006. Umudike, Nigeria: National Root Crops Institute

FARA, 2006. Agricultural Research Delivery in Africa: An assessment of the requirements for efficient, effective and productive National Agricultural Research Systems in Africa, March, 2006. Accra: FARA

Hall AJ (Ed), 2004. Innovations in innovation. ICRISAT, Patancheru, India

IAC, 2004. Realizing the Promise and Potential of African Agriculture. InterAcademy Council. (www.interacademycouncil.net).

Juma, Calestous and Lee Yee-Cheong (2005) *Innovation: applying knowledge in development*, UN Millennium Project: Earthscan, London.

Kaaria S, Abenakyo A, Alum W, Asiimwe F, Best R, Barigye J, Chisike C, Delve R, Gracious D, Kahiu I, Kankwatsa P, Kaganzi E, Muzira R, Nalukwago G, Njuki, J,

Sanginga P and Sangole N. 2006. *Enabling Rural Innovation: Empowering Farmers to take advantage of market opportunities and improve livelihoods.* Paper presented at the Innovation Africa Symposium, Kampala, 21–23 Nov 2006. CIAT.

Kibwika P, Mukiibi J and Okori P. 2007. *Draft of the Preliminary Findings of the Capacity Needs Assessment in the ASARECA Region.* Report to SCARDA

Ndulu, Benno J. (2007) *Challenges of African Growth – Opportunities, Constraints and Strategic Directions*, The World Bank, Washington D.C.

NEPAD (2005) *Science, Technology and Innovation for Africa's Development – A Plan for Collective Action*, NEPAD Secretariat, South Africa.

Ogbu, Osita (2006) "Knowledge dependence and its discontents: the demand for policy research in Africa in the era of globalization", Louk Box and Rutger Engelhard (eds.) *Science and Technology Policy for Development Dialogues at the Interface*, Anthem Press, London UK.

Pound, B and Adolph, B 2005. *Developing the capacity of research systems in developing countries: lessons learnt and guidelines for future initiatives.* Paper commissioned by DFID's Central Research Department. Chatham: Natural Resources Institute

Pound B, K Massawe and F Fazluddin. 2007. *Innovation partnerships for effective adaptive research and technology uptake.* Paper presented at the workshop "Enhancing agricultural innovation" organized by the World Bank and held in Washington, March 22nd–23rd 2007. Chatham: NRI

Pound, B. 2007. *Widening the Definition of Capacity to Respond to the Innovations Systems Approach.* Paper presented at the RUFORUM Biennial Conference on "Building Scientific and Technical Capacity through Graduate Training and Agricultural Research in African Universities", held at the Sun 'N' Sand Hotel, Malawi: 23–27 April 2007. Chatham: NRI

Triomphe B, Hocde H and Faure G. 2007. *Nurturing innovation processes by building multiple stakeholder partnerships: opportunities and challenges for research.* Paper presented at the workshop "Enhancing agricultural innovation" organized by the World Bank and held in Washington, March 22nd–23rd 2007. Montpellier: CIRAD

van Huis, A (Editor) (2005) *Convergence of Sciences: Creating Innovation Systems with African Farmers* – Proceedings of the 1st International Workshop of the Convergence of Sciences (CoS) Project held at the Elmina Beach Resort Hotel, Elmina, Ghana: University of Ghana, Wageningen University, CTA, The Netherlands.

Waters-Bayer A, van Veldhuizen L, Wongtschowski M and Wettasinha C. 2006. *Recognizing and enhancing local innovation processes.* Paper presented at the Innovation Africa Symposium, Kampala, 21–23 Nov 2006. PROLINNOVA.

World Bank, 2007. *Enhancing Agricultural Innovation: how to go beyond the strengthening of research systems*. Washington: World Bank

www.prolinnova.net www.innovationafrica.net

Case Studies

Tanzania: sustaining farmer-research groups (adapted from Pound et al, 2007)

In this case study local farmer research groups are at the centre of the innovation system, and are supported in their development and use of innovation by NGO, government, private and international partners.

In Tanzania, an NGO (FARM-Africa), working closely with District and Village government, has established a number of Farmer Research Groups to stimulate local innovation for improved crop productivity and natural resource management. The Groups were successful due to the linkages (facilitated by FARM-Africa) with national and international research organizations, government seed certification and training centres and private input suppliers.

However, the initiative is of particular interest for the ways that the Farmer Research Groups ensured their long-term access to these linkages, and a sustainable capacity to continue to investigate novel technologies of local relevance.

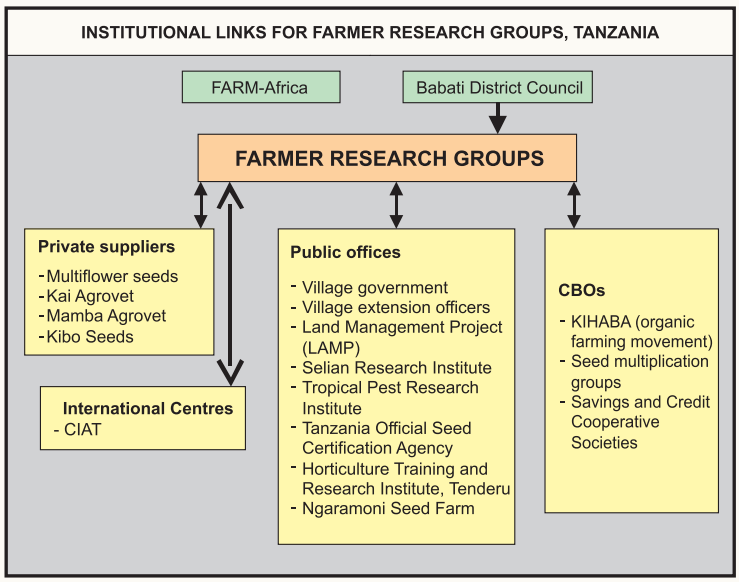
This they achieved through:

a) The establishment of **community-based seed multiplication schemes**, which provide income that can then be used to finance further experiments.

b) Community agricultural input supply shops, established by Farmer Research Groups in response to the need for local access to the technologies identified.

c) Savings and Credit Cooperative Societies (SACCOS), which enable members to accumulate capital for the purchase of inputs.

The production increases have resulted in farmers being able to store grain at harvest and either sell it at a better price later on, or use it to reduce food insecurity. They have become financially independent of external donor and government agencies.



Ghana: Transformation of the pineapple industry
(adapted from Essegbey, 2007)

This case study shows that where there is market potential, a commodity can be transformed from a minor food crop to a major export earner. In this case the private sector played the leading role in the transformation process. The government's role was important as it facilitated the process through the Ghana Export Promotion Council and other initiatives.

In the 1970s and 1980s, pineapple was a lesser food crop, with national average production collapsing to only 6,000 tonnes per year between 1977 and 1982. More recently, Ghana's policy of emphasising non-traditional export under the Ghana Export Promotion Council has contributed to a transformation of the industry, which now holds about 12% of the total European import market (export earnings about US$24 million in 2006).

The critical actors in the innovation process have been:

- Large scale exporters
- Smallholder and out-growers
- Government agencies (Ministry of Food and Agriculture, and the Ghana Export Promotion Council)
- Research institutes (CSIR)
- Donor agencies (World Bank, USAID)
- Local banks, transporters and shippers

Kenya: Private-led innovation in the flower industry
(adapted from Bolo, 2007)

This case shows how the private sector, backed by international expertise and finance, and supported by favourable policy, climatic and infrastructural environments, can develop a successful industry.

The floriculture industry contributes about US$200 million per year to the Kenyan economy. The industry is characterised by a robust private sector, comprising mostly large-scale growers. Small-scale growers contribute only 3% of exports.

Despite mounting competition from other countries, Kenya's floriculture industry is expanding because of good natural resources, infrastructure, transport links and favourable government policies.

The key government policy shifts that have assisted innovation and commercial success have been:

- Removal of monopolistic trends
- Reduction of government involvement in commercial activities
- Encouragement of the private sector to take on government functions

The key actors have been:

- Large-scale grower/exporters with sister companies in Europe
- Research, development and training institutions (national and international)
- Trade, investment and promotion agencies
- Credit and finance institutions

- Input suppliers (mostly international companies)
- Quality control and regulation agencies

While the case presents a rosy picture, there are challenges. One is the weak state of the small growers, who are disadvantaged by lack of voice, technology and access to markets. A second is that the national research system is effectively sidelined, with most information coming from international centres (e.g., Holland).

Ghana: Government-led cassava initiatives (adapted from Essegby, 2007)

Two government–led initiatives have attempted to stimulate the huge potential for cassava processing in Ghana, one being more successful than the other.

Cassava is a major staple in West Africa, and grown in most agro-ecological zones of Ghana. Cassava can also be processed into gari and into starch, which is the raw material for other industrial products. The government sought to use Ghana's comparative advantage as a cassava producer to transform the cassava industry into a major earner of export revenue in industrial starch.

Whereas a Presidential Special Initiative to do this through Corporate Village Enterprises has failed to achieve this, a much smaller initial initiative, the "Sustainable Uptake of Cassava as an Industrial Commodity" is having much more success. This initiative revolves around the creation of market linkages to provide market access for small and medium sized enterprises, new product development, quality assurance and the management of supplier-buyer business relations.

The critical actors are:

- Scientific research institutes: National (Food Research Institute) and international (NRI)
- Policy Institutions (especially the Ministry of Food and Agriculture)
- Business promotion organisations ((especially the National Board of Small-scale Industries)
- Producer/processing organisations

A major lesson learned was that market access doesn't happen by itself, but needs strategic support and deliberate cultivation. Trust also has to be built between suppliers and purchasers. The case study calls not only for strengthened links between research and farmers, but also between research and industrialists. Industrialists should challenge scientists to find solutions to the problems they encounter.

Nigeria: Spontaneous development of Gari processing

This case study directly contrasts with the Ghana cassava processing case by showing that strong and sustained market opportunity can stimulate a wide range of innovations at farmers, trader and processor levels without any coordinating input from government.

The south-eastern zone of Nigeria accounts for 53% of national cassava production. Processing cassava into gari for food and income is practiced by many Nigerians in rural areas. In order to harness the opportunities offered by the increasing market demand for gari, farmers devised several technical, social and institutional innovations.

Gari market began to emerge as middle men from urban centre besieged rural markets to bulk purchase gari from the farmers. Simultaneously, enterprising farm households discovered that higher

cash income can also be earned from same quantity of gari if they took it direct to urban markets thus circumventing the middlemen. Gari processors also began to spring up in urban centres, purchasing roots direct from farmers.

Several prevailing factors catalyzed the thriving of gari marketing:

1. The favourable natural environment
2. Wide socio-cultural acceptance of gari in local food systems
3. Income-generating potential of gari
4. Government stimulus of the market by inclusion of gari as one of the essential commodities in the strategic food reserve programme
5. Improved processing technology to reduce drudgery

The innovations are of four types

a. Technological innovations (e.g. improved varieties from research, fuel saving technologies, adding palm oil to improve colour, mechanisation of processing, reduction of the fermentation period, adjusting processing for specific market requirements)
b. Social innovations (establishment of cooperative societies, improving access to market, diversifying markets, emergence of private ancillary service providers)
c. Economic innovations (investment in equipment, partnerships to pool finances, use of informal local credit services)
d. Institutional innovations (contractual arrangements between parties, including gari in the strategic food reserve programme, government provision of N50 billion loan to farmers).

These have resulted in a more conscious, systematic and strategic use of naturally endowed resources and stimulus of rural and private sector entrepreneurial tendencies.

Challenges for research and development organisations include:

- Establishment of market information system for knowledge sharing and exchange among stakeholders in gari market enterprise.
- Assessing the impact of farmers' indigenous innovation in gari marketing on rural livelihoods in south eastern Nigeria.

Uganda: "Enabling Rural Innovation"—Nyabyumba United Farmers' Organization (adapted from Kaaria et al, 2006)

This case study shows how a farmers group first improved their production and then marketing to a fast food outlet in partnership with NGOs, research organisations and the private sector. The group followed the "Enabling rural innovation" approach which emphasises a "resource to consumption" conceptual framework and the creation of an entrepreneurial culture where farmers "produce what they can market, rather than trying to market what they produce".

The Nyabyumba farmers group of Kabale district, Uganda, was formed in 1998, with 40 members. The group, supported by an NGO Africare, focused on producing improved potatoes from clean seed provided by the National Agricultural Research Organization (NARO). In 2000, the Nyabyumba group formed a farmer field school (FFS) to improve their technical skills on potato production and increase yields. In 2003, equipped with the necessary skills for producing high quality and quantity of

potatoes, the group decided to increase their commercial sales and requested support from Africare, NARO, PRAPACE (Regional Potato and Sweet Potato Improvement Network in E. and C. Africa), and CIAT.

Through this consortium of partners, Nyabyumba Farmers'Group received training in identifying and analyzing markets opportunities and developing a viable business plan for the potato enterprise. From the market study the group identified "*Nandos*", a fast food restaurant based in Kampala and the local wholesale markets in Kampala. The group has set up a series of committees to manage, plan and execute their production and marketing process. To maintain a constant supply the farmers have set up a staggered planting system to ensure that there are up to 50 tons of potatoes are available each month.

To increase the competitiveness of production the group has conducted research supported by NARO to determine the most suitable nutrient levels of NPK fertilizer and time of de-haulming potato plants that produces big tuber size, with higher organic content, firm skin and higher yields as required by buyer. The farmers group has expanded to a membership of 120 members, 80 of whom are women. They have supplied 190 metric tonnes of potatoes to Nandos, bringing their income to USh 60,000,000 or approximately US$ 33,000.

Notes