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Enhancing innovation processes and partnerships

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Abstract

Rural innovation is "the process by which various stakeholders generate, and adopt novel ideas, approaches, technologies or ways of organizing, to improve on and off-farm activities, so that the rural sector becomes more competitive in a sustainable manner". Empowering farmers is indispensable to improving the relevance, effectiveness and efficiency of current research for development systems. Key components of innovation processes are summarized as: Farmer experimentation; strengthening human capital; strengthening social capital; Enhancing access to information; Linking local knowledge to scientific knowledge; strengthening partnerships; Scaling up innovation processes; and strengthening changes in formal sector institutions to support innovation processes. Participation between researchers, farmers, extensionists and other stakeholders is central to the concepts of innovation.

Key words: Innovation, participation, partnership, participatory research

Introduction

What are innovation processes?

CIAT's Rural Innovation Institute defines rural innovation as "the process by which various stakeholders generate, adapt or adopt novel ideas, approaches, technologies or ways of organizing, to improve on- and off-farm activities, so that the rural sector becomes more competitive in a sustainable manner" (CIAT, 2003). This process builds farmers' capacity to learn about knowledge intensive processes and biological and ecological complexities and can create a sustained, collective capacity for innovation focused on improving livelihoods and the management of natural resources. To support these processes, institutional changes are also needed in the management and funding of formal sector research and development to encourage this paradigm shift, to build new partnerships and to avoid business-as-usual in the formal sector. This enhanced capacity for innovation benefits rural people 's ability to demand and use science to develop technology for improving their livelihoods, and it spills over into and benefits rural people's initiatives for change in other sectors such as health, education, governance and social order

Enabling innovation requires a versatile approach to working with communities that centers on several related elements, which have emerged from experience and analysis. Innovation processes require farmer experimentation, social and human capital formation, access to information, leadership and entrepreneurship to develop new technologies, products and markets and ways of organizing, as well as policies and institutional arrangements which catalyze and enable innovativeness. The key components of innovation processes can be summarized as:

1. Farmer experimentation: The active involvement of end-users in research design and development enables researchers and stakeholders to understand local farming systems and the larger context within which they exist, to incorporate local knowledge into technology innovation, and to develop locally appropriate solutions. A hallmark of farmer participatory research (FPR) approaches is the link it establishes between the formal and local research systems (Ashby et al., 2000).
2. Strengthening human capital, which involves enhancing farmers' knowledge and understanding processes. There is growing evidence that building rural people's capacities to innovate is probably more important than just involving them in developing the technology. Enhancing farmers' technical skills and research capabilities, and involving them as decision-makers in the technology development, should result in interventions that are more responsive to their priorities, needs and constraints.
3. Social capital: Innovative collective action by rural communities with substantial social capital is an essential condition for enabling innovation. Various studies show that strengthening group working processes and enhancing social capital is an important asset that can provide a variety of supportive mechanisms for enhancing rural livelihoods. At the community level, strengthening the social capital of

rural communities and their organizational capacity is critical for horizontal and vertical linkages among communities, and between communities and rural service providers.

4. Enhancing access to information and linking local or indigenous knowledge to scientific knowledge are major resources in supporting innovation processes. A key issue is to understand how best rural innovation can be enhanced through supporting experimentation with effective combinations of local knowledge systems and formal scientific knowledge.

5. Strengthening partnerships and sharing roles and responsibilities across the research-for-development continuum is an important part of managing innovation processes. Building strategic partnerships allows us to decentralize control over the research agenda and permits a much broader set of stakeholders to become involved in research and the technology innovation process.

6. Scaling up innovation processes leads to "more quality benefits to more people over a wider geographic area more quickly, more equitably and more lastingly" (IIRR, 2000). Scaling up implies increasing the impact of an innovation or intervention to its logical or appropriate level, and also reaching larger numbers of people (Gonsalves, 2001). This definition also reflects the concern with quality of the impact in terms of sustainability and equity.

7. Strengthening changes in formal sector institutions to support innovation processes. It is important to integrate mechanisms that can influence policy making so that critical success factors for rural innovation are maximized, and bottlenecks overcome. This requires strategies that use information produced by research to influence policy and enhances key rural innovation processes and outcomes.

This synthesis paper provides an overview of papers submitted under the 'Enhancing Innovation Process and Partnership' theme. We organize our synthesis around each of the key elements identified as being fundamental to good practice for "enabling Innovation". We have summarized the papers accepted under each element with detailed lessons learned. The lessons and critical issues are then synthesized to develop conclusions, key implications for national research institutes such as NARO and a section on limitations and challenges.

What is participation?

There is strong evidence that involving farmers/end-users as decision-makers in the technology design and development process can lead to the development of appropriate technology and may increase the probability of adoption among the intended users. These participatory research and learning approaches are fast gaining recognition as a strategy for empowering poor farming families to articulate their priorities and to participate as decision-makers in the R&D processes. However, important questions that arise are: What is participation? Should all research be participatory? Is there good vs. bad participation? What is the optimum level of participation?

Conceptual framework

To understand the quality of participation that can be applied in research for development processes we apply a conceptual framework based on Johnson, et al. (2002) that links the typology of participation (Lilja and Ashby, 1999) to the different types of participatory approaches outlined by Biggs and Farrington (1991). Lilja and Ashby (2002) argue that the expected impacts of incorporating stakeholder participation in research are dependent on the stage at which stakeholders (especially farmers as end-users) are involved in the technology development process. They developed a typology of participation which defines the two decision-makers as "scientists" and "farmers." In their definition "farmers" is a generic term representing end-users and the term "scientists" is used to describe outside agencies, the extension system or formal R&D agencies. An important premise underlying the typology of participation is that differences in who makes a decision (between the "farmer" and "scientist") will result in different decisions being made and in different types of impact on the innovation process. Farmers can be involved in the technology development process in any of the three stages of innovation process (design, testing and diffusion). In each of these stages different decisions related to technology options are made. For example, in the design stage decisions on opportunities and problems, and prioritization of research options and potential solutions are made. In the testing stage, testing and comparing possible solutions is conducted. During this stage decisions are made about what type of experimentation and how different stakeholders will be involved. The final stage is diffusion, which involves dissemination of results and building the capacity for implementation of recommended solutions among future users. This stage leads to full or partial adoption (if necessary after further adaptation by users), or to no adoption.

In order to understand the balance of power in a participatory process, a critical question is to find out who makes the decisions at each stage of the technology development process between "scientists" and "farmers." Biggs and Farrington (1991) define five different types of participatory approaches depending on who makes the decisions at each stage in the innovation process. The different types are detailed below:

1 Conventional (non-participatory): Scientists make the decisions alone without organized communication with farmers.

2 Consultative (functional participation): Scientists make the decisions alone, but with organized communication with farmers. Scientists know about farmers' opinions, preferences and priorities through organized one-way communication with them. Scientists may or may not let this information affect their decision.

3 Collaborative (empowering participation): The decision is shared between farmers and scientists, and involves organized communication among them. Scientists and farmers know about one another's opinions, preferences and priorities through organized two-way communication.

The decisions are made jointly; neither scientists nor farmers make them on their own. No party has a right to revoke the shared decision.

4 Collegial (empowering participation): Farmers make the decisions collectively in a group process or through individual farmers who are involved in organized communication with scientists. Farmers know about scientists' opinions, preferences, proposals and priorities through organized two-way communication. Farmers may or may not let this information affect their decision.

5 Farmer experimentation: Farmers make the decisions individually or in a group without organized communication with scientists.

Why does it matter who makes the decisions?

Lilja and Ashby (2002) argue that farmer participation at different stages of innovation can have different impact on the technology or innovation design, as well as, on the potential adoption or acceptance among the intended users. If scientists make all the key decisions without farmer participation in the early stage of an innovation process, farmers cannot influence many features of the innovation that are of most interest to them. Their participation in planning and setting goals will help focus research more directly towards farmers' priority needs, thus reducing time to conclusion, improving the efficiency of the process and reducing the likelihood that the technologies being developed are ultimately unacceptable to farmers. There is evidence (Douthwaite, et al., 2002; Johnson, et al., 2002) that farmer participation at different design stages may steer research into completely unanticipated directions or may identify different priorities different beneficiaries.

We maintain that farmer participation, together with a broadening of research for development partnerships, can harness additional and much-needed expertise and resources to solving practical problems and reaching a greater number of beneficiaries, while eventually allowing the formal research sector to reallocate resources towards strategic research that addresses the problems that need to be faced in the future.

Farmer participatory research approaches

Farmer participatory research (FPR) draws heavily from earlier models developed to work with rural communities, such as the farming systems research and extension (FSR&E) of the 1970's. These approaches to farmer innovation and agricultural research received widespread recognition with the publishing of the "Farmer First" (Chambers, 1989) and later "Beyond Farmer First" (Chambers, 1994). The term 'farmer participatory research' is used to define a diverse group of research-related approaches where farmers and rural communities are involved at different stages in the research process (Okali et al., 1994; Selener, 1997). In practice, the term FPR is used interchangeably with other terms such as participatory technology development (PTD) or farmer experimentation (FE) approaches. It is now widely accepted that farmer participatory research may have wider applications for improving rural livelihoods in complex and diverse low potential areas where a "systems" approach is critical for the analysis and improvement of the production systems (Chambers and Jiggins, 1986; Okali et al., 1994).

This section reviews different participatory approaches that have been used to involve farmers or end-users in the technology design and development process. The approaches are divided into: (1) Approaches for priority setting; (2) Approaches for farmer experimentation; (3) Approaches to extension; (4) Successful examples of impacts.

Approaches and methods being applied to meet various objectives

Approaches for priority setting

The manual of Tripp and Woolley (1989) has long been a standard reference manual for priority setting in on-farm research; following a clearly outlined farming systems approach, this methodology has been widely adopted in the intervening years. The planning stages are described as: identifying problems that limit the productivity of a farming system; ranking the problems; identifying their causes and analyzing interactions among problems and causes; identifying possible solutions; and evaluating those solutions. ISNAR long advised an analogous approach for setting priorities at the broader level of national or zonal agricultural research, in which local concerns should be harmonized with national policies and objectives; many NARIs have followed this, if often in a less exhaustive and data-demanding manner.

A Ugandan example is given by Grimaud et al. (2004), who identified research activities for dairy sector development in Mbarara. These authors describe a participatory rural appraisal (PRA) by researchers of the main dairy farming systems in the study area and a rapid questionnaire survey of a random sample of farms. From these results, researchers deduced a farm classification (typology) based on three "poles": the farmer (status and activities), the herd (composition and use) and the environmental conditions (feeding system, housing conditions, moving). Researchers assessed needs for each production system and proposed interventions that would meet the requirements of producers. Research priorities included basic biological relationships (e.g. the importance of genetic variation in growth rates of Ankole calves) and understanding the system (e.g. possible health implications for people). Although Grimaud et al. comment that the identification of interventions can be made by local experts based on a participatory interview of farmers, the farmers' opinions do not come through as an essential element in this approach. Thus the reliance upon researcher measurements required an 18-month period of farm visits before constraints and interventions could be identified.

Variation among farms and farmers almost always needs to be faced. As commented by Mburu and Macharia (2004),

"Diversity exists in soil management because different soil types often require different management regimes. Even when farmers are in the same area and managing the same type of soils they may do so differently, because they are faced with different social and economic conditions." In this Kenyan case of re-orienting the research priorities of a regional research center, the research team was constituted to be interdisciplinary — bringing together specializations in farm management, socio-economics, animal science, agronomy and crop physiology, land-use and soil fertility – so as to take a holistic approach to farming systems. The team also emphasized participation of stakeholders farmers, extension staff, researchers and local administration personnel.

A critical improvement on the usual practice was the holding of farmers' meetings at which PRA results were used with soil maps, farmer-drawn matrices and group discussions to "jog the memories" of both men and women. Identifying farm types, using farm observations, semi-structured interviews, farm sketches and a household survey facilitated the identification and ranking of soil management problems, causes and opportunities for each farm type. Information was then verified by transect walks along a route selected by farmers, government extension staff and the research team (allowing observations on soils, land use and management practices), supported by a formal interview with a selected number of farmers. An unusual strength of their approach was the use of a farmer-led evaluation of the process itself.

In this case, farmers themselves identified the set of criteria used to determine whether soil and water management was good or bad — recognizing that soil and water management level is determined by access to and ownership of resources. In small groups guided by a facilitator – another key ingredient — farmers in each management category identified the main problems using problem-causal trees and ranked the corresponding opportunities.

Mburu and Macharia (2004) summarize well: "Learning and sharing with the farmers in a participatory manner helped to converge local technical knowledge with the outsiders' knowledge. Making sense of the data through pair-wise ranking and wealth ranking was important in identification, analysis and prioritization of constraints and opportunities. Screening of prioritized options on the basis of economic competitiveness, their contribution to social equity and appropriateness to environment conservation led to identification of relevant research issues." Gender analysis took into account the different perspectives of male and female farmers: for example, acquiring cash and labor for soil fertility interventions would be tackled by men through farm produce sales and adoption of implements respectively, and by women through group activities.

Soam (2004) describes an analytic hierarchy process (AHP) that employs multiple criteria based on trade offs and the relative importance of criteria and research alternatives as perceived by various stakeholders. Farmers screened alternative objectives, criteria were identified jointly, but both objectives and criteria were evaluated by the scientists on the grounds that they have to carry research under their constraints, opportunities and policies. The strongest element of the AHP method seemed to be in stimulating group discussion to incorporate farmers' knowledge, resources and expectations. Another variant is to apply congruence analysis to allocate research resources in proportion to the relative value of a production system or product.

Lessons learnt

In drawing out best practices, we need to remember that the term "PRA" is overused and has come to mean little – because the devil is in the detail of the methodology as it is applied. Of the three priority-setting papers reviewed, only Soams draws specific attention to the risk of suppression of farmers' opinion by the scientists' opinion. Full participation of farmers in setting research priorities is even more important as system complexity increases – for example, time and costs in setting initial priorities might have been reduced considerably in the Ugandan dairy case.

Instead of a general blanket technological recommendation, even if honed to each farm type, a basket of options should normally be the aim of initial priority setting, with some interventions ready for extension and further confidence-building with farmers and others emerging as items in the new research agenda. Pair-wise comparisons are useful both in ensuring rigor and in encouraging shared decision-making with communities. The criticism that the method is time-consuming and tiresome can be reduced by short-listing the criteria, and the researchable options, at the farmers' level, followed by a two-stage process of design and evaluation.

A good practice would be to use early and highly participatory setting of some priorities and thereby allow R&D activities to proceed quickly, with researchers and farmers continuing to interact and define or refine other priorities over the subsequent couple of years. Getting more quickly to the stage of testing a few interventions of interest to farmers is particularly important because their expectations of a new and more productive relationship with researchers are likely to be raised by the priority setting activities.

Farmer experimentation

The active involvement of end-users in the design and development of technologies enables researchers and stakeholders to examine and understand the local farming systems and the larger context within which they exist, to incorporate local knowledge into technology innovation, and to develop locally appropriate solutions. The examples that for follow show how various projects have endeavored to involve end-users in the technology design and development process.

Sanginga et al. (2004) outline an integrated approach for demand-driven and market-orientated agricultural research

and rural agro-enterprise development. Termed Enabling Rural Innovation (ERI), this approach offers a practical framework to link farmer participatory research and market research in a way that empowers farmers to better manage their resources and offers them prospects of an upward spiral out of poverty. ERI uses participatory processes to build the capacities of farmers' groups and rural communities in marginal areas to identify and evaluate their market opportunities, develop profitable agroenterprises, intensify production through experimentation, while sustaining the resource base upon which their livelihoods depend. The approach emphasizes integrating scientific expertise with farmer knowledge, and strengthening social organization and entrepreneurial organizations through effective partnership between research, development and rural communities. As part of the strengthening of human and social capital, ERI encompasses effective and proactive strategies for promoting gender and equity into accessing market opportunities and improved technologies, and in the distribution of additional incomes and other benefits.

A unique aspect of ERI is that the approach links the management community assets (natural, human, social, physical and financial) to production, post-harvest handling and marketing in a resource-to-consumption (R-to-C) framework. The R-to-C system (for more details see Kaaria and Ashby, 2001) expands conventional production-to-consumption or commodity chain approaches by explicitly basing decisions on what productive activities to engage in and the combination of community assets that will best meet the dual needs of household food production and income generation.

Brummett et al. (2004) provide a realistic alternative to traditional technology development and transfer that has been utilized by the WorldFish Center to integrate pond fish culture into farming systems in Malawi and Cameroon. This aims to create joint learning exercises whereby research is driven by real problems, extension delivers clear messages and farmers get the technology they need. Farmers, extension agents and researchers get together at the end of the season to present, compare and discuss findings, in preparation for another cycle of research. The approach, called the Farmer Scientist Research Partnership (for details see Brummett & Noble 1995), involves: (1) The Research-Extension Team (RET) model using a research scientist to guide joint learning exercises (participatory research projects) undertaken by farmers and extension agents working together. (2) Resource flow diagramming (RFD) to characterize the farms in terms of their resource base and show the movement of resources around the farm and into the surrounding economy. (3) The theoretical farming system model created during the re-drawing session is used by farmers and researchers as a guide for conducting applied experiments both on-farm and on the experiment station. (4) A monitoring and evaluation tool, RESTORE, is used to assess farming systems transformation and longer-term ecological, capacity and economic development of farms and farmers.

Danda and Lewa (2004) present an example of an empowering approach drawn from Kenya's Agricultural Technology and Information Response Initiative (ATIRI), which was started in response to low adoption of technologies developed by the Kenya Agricultural Research Institute (KARI) and other research organizations in the country. The initiative links stakeholders in the research to extension continuum, including farmers, community based organizations, NGOs, extension and in some cases the private sector. The approach attempts to link farmers' priorities, opportunities and challenges with the available technologies. This contrasts with the other models in that technologies and knowledge are extended to communities according to diagnosis of problems by farmers in conjunction with research teams, and discussion of possible intervention strategies with the guidance of research teams. The initiative is supported by an elaborate monitoring and evaluation at the institutional level, with various steering committees responsible for assessing the progress of farmer groups and community based organizations that have benefited from the grants.

Mubiru et al. (2004) share experiences of the Soils and Soil Fertility Management Programme (SSFMP) of Uganda's National Agricultural Research Organization (NARO) and its partners to illustrate the variety of participatory approaches they have used. The approaches reviewed include participatory on-farm trials/demonstrations, Farmer Field Schools (FFS), Participatory Development Communication (PDC) and Participatory Learning and Action Research (PLAR). Participatory on-farm research (POFR)/ demonstration has three components, the diagnostic component to understand the farm and its environment as well as the farmers' goals, challenges, and opportunities; the experimental component involves designing appropriate innovations and testing under real farm conditions; and the monitoring and evaluation component, and analyzing the causes of non-adoption (see Mutsaers *et al.,* 1997 for details). Farmer Field Schools (FFS) aim to empower farmers to be technical experts on major aspects of crop and livestock production, improve the farmer decision-making capacity and stimulate local innovation (Braun *et al.*, 2000). Additionally, the integration of farmer experiences and knowledge with research and extension stimulates technology adaptation and adoption. A school curriculum is designed to provide basic agro-ecological knowledge and skills but in a participatory manner so that farmer experiences are integrated in the learning process. The schools are coordinated by a facilitator who meets with the farmers regularly (at least once a week) in the farmers' communal gardens. The PLAR approach uses PRA tools to allow farmers to identify their agricultural production and socio-economic opportunities and challenges; farmers then identify their soil fertility management classes and constraints to good management; and, finally, farmers design experiments to test and evaluate various options to improve soil fertility management. The PDC approach underscores communication as a tool for development and entails several

mechanisms for disseminating information among various stakeholders, applying PRA methods to identify agricultural production and socio-economic opportunities and challenges; from these challenges, community groups are formed and facilitated to develop participatory action plans that define communication needs, objectives, activities to achieve the objectives, and a tool to execute the activities.

Snapp et al. (2004) present a case study from southern Africa of the mother and baby (MB) trial design to improve maize-based system productivity through legume intensification. This participatory approach is an upstream methodology designed to improve the flow of information between farmers and researchers about technology performance and appropriateness under farmer conditions. The trial design consists of two types — mother and baby trials. The mother trial is researcher-designed and conforms to scientific requirements for publishable data and analysis. A baby trial consists of a single replicate of one or more technologies from the mother trial. A single farmer manages each baby trial on his or her own land. A typical implementation of the methodology would include a single mother trial and numerous baby trials within a village. The MB trial methodology has three goals: (1) To generate data on which to assess technology performance under realistic farmer conditions. (2) To complement the agronomic trial data with farmers' assessments of the adoption potential of technologies; this information helps researchers understand how the technologies fit into farmers' broader farming and livelihood strategies. (3) To encourage farmers to participate actively in the trials and stimulate farmer experimentation with, and adoption of, new technologies and practices. MB trials attempt to address market linkages and seed multiplication issues as a strategy for scaling up the impacts.

Ssewannyana and Rees (2004) present a new method based on the three livestock improvement sub-projects funded by COARD project where farmers were fully involved in all activities and played central roles in the improvement programs. The three sub-projects followed five main areas: (i) Setting the benchmarks, which involves capturing data on the socio-demography of households (land size, family size, level of education, marital status of household head), data on livestock (types, numbers, management, animal health, marketing and indigenous technical knowledge) and feed resource bases. (ii) Trainings using experiential learning where discussions, dialogues and sharing experiences were key features. (ii) Implementation modalities where farmers were fully involved in the development of the improved animal breeds – from planning, designing, implementation, monitoring and evaluation. (iv) Sustainability, which is achieved by an emphasis on the formation of Farmer Breeder Associations with elected executive committees with written constitutions and registration certificates from the relevant government organs. (v) Networking among breeders associations, SAARI and the National Animal Genetic Resources Center and Data Bank (NAGRC&DB).

NARO's COARD project (Rees et al., 2004b – see also Section 3 and 7) assesses the type and quality of participation found during subsequent implementation of COARD's research sub-projects. They found that the type and quality of participation varied considerably – roughly three-quarters were classified as contractual or collaborative participation, and only a quarter as collegiate. The authors state that "Internationally supported NGOs seem to have the highest capacity for proposal writing and implementing collegiate-style, participatory type projects, but generally have to out-source technical expertise. Many NARO staff also have good capacity for proposal writing and implementing participatory type projects that can be classified as collaborative or contractual. Local NGOs and local government extension staff seem to have least experience with proposal writing and participatory approaches. Most, but not all, university-led proposals received were extractive in nature, with farmers' roles seen as testing solutions designed by university staff." Internationally supported NGOs also seemed to have the highest capacity for partnership rather than individualistic approaches to projects. The Nepal case frankly reports that research scientists and reviewers are "still largely entrenched in the old supply-driven technology generation paradigm that sees technologies being delivered to a grateful extension service, who then instruct willing farmers on what they should be doing."

Lessons learnt

At the beginning of this section, we argue that the point at which farmers or end-users are involved in the technology design process will influence the results of the project. So for example, when farmers are involved in priority setting, it is more likely that technology development will respond to the needs and priorities of the community. When farmers and end-users have a collaborative or collegial relationship with scientists and are involved in all stages of the technology development process — from design to diffusion with a strong capacity building component — then this leads to empowerment. However, when farmers and scientists are involved in a consultative relationship in which scientists make the decisions and the initial priorities, a functional type of participation is the likely mode. One of the challenges with the functional type of participatory approaches, , is that project objective and activities are usually already well defined by the time the project is implemented so the scope for farmer influence is limited to providing information on how technologies work on farm, on assessments and rankings, and can be useful in selecting technologies for future testing.

In considering what is best practice for technology innovation, an important issue raised by two of the papers is the aspect of linking research to markets. Experience shows that smallholder farmers key concern is not only agricultural productivity and household food consumption, but also increasingly better market access. Once farmers are able to produce enough, then accessing markets to sell

surplus becomes an important concern. Therefore, it becomes critical to enhance the ability of smallholder, resource-poor farmers to access market opportunities and their links to markets.

An additional factor noted was the limited use of gender-sensitive participatory approaches, and therefore limitations in addressing the specific needs of small holders, especially women and the poor. The issue of social and gender differences is clearly highlighted in the paper by Sanginga et al. (2004). While in their review of the PLAR approach Mubiru et al. (2004) mention wealth differences and its effect on testing of soil fertility management options. If end-users such as women and the poorest are brought into the research process at a very late stage, particularly to evaluate technologies that have already been developed and are ready for dissemination, such technologies are often inappropriate for the needs of the poor and women.

Participatory approach to extension

The two main objectives of research are to generate knowledge and disseminate/adapt that knowledge so that it can be applied. In the last few decades, a lot of research by both national and international research institutions has culminated in new knowledge and new technologies that have potential to increase agricultural production but without translation into increased production and improved livelihoods for the intended beneficiaries. Some of the impediments have been lack of awareness of the new technologies by the intended beneficiaries, low adoption due to inadequate practical applicability and feasibility of the technologies, and low capacity of the intended beneficiaries to adopt them.

The role of extension is to provide a bridge between these technologies and new knowledge and the intended beneficiaries by creating awareness of their existence, providing the necessary information in a way that is easily understood and applicable, and generally assisting them to implement and adapt these technologies to their local situations. Up to the late 1980s, the most common method of disseminating results and technologies was the training and visit system. However with declining resources to national agricultural extension systems, this expensive and inflexible approach has been generally dropped. A myriad of participatory extension approaches have been tried, such as the Farmer Field Schools, the PEA approach, the client oriented approach, farmer-to-farmer extension and the demand driven approach. The papers in this section describe and give results of several attempts to understand and use some of these approaches.

The ATIRI initiative of Kenya

The ATIRI project in Kenya (Danda and Lewa, 2004; see also section 2.2) invites groups of farmers to write proposals to KARI to utilize any of the technologies that KARI has developed. The farmers are assisted to do this by scientists, extension officers, NGOs and/or CBOs. KARI gives farmer groups a grant to purchase the technology, inputs required to implement the technology and to pay for technical services. The initiative has assisted the institute to reach large numbers of farmers within a relatively short time with their technologies and services. The grant has removed the financial constraints usually associated with non-adoption of new and improved technologies by farmers. The formation of groups has created entry points for other service providers such as NGOs, private sector, and micro-finance institutions that enhance farmer access to other services. This initiative makes several assumptions. One is that farmers will prioritize their problems and appropriately match these problems or constraints with the available technologies. This is a big assumption considering that farmer groups may not have information on the full range of available options or the knowledge of which options are most suited to solving their problems or constraints. The other main assumption is that the NGOs and government extension have adequate capacity to support farmer groups in problem diagnosis, proposal development, management of funds, monitoring and evaluation, and other skills that the farmers need to implement these technologies. In practice, the capacity of the NGOs and CBOs as well as other service providers need to be strengthened for them to effectively support farmers. The paper makes a good attempt of documenting the achievements and impacts of the initiative at the levels of research, extension, farmer group and community. These are, however, at the very basic (activity) level of what was done, with little information on results or outcomes that would measure the impact in a more robust way. Linking this to the later issue of monitoring and evaluation, it would be critical to try and measure impact from the perspectives of the farmer groups themselves and the community based organizations.

Sinja et al. (2004) focus their work on identifying characteristics that influence farmer-to-farmer extension. The role of farmer-to-farmer extension has been appreciated for a long time, because there is ample evidence in literature that farmers get much of their information on various aspects of their lives from their peers. Arising from this fact, studies have been carried out to understand farmer-to-farmer extension, what contributes to this and how effective it is, and what kind of messages are suited to this form of extension. This paper looks at the farmer and farm characteristics that influence farmer-to-farmer extension of fodder technologies in Kenya. They discuss factors such as the age of the farmer, education, distances to markets and off-farm income, and using a Tobit model analyze their significance in influencing whether farmers pass on technologies and information to other farmers.

The paper does not mention or analyze the social networks that exist in communities and have a great influence on how farmers share and exchange information and technologies. Typically, farmers share information and materials with their kin, extended families, and friends — social interactions within communities that may largely explain farmer to farmer extension irrespective of distances to markets, farmer's age or education. The type information

shared by farmers is also crucial to analyze so as to understand whether some information types are passed on to other farmers more than others, why this is so and whether these can be supplemented by external information sources. The modes of passing technologies and information by farmers are varied: they may sell technologies such as seed but give information free; they may sell technologies to neighbors but give the same free to relatives or friends; others may sell both information and technologies. These modes of passing information have a bearing on the members of the community that have access to these technologies: if they are passed on by sale, poorer members of the community may not have effective access.

A major reason that has been advanced for non-adoption of improved technologies by farmers is the nature of the technology recommendations that are given to them by both researchers and extension officers includes; how easy the technology is to implement, what are its requirements for implementation, whether the technology is in conflict with previous recommendations for this or other technologies amongst others. The paper by Ramaru et al. (2004) on facilitating linkages between farmers and other service/input providers provides useful insights into participatory processes that can yield multiple benefits for smallholder farmers, including access not only to technologies but also to other services such as inputs. This, as the authors argue, requires great organizational capacity on the part of the farmers, a capacity that does not just happen but requires facilitation by intermediaries such as extension officers or NGOs.

Mutimba (2004) in their paper on extending soil and water conservation technologies assess outcomes of soil and water conservation extension messages using student projects at the Department of Agricultural Extension Education in Makerere University. The paper has crucial findings that those planning and carrying out farmer extension should be concerned about and address. In this example, incorrect diagnosis of farmer problems led to inappropriate recommendations on soil and water conservation — such as erosion control while the key constraints were related to soil fertility. This raises the issue of whether researchers and extension recommend what farmers actually need based on their resources, or just recommend what they themselves have information and knowledge about their pet subjects. The applicability or feasibility of the recommendation given to farmers is also brought into question in this paper. For the most common recommendations for soil and water conservation, farmers did not have the resources to implement them and, as a result, they implemented them partially or not at all due to scarcity of resources for the recommended technologies. Mutimba (2004) argues that recommendations, such as mulching, would lead to more serious environmental concerns than those supposedly being addressed by the research since the materials for mulching would have been obtained from the already degraded wetlands.

Multiple and sometimes conflicting recommendations for the same technologies from different sources, or conflicting recommendations from different technologies, makes it very difficult to assess whether farmers have followed correct technological specifications — or indeed whether they have the correct information. Measuring the effectiveness of these extension recommendations is very difficult.

Successful examples of impact

More and more often, agricultural research projects are experiencing a shift away from centralized, biophysical technology-led top down approaches towards more decentralized participatory approaches, which are flexible and iterative. Agricultural research is less and less about generating finished technologies (high yielding varieties, fertilizer recommendations) but is becoming more concerned about reaching resource poor farmers and other stakeholders, and building their capacity to adapt to changing conditions. An important component of any innovation process is therefore to demonstrate the extent to which it creates positive impacts to the livelihoods of poor people, or result in improving the performance and effectiveness of agricultural research and development organizations.

Nina et al (2001) distinguished three broad types of impacts: technology impacts, process impacts, and cost impacts. More recently, IDRC introduced the concept of outcome mapping to capture behavioral and institutional changes brought about to project boundary partners. Technology impacts are related to direct benefits of the technology or innovation been promoted, and the direct benefits to its users. These are referred to in a range of terms, for example, adoption rates, incomes, yields increase, or productivity changes. Increasingly innovation system approaches are being promoted as part of co-learning processes relating to the building of farmers and stakeholders capacity to innovate and conduct experiments, leading to the impacts of human and social capital benefits from participation. Johnson et al. (2002) argue that these process type impacts relate to the types of approaches and occur as a result of the participation itself rather than as a result of the technologies developed via participatory research methods. Process impacts are often qualitative impacts relating to the empowerment function and capacity building of an innovation system. They include impact assessment systems which look beyond the technical indicators of agricultural research (such as yields, resistance to pests and diseases), and other socio-economic indicators (adoption rates, income, cost-benefits), to focus attention on the process of participation, their outcomes and impacts.

Most papers in this theme demonstrate that the use of innovative research and development methods has resulted

in considerable technology impacts. Brumett et al. (2004) show that in areas where participatory research approaches to aquaculture have been tested, typical adoption rates by farmers reached 86%, with about 76% of farmers adopting more than one technology. The number of farmer groups has also expanded significantly reaching more than 225 farmers from the original 34 farmers practicing aquaculture. Similarly, Odogola et al. (2004) demonstrate that the institutional building approach to micro-credit initiative attained a 250% increase in community membership from 163 persons to 471 persons in four years. The accumulated membership savings also rose eleven fold to over 15 millions UShs. In Soroti, some 192 farmer field schools (FFS) involving over 4800 farmers have been established and trained in various agricultural technologies and management practices.

Friss-Hansen and Kodoido (2004) show that members of FFS and NAADS groups have significantly higher levels of technology use and adoption compared to other farmers. Similar findings are reported by Kayobo and Laker-Ojok (2004) who found that the LIFE project has resulted in significant achievement and higher adoption rates of a range of recommended agricultural technologies. Participating farmers generally reported higher incomes, increased food availability, and improved ability of poor households to send their children to schools, improve their housing conditions and meet other livelihood requirements (Odogola et al., 2004).

Lessons learnt

Some papers report evidence of farmers' priorities influencing the FFS program to include in their curricula other livelihood aspects beyond agriculture that have impacts on their livelihoods. The FFS curricula now include HIV/AIDS awareness, nutrition and hygiene, reproductive and family health care, business management, etc. This multi-dimensional approach has led to strong partnerships between NAADS and other government departments, NGOs and other rural service providers. It was also observed that, gradually, the emphasis in determining research objectives and programs is gradually shifting from formal research systems, to more consultative and collaborative processes where farmers have a greater role to participate in research planning and early testing and evaluation of technologies. However, there is little evidence in the papers on the impacts of the innovation on research and development organizations, and on boundary partners in terms of changes in their organizational practices and behaviors. Sanginga et al. (2004) give examples of changes in partner organizations as a result of collaborative research on enabling rural innovation in Africa.

One missing component of impact assessment in all the papers is outcome mapping. Outcome mapping means a detailed description of the changes in the behavior relationships, activities and actions of stakeholders that can be logically linked although not necessarily caused by a project, a program or a development actor (Earl et al., 2001). It seeks to characterize and assess the contribution made by stakeholders and development partners, projects or organizations to the achievement of specific outcomes. Another important concern is the assessment of the distributional impacts of innovation, especially on gender, power relations, and poverty.

Most studies expressed the limitations of current approaches to address issues of gender, equity and sustainability. Friss-Hansen and Kodoido (2004) observed that although both NAADS and the FFS approach advocate equity and a pro-poor focus, the poorer sections of the population (women, elderly, poor) have been excluded and have not benefited.

Another aspect that is not covered by the papers is the impact of participation on research organizations' costs. This is important because a criticism of participatory approaches is that the process is slow and increases costs of doing research. On the hand, proponents of participatory approaches argue that involving end-users reduces research costs to formal research organizations because research roles are shared and borne by the various stakeholders. These papers do not analyze cost impacts of the innovation. Aspects of building farmer knowledge and capacity are also addressed in Section 5 below.

Building farmers' knowledge and understanding of processes

The combination of scientific and local knowledge systems has been studied extensively over the last two decades in an attempt to see how research knowledge can be targeted to better address local needs, rather than following the one-solution-fits-all approach (Altieri, 1990; Barrios et al., 1994; Walker et al., 1995; Sandor and Furbee, 1996). The use of participatory methods to evaluate technology options with farmers or to include farmer criteria for taste, color, etc in breeding programs is well documented. Rural populations are facing the threat of increased poverty and further land degradation unless increased resources or knowledge generate adequate income and opportunities to overcome soil degradation. The two examples presented to this conference cover aspects of linking knowledge systems for genetic diversity and participatory land use management to address these constraints.

The first paper (Mulumba et al, 2004) undertook to identify and understand the best practices for conservation of rare banana landraces in Uganda's semi-arid area and showed that farmers are actively conserving this diversity within their communities but that climate change, increasing land pressure and cultural changes are affecting their ability to do so. It was difficult to see if the management practices identified were really related to the different varieties or if farmers just invested more time and, therefore, used more management practices, on the more commercial and food security varieties rather than targeting management practices specifically to conserve a variety.

It would have been very useful in the study if the varieties that were wanted by the communities were identified, the most important characteristics of each and, from the community's perspective, what warranted conservation. The approach taken of identifying the amount grown of each variety and then correlating this to how they were managed did not allow this to be done and has therefore missed the opportunity to develop a more participatory approach that could have elicited key steps in ensuring genetic diversity related to land management.

Gowing et al. (2004) aimed to develop a methodology for integrating scientific soil survey products with indigenous knowledge surveys for improved decision making. The research highlighted the importance of a systematic and iterative exploration of indigenous knowledge, which must extend beyond the level of rapid rural appraisal and include several different techniques of cross-validation of interpretations of indigenous soil classification systems to avoid premature conclusions being drawn. In many studies, the first impression from comparing scientific and local knowledge soil maps is that farmers' knowledge of soils is inconsistent and unreliable, but experience gained through research in this paper and others shows that much of the apparent variation derives from the method of investigation. For example, in Uganda, it became clear that an apparently dominant soil type (*Eitela*) was in fact a land-use term and deeper communication with farmers led them to abandon the term and propose more specific soil names.

The type of question and approach taken largely determine the outcome and quality of the integration. Determining a local soil classification does not mean asking questions about soils *per se*: for example, plant species have been used extensively as indicators for determining the fertility status of soil (for example, Barrios et al., 2001).

This research is now being used as a starting point for the development of a practical field-based survey procedure. This combined approach offers a possible solution to the time and cost constraint inherent in detailed soil analysis and scientific soil survey. New approaches need new tools, and researchers and extension staff would need to learn new skills to allow them to explore local knowledge without imposing their own conceptions.

Access and use of information

Adoption of improved germplasm and technology options has also been hindered for many years by the lack of coherent and delivered messages through extension services. This has been caused by a range of factors, from lack of information reaching extension agents to the wrong messages being delivered. Therefore strong linkages between farmers, extension services and research are critical to speed up information flows and diffusion of technologies. As Uganda's national agricultural research and dissemination systems embrace the principles of farmer-demand for services (both technology and development), there is clearly a need to harmonize the demand and the supply sides of information dissemination and communications (NAADS, 2003).

One of the main problems facing dissemination is the format and information contained in the dissemination materials. Generally extension materials are the results of scientific research and therefore contain mainly technical considerations and often lack key information that farmers need to be able to make informed decisions on adoption and adaptation. Some of these gaps, identified by Pound et al. (2004) are the economic viability of a technology, the risk involved, the resources required to adopt the technology (land, labor, capital, materials, skills), the local availability of inputs, mechanisms for realizing the benefits of technologies at a group level, and the availability and characteristics of local and distant markets. In addition, markets and post-harvest issues, gender roles, economic benefit, risk, group organization and effective use of locally available inputs, are all examples of information that farmers need but have little access to at present.

NAADS and the Uganda experience

A key challenge for NAADS is to ensure that private service providers have access to and use up-to-date information and information that addresses these gaps. A key concept adopted throughout NARO's Client-oriented Agricultural Research & Dissemination (COARD) Project was "effective and planned communication is paramount at all stages in the production, testing, adaptation and delivery of agricultural services, whether a physical technology or a management practice" (Rees et al., 2004a).

Two research projects reported here from Uganda address these needs: the COARD Project (Rees et al., 2004a) and the "Linking demand and supply of agricultural information (Linking)" (Pound et al. 2004) and some of their findings and those of others involved in their work are reported here (see also, Agwaru et al., 2004; Mubangizi et al., 2004). The linking project piloted in Tororo and Arua Districts identified available research and extension information, against farmer information demands, and designed an on-farm adaptive research process to generate the missing information on data such as economic benefits, risk assessment, labor considerations, input availability and markets. Comprehensive, user-friendly extension materials are then produced, incorporating the technical and socio-economic information required by extension service providers and farmers. Rees et al. (2004a), sharing the experiences of COARD, focused more on 'end-users information, media preferences and needs, and scientists' and intermediary-users' communications practices and abilities were reviewed and strengthened.

Rees et al. (2004b) identified a considerable number of agencies involved in the production and sharing of information and concluded that some coordination of packaging and dissemination of research outputs is necessary. Just as most research services should be based on farmer-demand, the production of information materials on particular technologies, and the media in which they are

produced, should also be based on farmer-demand to the extent possible.

Translation of research results

Butterworth et al. (2004) discuss the main challenges in the dissemination of research outputs based on experiences from the 'Linking' project where existing research reports were translated into extension materials that could easily be used by intermediary organizations and final end users. They outlined the process used and where farmers prioritize their constraints, and a team of scientists then tried to match these constraints with research that has already been done and translate this into fact sheets that can be used by farmers and intermediary organizations.

Butterworth et al. concluded that this process was very time consuming, some research findings lacked clarity, while others lacked information that is useful to farmers or illustrations that could more easily be understood by farmers. Various reasons are advanced for this state of affairs: the relatively short project time that does not allow research teams to develop more appropriate dissemination material, the lack of a dissemination component in projects and lack of feedback. The paper contrasts the methodology used with that of COARD, where a group of scientists and extensionists came together with the backing of artists and graphic designers to develop extension materials (Rees et al.). The 'Linking' and COARD projects therefore set up a cross-institutional (NAADS, NARO Outreach Partnership Initiative, ARIS, COARD, MUK, IITA, CIAT, "Linking" Project) Working Group, which has developed and tested a set of headings that capture the different types of information that farmers need.

Private sector providers

In a study by Mubangizi et al. (2004), almost all the 43 private sector providers (PSPs) were male, educated up to diploma level but having minimal working experience. PSPs get information from school/college notes, books, radios, manuals, newspapers, district departments and research institutes, using manuals perceived to be the most important in both districts. There seems to be no deliberate efforts by information sources to target PSPs, while information quality assurance is lacking and/or haphazard. Constraints of private service providers in accessing and processing technical agricultural information were reported to include lack of resources, no and/or limited information sharing among PSPs and public extension staff, inadequate amount of information, unavailability of internet and difficulty in translating the information from English.

Some of the main findings of these papers are:

1 All approaches were unable to meet the interests of the very poor, as information dissemination was not disaggregated by wealth and tended to focus on a "one solution serves all" approach that appears to take first priority in technology dissemination (Agwaru et al. 2004)

2 Reviews of farmers' information networks by wealth-disaggregated farmer groups in Soroti & Lira districts emphasized the lower access of poorer compared to wealthier farmers to government and non-government extension workers, agri-business sources and to print media (Rees et al. 2004a)

3 Local markets and middlemen were important sources of information by farmers in urban areas, but less so in remote areas - 29% of groups in remote areas mentioned local markets as a source of agricultural information compared to over 50% in semi-rural and urban areas. Churches and schools were more important as information sources in remote areas, compared to more urban settings (Rees et al. 2004a)

4 The most frequent source of agricultural information for farmers was based around their social networks, i.e. easily accessible family, neighbors and friends (Rees et al. 2004a).

5 Men gave higher weight to radio and extension than women did, suggesting unequal access to these media between men & women (Rees et al. 2004a)

6 Little marketing information was currently available to farmers, and a considerable demand for this was expressed (Pound et al. 2004).

Getting the priorities of the community clear so that the right information is given to them is of paramount information. Community priority setting therefore needs to be rigorous and take into account information needs of different groupings within the community — the resource poor, the women, the youth, etc. One of the strong points repeated in these papers is that information on technologies needs to be accompanied by other information on the requirements for the implementation of the technology — such as the cost of implementation, labor requirements and expected benefits, all of which are important in assessing its feasibility and practicality. One has to be cautious, however, as these elements may change according to location, adaptation of the technology, etc.

Scaling up

Scaling up the impacts of agricultural research outputs has become the center of much recent debate within research and development (R&D) organizations. This concern has arisen in the context of growing concern that R&D has not demonstrated its ability to benefit large numbers of poor people across wide areas within sensible time frames. Other concerns with scaling up include: Increasing pressure from donors and civil society that money spent in R&D must brings about lasting impact on the lives of the rural poor. Many donors are demanding that the R&D projects they finance show increased impact, to ensure maximum benefits from reduced financial support to agricultural R&D. The recognition that many relevant technologies and approaches are not achieving their full potential impact because of low levels of adoption has lead to greater emphasis on the effectiveness of research to produce adoptable technological options.

This section draws heavily from Menter et al. (2002) because there were limited case studies focusing on scaling-up in the papers reviewed. This paper summarizes the key

strategies that are critical to scaling-up the impacts of Research and Development outputs.

1 Incorporating scaling up considerations into project planning
2 Building capacity
3 Information and learning
4 Building linkages
5 Engaging in policy dialogue
6 Sustaining the process (funding)
7 Developing an appropriate extension process to disseminate research outputs

Incorporating scaling up considerations into project planning

A key strategy for scaling e impact of research, scaling up must be considered from the beginning of the research and planning process. This implies building scaling up strategies into the technology development process and including them in project proposals can ensure that these considerations are given full attention throughout the life of the project. Experiences show that scaling up can be increased if key opportunities and challenges are identified at an early stage, thereby allowing key channels for scaling up research activities and development outcomes to be identified and to form an integral part of the technology/ methodology development process.

Capacity building

In order for complex innovations such as a soil nutrient management tool to be adapted and applied in a variety of different contexts, those involved need to have a good understanding of the knowledge and principles underlying the innovation. This implies rigorous capacity building of staff in local institutions and building the adaptive capacity mentioned above, within local institutions and local communities. This process often occurs implicitly in participatory research process, but needs to be made explicit in scaling up.

Capacity building is an important strategy especially in the implementation and exit stage to internalize new ideas within communities, and institutions. Additionally, for farmers to be able to participate in technology innovation process and to demand technologies and other extension services, their capacity will need to be increased. Capacity in local organization, group formation, literacy skills, monitoring and evaluation are crucial if participatory extension is going to succeed. For interventions and innovations to be owned by farmers, they need to feel that they are part of these interventions — this can only happen if their capacity to participate is enhanced. Capacity building is also crucial to create a critical mass of people with skills and expertise in supporting innovation processes. It also involves building the capacity of scientific personnel and the institutional systems to sustain and replicate the process.

Information and learning

There is need for systematic monitoring and evaluation systems at both community and institutional level to provide a credible evidence of impact. For group based and other participatory extension systems, there is need for strong local level monitoring and evaluation systems that will allow these groups, communities or CBOs to monitor and evaluate their progress, to learn and to adjust their activities accordingly. Monitoring and evaluation at community, farmer group or CBO level is also very empowering as communities become able to monitor through their community or group action plans, collect information that they need to make decisions, analyze this information and use it for making decisions. An institutional monitoring and evaluation system is not enough to serve the farmer groups and other grassroots organizations, although an institutional monitoring and evaluation system is also needed to recognize farmers' views on what they are seeking so that impact is measured from both the institutions' as well as from the farmers' perspectives. Additionally, effective impact assessment is necessary in order to learn from and gain credibility on effectiveness and extent of impact of innovations and to provide validated evidence to influence decision-makers at different levels.

Engaging in policy dialogue

Engaging policy makers in an active dialogue throughout the project process is crucial for gathering support for innovations and projects, and for creating the right institutional environment for innovations to be scaled up. Policy-makers should be consulted at an early stage of the research project so as to shape the overall project design, and additionally through regular reviews of the project or at other development discussions. This type of dialogue is necessary to convince managers and encourage the changes within the institutional structure necessary to overcome the institutional barriers to change.

Translating research outputs to extension messages

Most scientists, after years of research effort, package their results in project reports, annual reports and other reports that are not accessible to their intended end users or beneficiaries. Information in these research reports is sometimes not specific and does not give recommendations on how the technologies should be implemented by end users. Packaging this information in ways that are accessible and can be used by the intended end users can greatly increase the adoption and use of new and improved technologies. Projects should have both research and end user dissemination as key outputs, planned from the start and with enough funds and time allocated for the dissemination component.

Understanding the extension process

More research is needed to understand extension processes. Different extension systems have been used to pass information and technologies to farmers, including farmer-

to-farmer extension, group based extension and participatory extension. Robust and more vigorous research needs to be done to understand and learn from these processes, to define what type of technologies are suited to what type of extension methods, whether some of these methods are more exclusive than inclusive of those that most need the information and technologies.

Doing extension right

Getting the problems and the solutions right

Proper problem diagnosis is a key step in extension. If the problem is not correctly diagnosed, then the recommendations will also not be right. Teams of research and extension officers and farmers should do problem diagnosis so that farmers diagnose the problems with full information provided by the researchers. It is only with full information that farmers will be able to participate in the participatory extension process.

Achieving a re-orientation of extension

For a long time the training and visit system was the main extension method in most African countries. To carry out this method, extension officers were trained to be teachers and their main role was to teach farmers new methods of farming. With the advent of new research and extension approaches aiming at stimulating innovation, the role of the extension officer is now changing from one of a teacher to a facilitator. This changing role, however, often is not reflected in the educational institutions that are responsible for training extension officers – a notable exception being the SAFE initiative at Makerere and other universities in this region. Extension education needs to take into account this changing role in order to equip extension officers with skills that they require in order to fit into this role; such skills include facilitation, participatory approaches and social extension.

Micro-credit

Access to credit to support the intensification of agriculture and scaling-up of impacts, while long a major theme in rural development in Asia and Latin America, is increasingly being reported as a limiting factor in Africa because of the current encouragement for market-orientation among smallholder farmers. Traditionally, some small farmers have drawn on local, informal sharing arrangements such as women's saving groups, while formal credit sources (those supervised by official bodies) have generally been available only to a prosperous minority able to develop acceptable business plans and to put up enough collateral to secure a bank loan.

Semi-formal

A preliminary regional study (Anandajayasekeram et al. 2001) by the Farm-level Applied Research Program for Smallholder Farmers in East and Southern Africa (Farmesa) indicated that informal micro-credit for lending to smallholder farmers or entrepreneurs were "predominantly supply-led, often originating from external donors or government rather than from local savings in the rural economy and charged interest rates below the market rates" or even interest-free, and hence were unsustainable. Odogola et al. (2004) report on a case study in two Ugandan districts where, after identifying demand and the critical need to catalyze a savings culture and foster community-based capacity, the Farmesa partnership launched a sensitization exercise among farmers immediately followed by rigorous training in business analysis and planning.

Though experience elsewhere indicated an ideal size of a community credit association as consisting of 25-35 members, the high demand for participation in other Farmesa project activities in Uganda led to formation of groups of 50-70 persons. These same groups were later taken on to form community micro-credit associations that managed funds and received constant training for its members. Over the last 6 years, membership has risen 250% to 471 persons, notably with slightly more than half being women. The calculations show that average per person savings have risen from about UGX 8550 (US$5) to UGX 32,500 (US$16), with a current loan portfolio at about three times this level and total beneficiaries nearing 2,000. Success was reported also in terms of 90% to 95% repayment rates, impact on livelihoods and reduced household and community quarrelling.

Best practices for this form of savings-led credit scheme are generally similar to those for other forms of community-based organization – formation of small homogeneous groups of 5-7 persons whose members share common interests whose social capital serves as the mutual collateral for group lending; establishing a constitution and elected leadership at the level of the larger community group; full inclusion of women (who proved to be more trusted as treasurers); the development of business plans; building self-regulated procedures for loan request, committee approval and funds disbursement; participatory decision-making and transparency; agreement upon a commercially viable interest rate (15% per crop season or 30% per year); good links with district and other authorities (including formal registration) – and supported at each step by the provision of plenty of training in relevant skills.

It is laudable that projects such as Farmesa and the African Highlands Initiative (AHI) encourage NARS scientists to carry out action research – and not simply studies – into micro-credit as a development issue. The effects of improved credit access upon adoption of technologies in Uganda, and whether the commercial credit sector will start to become attracted to investing in smallholder agro-enterprises, has yet to be seen.

Partnerships and capacity building

Partnerships

NARO's experience in partnership formation is that partnerships take time to be consolidated. Quickly and

loosely formed partnerships tend to depend on personalities, and disintegrate when the effective person leaves. It is important that stakeholders intending to go into partnerships first define a common goal and objectives, identify areas of conflict and/or duplication, and recognize the strength, weaknesses and expectations of each stakeholder. Special effort must be made to facilitate partnership formation for NARO. This may imply a partnership desk that (among other things) encourages the signing of MoUs, and organizes workshops with partners to identify points of convergence. Enhancement of innovation processes and partnerships is key to linking technology uses to technology developers, and agro-production to consumption. It is also an important component in NARO's research agenda (linking all five themes): this is the theme that will help maintain the right focus on actors, process and product.

Greater attention needs to be given to FPR practice in the training of agricultural professionals, and experienced individuals need to be retained and included in field teams. Current trends in agricultural development emphasize innovation systems and agri-food systems, and knowledge development and dissemination perspectives. This requires systematic networks of partners with good feedback mechanisms. Partnerships are characterized by sharing of roles, resulting in increased synergy in technology development and dissemination. Working and learning together encourages the evolution of networks that enhance the flow of quality information. Partnerships also increase innovativeness by trying new and alternative ways of doing things and by amalgamating scientific technologies with farmer innovations.

Global reforms have led to the redefinition of the role of government in research and increased decentralization of research activities. In Uganda the NARS reform calls for separation of research services delivery from financing, and for increased market responsiveness and client orientation. NARO has now adopted an integrated research and development approach that addresses the whole production to consumption continuum from understanding people to linking producers to markets and policies. This means increased stakeholder participation and requires strong linkages and partnerships.

The effectiveness and relevance of different partners and partnership arrangements is determined, to some degree, by the type of partnerships and the way the stakeholders relate to one another. Effective partnerships may be formed with other public institutions, private sector community based organizations, non-governmental organizations and individual farmers such partnerships may also have international and regional linkages. A partnership should be an alliance among partners who agree to address a common goal, with people who are able to work together and share resources, risks and benefits. They should be willing and have mechanisms for reviewing — and if need be revising — their relationships and agreements. Following is a synthesis of two papers submitted for IAR4D.

Prasad et al. (2004), reporting on a multi-stakeholder partnership through participatory research in rice breeding and seed dissemination, make good points demonstrates some qualities of good partnerships including private, public institutions and community/individual farmers. Outstanding are (1) the multi-stakeholder partnerships among Donors (DFID, Rockefeller foundation), Public institutions (Research centre and University), NGOs, Individual farmers and Private sector (in seed multiplication); and (2) the global outlook (north-south partnership) shown in the collaboration between University of Wales in UK and a local (Indian) university and research centre. Other good characteristics were: that the initiators had a common goal with a poverty focus and fair gender consideration; high level of participation of different partners reduced the gap between technology development and dissemination; NGO played a big role in technology dissemination; and good links between scientists and end users.

There were some obvious weaknesses as well. The partnership was formed on basis of a common need, and when the need is satisfied the partnerships may disintegrate. The partnerships were not bound by any form of agreement, and partners may not feel bound to the arrangement. The roles and obligations of each partner should have been defined. Furthermore any references to scaling up/out referred to the technology and not to the partnership. This clearly indicates that partnerships are means to a desired output — they are context/situation based, their evolution may depend on the mutual benefits, and if the benefits are insignificant or not obvious some partners may feel that they are only being used by others.

The biggest challenge was maintaining the interest of the private sector: any partnership that will not result in financial gain will not interest them. Other partners need to keep this in mind. The private sector may also want to exploit other partners if they monopolize the supply side (e.g. seed multiplication in this case). Other partners should have a contingency plan or be innovative enough to go round the problem.

Nagawa et al. (2004) report a partnership for soil erosion management in Bundibugyo district, Uganda, between local government, a public research institute (FORRI), an international research organization and the community. However the real partnership is between the local government and the World Agroforestry Centre (ICRAF) who are bound by a memorandum of understanding. The partnership is demand driven in that the Bundibugyo local government requested ICRAFs help; as in the above case of rice, others were collaborators. All partners participated in stakeholder identification and in planning — important for scaling out at a later stage. The increased use of participatory methods was a key factor drawing the community into the partnership.

The team had a well defined common goal which addressed the needs of the community. The core partners endeavored to build capacity of collaborators and this would ensure sustainability. The weakness is that the core partners

assumed that the communities were partners by virtue of their interest in the research issue. However, this only makes them transitory participants. Both of the above cases dwelt on the problems to be solved and paid little attention to strengthening the partnerships.

While farmers of different categories can be expected to have their own expectations, scientists' training and knowledge tends to lead them to another set and Soam (2004) pointed out that in public institutions mismatch of these is quite common. Planning is therefore no substitute for intuition, experience and intelligence. Exploring the biases of researchers in their use of criteria for selecting among interventions in an Indian case study, Soam concluded that local researchers are the best judges and those most likely to give credence to farmers' preferences, although researchers working elsewhere can also make useful contributions, especially for scaling up – but only if these "outsiders" are sufficiently knowledgeable and experienced and if provided with relevant information from the field sites. Greater attention needs to be given to FPR practice in the training of agricultural professionals, and experienced individuals need to be retained and included in field teams.

Capacity building

The issue of building the human and social capital of all participants in Research for Development calls for targeted training so that the research-extension-farmer linkages required can be developed and maintained. Sayer & Campbell (2001) concluded that sustained improvements to the livelihoods of poor tropical farmers require a different type of research, aimed at enhancing the capacity of the rural people to adapt to changing conditions, rather than at delivering 'finished' technologies. Clearly, farmers and communities need to be empowered to solve their own problems, and access technologies through methods that emphasize active participation and innovation (Hellin and Higmann, 2001; Sayer and Campbell, 2001). Two good examples of this are reported by Daane ad Booth (2004) and Sharma (2004).

Daane and Booth (2004) summarize the experiences of the International Centre for development oriented Research in Agriculture (ICRA), the Netherlands, who in response to changing demands and expectations placed upon agricultural and rural development professionals and institutions have designed a tailored capacity building program. All of ICRA's learning programs are designed to guide interdisciplinary and inter-institutional, multi-stakeholders teams through a process of solving a jointly identified complex problem that cannot be effectively addressed without collective action of all concerned. This requires a serious commitment of partners and annual 28-week "core" learning programs, which includes a 13-week fieldwork reflects this. Due to increasing demand for their trainings they are now developing a Global Partnership Strategy linked to research and training institutions in the South. This is illustrated with an on-going collaborative initiative with NARO and Makerere University in Uganda and efforts to expand the approach to other countries of the region and to build up a sub-regional, networked capability in capacity building is targeted.

An alternative approach was used in a project based training of scientists to give research scientists the skills they required in assessing clients' needs, and screening existing technologies against social equity, economic competitiveness and environmental sustainability (Sharma, 2004). Similarly to Daane and Booth (2004), practical use of these new skills was made with partners in the field and used to develop research questions and research projects.

Strengthening social capital

It is interesting to note that the experiential farmer learning approach used in FFS and NAADS has enabled farmers to engage in demand driven agricultural services, and thereby contribute to the success of NAADS in Soroti district. This observation concurs with earlier findings by Hagmann et al. (1999) and Sanginga et al. (2001) who found that increased knowledge and understanding gained through group approaches strengthens farmers' confidence and ability to choose between options, develop and adapt appropriate solutions to their circumstances. It is argued that group approach is more effective as it promotes collective learning and exchanges that occur in group settings (Hagmann et al., 1999; Heinrich, 1993), and ensures that more people participate. Working with group may reduce the cost of delivering services and technologies to many farmers, thus making research more cost-effective, and relevant to the needs of different categories of farmers. Given the diversity and complexity of farmers' needs, the more people participate in the research process, the better the benefits should be. Kayobyo and Laker-Ojock (2004) also observed that farmers develop their capacities faster when organized into groups, and when these groups involve a significant number of women. The capacity of micro-credit associations has also grown significantly to the extent that members are now accessing much bigger loans and able to invest in more profitable enterprises, creating employments in their communities. The FFS approach has resulted in a number of process impacts, such as, enhancing bargaining power of farmers, stronger leadership, increased capacity to manage resources, including grants, and access to funding opportunities. Second-order associations for micro-credit, and second generation groups have been formed reinforcing the culture of savings and loan repayment in rural communities.

Approaches to funding of R&D

Competitive agricultural technology funds

Organizational and institutional change is needed in the formal R&D sector if new, demand-driven partnerships are to be output-oriented and more accountable to end-users. Competitive agricultural technology funds (CATFs) are

currently seen as a promising way to encourage these objectives. Two broadly similar examples are critically reviewed in excellent papers on NARO's COARD project (Rees et al., 2004b – see also Section 3 above) and from the longer-established National Agricultural Research and Development Fund (NARDF) in Nepal (Sutherland et al.).

COARD's broad stakeholder committee has reviewed 590 applications and approved 43 for funding; 39 sub-projects had been funded, involving over 50 Government offices and 40 CSOs, with over 3,400 farmers. All funded sub-projects are collaborative efforts of several organizations, 23 of which were led by NARO scientists, 11 by NGOs, and 5 by government organizations – confirming, not too surprisingly, the growing orientation of the NARI towards client-oriented research but also indicating progress towards the (often elusive) concept of a truly multi-institutional "NARS". It would be useful to explore what measures could further develop the overall NARS and its linkages. Even though local companies and entrepreneurs found little to attract them in the project or in new and untested technologies, the reach of the sub-projects represents a substantial mobilization of additional capacity for agricultural development in the region with only modest physical resources.

Increasing stakeholder involvement in decision-making and management in COARD started with broad consultation and led eventually to a management committee that included representatives of district-level public extension, the revised public extension system "NAADS", NGOs, the private sector and farmers organizations, as well as NARO, Makerere University and a national representative. Representatives of government bodies were appointed, while others were elected through an "Electoral College" by secret vote, with NARO acting as observer only. Sutherland makes the point that CATFs are likely to be most useful where the available pool of R&D institutions and especially of researchers is large; these conditions did not apply in either case study, and extra measures were taken by the Nepal case to develop a peer review group that was separate from research, while Rees et al. (2004b) suggest that establishing a management unit separate from the NARI that is executing many of the sub-projects would enhance credibility of the scheme.

Good practices by these case studies in ensuring transparency in decision making included scoring against merit criteria that had been previously discussed and agreed by the whole committee. Criteria should normally include consideration of prior studies of end-user demand or needs, poverty and gender orientations, environmental aspects, likelihood of successful outputs and impact, and the time frame. The use of cards minimized the risks of professionals dominating the inputs of farmer representatives on the COARD committee.

Efforts by COARD to ensure accountability to clients involved *ex ante* assessments of the likely impact of the project by beneficiaries and implementers, and using these assessments to develop monitoring indicators. It is not clear from this paper to what extent this was followed through in developing — and then in applying — indicators in a participatory monitoring and evaluation (PM&E) system; the intention appears to be there. Clearly one strength of the project has been the production of leaflets, brochures, manuals, posters, a video and audio cassette with participating farmers.

The Nepal Government's case appears to place more explicit emphasis upon improving research reach to the rural poor and socially excluded groups than the Uganda case, and upon enhancing the research capacity of both the public and private sectors through training in proposal writing, management and implementation of projects. The Uganda case identified problems in the relatively poor and very slow financial services by rural banks, the needs of farmer groups for help to understand accounting procedures, and difficulties in getting financial staff of big organizations to adapt their customary practices to accommodate those of other partners engaged in pluralistic service delivery. It would be useful to explore which stakeholders might best address each of these constraints.

As with many fashionable trends, however, CATFs that focus resources on short-term impact risk are becoming seen as panaceas. Sutherland et al. rightly draw attention to the desirability of addressing technology dissemination as an integral part of most technology development activities, rather than by developing a CATF to support a series of add-on sub-projects focused on dissemination. Other aspects of the institutional incentive systems besides a CATF need to reward researchers for a client orientation and impact creation. Long and varied experience within the regional research networks of ASARECA suggests that contractual and competitive modes of funding can be complementary: competitive funding is probably best practice in changing the way of doing business, and also allows a committee to identify transparently the most reliable partnerships for contractual arrangements that tend to have lower transaction costs and fewer delays. Eventually, the success of short-term CATFs is also likely to become dependent upon a supply of outputs from longer-term research, often on far-sighted yet more elusive topics, for which contractual arrangements may still be more appropriate. Foreign donors and governments beware!

Conclusions, limitations and challenges

After reviewing the submitted papers, from our own experiences and after reviewing the literature, we have drawn several conclusions and recommendations for how to enhance innovation systems and work in partnerships with other research and development actors for rural development.

We believe that serious attention to empowering farmers is indispensable to improving the relevance, effectiveness and efficiency of current research for development systems. Farmers of all kinds need to be integrated into these systems in ways that make most use of their potential skills and complementary contributions. Like other actors in the

system, they will need support to attain their potential but achieving this will not be a panacea: upstream and on-station research will still be needed, arguably more than ever, once NGOs and farmers can take on more of the adaptive research that NARS researchers are now doing.

Greater attention is needed to understanding human and agroecological diversity. The implications for research programs on poverty alleviation, equity of benefits and gender issues most be addresses in research programs to enable targeting of research and development efforts,

Working with farmer groups generally is more cost-effective than working with individuals, provided that appropriate methods are used. Farmers' human and social capital needs to be assessed before outsiders assume that new groups should be formed, as working with established groups has more often than not proved to be more successful. Social capital also warrants further study generally, as it affects many aspects of empowerment and livelihoods. Farmers' organizations are growing in strength and importance, and could rapidly become valuable partners in innovation systems.

A market orientation in production needs to be implemented sensitively with respect to equity and gender issues. Women can become producers for the market, but may be interested in doing so with different enterprises than men. These differences must be captured and worked with by researchers. Women are better managers of micro-finance but can they maintain control of the resources and income associated with market orientation once their husbands see them earning some income?

Development and uptake pathways for a technology should be defined right from the start of a research project. However, dissemination should not be seen as an add-on activity after the research is completed, research projects will need careful phasing that includes the entire technology development to dissemination continuum and maybe longer periods of funding. The program budget needs to reflect these scaling-up and scaling-out activities, including monitoring and evaluation programs for measuring impact.

Ensuring that information from research is translated into forms useful for farmers and is conveyed effectively to the users should be integrated into every project and become the responsibility of every researcher and program leader. So much the better if a communication specialist is available to assist, but the lack of such a person should be no excuse. Validation and testing of these dissemination materials with development partners and farmers is also critical.

There needs to be awareness of the needs and limitations of a technology, and researchers need to be prepared to catalyze some initial arrangements through partner institutions rather than leaving this as a "policy" issue. For example, farmer access to inputs, including credit, may have profound implications for wide adoption of a technology, especially in a market-oriented environment.

We anticipate that the separation of roles between a NARI, a development agency and a farmer organization will become less distinct, due to farmers becoming better partners, as well as, to researchers and development agencies becoming concerned with and accountable for the development outcomes of their activities (rather than being concerned only with their immediate research outputs).

While NARI scientists need to be directly involved in scaling-out to nearby and similar sites in order to be sure of the robustness and the limitations of a technology, they need to seek out and work with development partners with whom they can scale-up and therefore achieve much wider impact.

Concern for outcomes will contribute to a more enabling environment for the creation of partnerships. However, the wider environment contains both competitive and complementary forces, and the successful institutions will be those that are ready to give up some control and share credit for success in order to achieve greater goals. Doing this will require good leadership, delegation of authority and skills in negotiation, plus a recognition by research managers that not all staff can do everything and that working in a development partnership is equal to on-station basic research in terms of delivering changes at the farm level.

Empowering farmers to reach their potential requires investment, which generally should be the responsibility of development agencies, formal extension, NGOs and, increasingly, of farmer organizations themselves. However, even many NGOs and their staff still have much to learn about how best to do this, and key NARS scientists have an important role in developing, monitoring, learning and promoting these processes.

Capacity building for understanding farming and social systems, collaborating with farmers and working across innovation systems is an urgent step. Biophysical scientists will need to "let go" of control of their technologies very much earlier, and recognize the strong and weak points of themselves and of their farmer partners. All scientists will need the ability to understand and work in teams with other disciplines, and many more scientists than at present need skills in communication and facilitation and other participatory tools. Skills building for assistant staff working most closely with farmers should not be overlooked, and is often more critical, and those staff will need more delegated authority to take joint decisions with farmers or allow farmers to take a decision.

NARIs will need more social scientists – especially those with sociology and anthropology training, rather than classical agricultural economists – and governments and universities will need to assess how to make agriculture more attractive to the large numbers of social scientists who, in most countries of the region, currently go into urban and health fields.

We anticipate that the demand for the products – more often prototype products – from strategic upstream research may actually increase as the effectiveness of the overall innovation system rises with increasing relevance of downstream research and identification of research needs from development and farmer group partners. So what will

be the appropriate balance between adaptive on-farm and station/laboratory research? Success with farmer empowerment may enable NARS to refocus more on what they do best, particularly at the higher-technology end. NARS should also be able to devote more resources to solving longer-term and difficult problems, such as those natural resource management (NRM) challenges posed by global warming. As farmers become more important partners, however, researchers should have less recourse to trying to recreate carefully controlled farm conditions and devote more attention to working with the range of variation that characterizes much of African rain-fed agriculture (and making greater use of non-parametric methods of analysis).

Whether and which kind of small farmers will be able and willing to pay for information and research services is a large issue for the future. Policy decisions will need to take account of equity issues and ensure that returns to investment in information is seen, otherwise it will not be demanded and paid for.

However, institutional change is usually difficult, and nowhere more so than in the public sector. Institutional change needs its champions; and researchers typically respond best to relative freedom as to how they achieve the expected but well-defined outputs. Incentive systems for agricultural scientists remain problematic in many countries, yet developing and working within a dynamic innovation system demands retention of the best brains and the utilization of some of the accumulated experience to help guide field teams. The director who guides research, rather than administers it, should become a more common phenomenon.

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Enhancing integrated management of natural resources

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Abstract

A simple conceptual framework to show how natural resources are linked into production or other transformation processes at different scales are discussed in this paper. Four key aspects of Natural Resource Management (NRM) are drawn out and these include: scale; externalities, context specificity, and tradeoffs. Natural Resource Management (NRM) operates across a variety of spatial and temporal *scales*; and in fact it integrates results from different scales to properly conceive cause and effect relationships. Closely related to scale issues is the concept of *externalities* – positive or negative consequences that a behavior or action by one person or in one location may have on other persons or other locations; or the effects of resource use today on resource users of future generations. Achievements and gaps are discussed for management of soils, water, trees, forests and fisheries, and an overview of the natural resource management that addresses issues of integration across resources, property rights, and conflict resolution is provided.

Key words: Integrated, management, natural resources

Introduction

Purpose of Paper

This synthesis is being undertaken with the goal of contributing to the development of a research and development strategy for the theme of "Enhancing Integrated Management of Natural Resources," one of five themes created by the National Agricultural Research Organization (NARO) of Uganda. The purpose of this synthesis is to review recent developments, the state of the art, and best practices from around the world of importance to the theme and to use this review to propose key research areas for NARO.

Description of the Enhancing Integrated Management of Natural Resources Theme

The goal of this theme is "to increase benefits from integrated management and utilisation of natural resources (water, soil, air, fauna and flora) and of products derived there from." Its principle outputs are:

- Strategies for harnessing and commercialising natural resource-based products developed and disseminated.
- Strategies for mitigating adverse environmental effects developed and disseminated

In order to evaluate its success, the theme intends to have the following impacts:

- Reduced losses due to adverse environmental and human effects
- Enhanced natural resource productivity
- A cleaner and healthier environment
- Improved social stability

These will be measured by, *inter alia*, the following indicators:

- Inventories on biodiversity and its potential.
- Number and types of technological packages for developing and sustainable natural resource-based products demonstrated, adopted and being applied
- Number and types of technological packages for utilisation of renewable energy sources demonstrated and adopted
- Number and types of technological packages for mitigating adverse environmental impacts demonstrated and adopted
- Type of partners involved in the process of generating technologies above
- Number stakeholders given access to information of the technologies

Overview of the Paper

Though the outputs state the word "strategy," it is assumed in this paper that "technologies" would form a critical component of any strategy and therefore natural resource management (NRM) technologies, practices, or transformations are also deemed to be part of this review. Indeed, the synthesizers were requested to review a number of contributed papers related mainly to NRM practices. As such, there may well be some overlap between this review and that of theme 4, which emphasizes improved technologies for crops, livestock, fisheries, and forestry. Certainly, many of the improved NRM practices will impact on the productivity of these same enterprises. In some ways this overlap is good, because there are multiple constraints affecting the productivity of smallholder agriculture and

effective solutions are likely to involve the integration of improved practices in NRM, in crop husbandry, in livestock management, in post harvest handling, and many others. On the other hand, this synthesis paper will not delve far into the topic of theme 2, "Enhancing Innovation Processes," though they are vital to successful NRM. Rather, this synthesis will focus on the unique implications that integrated NRM might have on working with or facilitating community and farmer institutions and practices.

The paper is comprised of five sections, with section 1 being this introduction. The next section presents a conceptual framework that may prove useful to analyzing the science literature related to the theme. Section 3 tries to set the context for research and development in the theme. It identifies several major driving forces that will affect agriculture and NRM in the future and also examines the current structure of research and development organizations affecting Uganda. Section 4 provides highlights of recent developments and mentions some state of the art and best bet practices. This covers research and development approaches and methods, research and technological achievements, and gaps. There is more emphasis on soils, water, and forestry resources, with somewhat less on fishery resources and others. That does not reflect their relative importance as much as it does the author's knowledge. The section concludes with a discussion of achievements in integration of management across these natural resources. Lastly, section 5 summarizes the main findings, outlines some key opportunities, and presents a few challenges.

Understanding the Natural Resource – Transformation Links

In order to achieve some value added from this review, it is important to establish a conceptual framework that shows how natural resources are linked into production or other transformation processes at different scales. Izac and Swift (1994) present a very detailed description of how natural resource systems are related across scale. However, a simpler table is used hear to illustrate the point. The first thematic output makes it clear that we are concerned with generating flows from natural resources to production or other transformations in order to raise productivity and income. The second output similarly shows the importance of addressing the possible flows from transformation processes to resources. Therefore the two outputs describes a fully connected feedback loop between natural resources and production (including processing and other transformations), as shown in the last row.

It is further clear that the resources identified in the outputs can be found anywhere on the landscape – the greater "environment." So this theme is about seeing farms or any other production site such as a fishing pond, a charcoal burning pit, or a communal grazing kraal, in their greater agro-ecological landscape. These producers typically utilize resources from their production sites as well as from outside. In the case of farmers, they use a range of resources from the farm and from the surrounding areas and some examples are given in Table 1. Table 1 also shows some resources used by other types of resource users. The final column shows many of the same resources as in column 1, but along with some of the impacts that may arise from the use of resources. The resource inputs and impacts may occur on farms or off farms and there could be positive or negative consequences depending on the management systems used. For example, if a farmer harvests water from road runoff, this can improve her productivity and at the same time reduce erosion off-farm. The heavy use of grazing land, on the other hand, can lead to degradation in the form of vegetative loss and hardening of topsoils. Some more complex relationships can be the promotion of high value agriculture near forest margins or

Table 1. Conceptual Framework of Resource and Use/Production Linkages

	Resource Inputs	Farmers/ Processors/ users	Resource	Outputs – Impacts on Resources
Farms	Soils	Crops cultivation		Soil fertility and erosion
	Rainwater	Milk		Water table and salinity
	Irrigation	Fruit	harvesting/ processing	
	Trees			
Off-Farm	Grazing land	Charcoal burning		Deforestation
	Lake and stream water	Cooking		Vegetative cover
	Firewood collection	Construction – repair		Biodiversity – commons lands
	Thatch	Domestic water use		
	Wild foods	Fishing		Hydrological flows and watershed functions
	Medicines			
Theme outputs	Harnessing natural resource products	Commercialization		Mitigate adverse environment effects

in fact the development of commercial tree products. In the former case, research has found that intensification of agriculture may either help to prevent more land clearing or induce a faster pace of deforestation, depending on the extent of markets and costs of labour, among other things (Angelsen 1999). When tree products become commercialized, there is a chance that this may lead to the disappearance of trees on the landscape if profit seekers harvest trees in the wild rather than supporting their domestication on farm (this in turn depends on many underlying policies such as property rights).

Some of the implications of this framework on research approaches or considerations are worth highlighting. They may not be unique to this theme, but are clearly at the forefront.

Scale. It is clear that this theme will operate across many spatial scales and in fact must try to integrate results from different scales (Swift et al. 2004). The concept of "environment" denotes at least a landscape scale if not larger (e.g. watershed) and "commercialisation" likewise denotes linkages from farm to urban / national and perhaps international scales. At the same time, much work will undoubtedly take place on farms and on plots where specific NRM practices are tested and monitored. It will be important to be able to link together information across the scales to properly conceive cause and effect relationships. The use of models should be helpful in this regard. Similarly, a variety of temporal scales will be examined to detect fast moving variables (e.g. soil chemical composition) and slower moving variables (e.g. lake water quality). Many NRM investments are of the type that costs are incurred today, but benefits are not realized for many years. Reducing the time to benefit is itself a challenge of NRM research.

Externalities. The notion of scale raises the concept of externalities. These are the positive or negative consequences that a behaviour or action by one person or in one location may have on other persons or other locations.[1] Positive externalities include the conservation of soil on a hillslope that can reduce run-off for farmers lower down or woodlot planting that reduces pressure to cut trees in the forest. However, there can be negative externalities also such as increased offtake from irrigation reducing the amount of water for downstream users or the introduction of a plant that becomes a weed on the landscape. The failure to account for externalities leads to sub-optimal NRM investment. For example, if irrigators do not take into account the effect that they have on downstream users, they may harvest large amounts of water with diminishing productivity resulting lower production levels for all users combined. Conversely, if positive externalities are not taken into account in decisions then there may be under-investment in those activities that bring about the positive externalities (Barrett et al. 2002).

Context specific research. In integrated natural resource management (INRM), on soils for instance, researchers are confronted with context specific situations, defined by the subtle and not-so subtle variations in soil types, altitude, topography, vegetation cover, temperature, rainfall, and flora and fauna biodiversity. Further, some of this variation occurs within a very small geographical area (especially in highland environments). This makes it challenging for INRM research to identify sites that can control for a number of variables, to develop testable hypotheses, and especially to learn general principles from site specific work — that is, what works where and why is this so (Harwood and Kassam 2003). It certainly doesn't preclude sound research, but places an extra emphasis on research design

Tradeoffs. The two outputs of commercialising natural resource products while at the same time mitigating adverse environmental impacts suggest that there may be tradeoffs involved in the impacts of single interventions and in the comparison between interventions. There are obviously a limited number of interventions that can provide high profits and be protective of the environment across a range of environments. For example, certain crop varieties or tree species are often higher valued in the market but this may lead to reduced diversity on the landscape. Commercialisation of a natural product found in forests or woodlands can also lead to the rapid harvesting and degradation of the resource without proper countervailing institutional development. An objective of research would be to seek out win-wins where possible, to reduce the negative effects of interventions where possible, or to find combinations of interventions that together can produce win-win results or win-neutral ones.

Setting the Context for Agriculture and Agricultural Research

A considerable amount of research is driven by short-term priorities — the need to overcome the "immediate" constraint/problem or seize the "current" opportunity to generate impacts on farmers. But research is also forward looking, paying attention to problems or opportunities that may have more importance in the coming years. We briefly discuss several of these important future scenarios that may be pertinent to Uganda. We then say a few words about how other organizations aside from NARO may similarly contribute to addressing agricultural constraints and designing interventions.

Some major driving forces

Climate change. Climate has changed over the past 100 years and is expected to continue to change (Hulme et al., 2001). Unfortunately, the future cannot be known with certainty; but in the case of Uganda, analysis of the previous 100 years show slight increases in temperature and rainfall and that several future scenarios generate the same predictions. Relative to the rest of Africa, the east African midlands and highlands are predicted to become relatively more favourable than most other regions of Africa. This is not the case in the drier regions. The eastern sahelian zone that stretches into Uganda might well experience quite

different changes. Variability is difficult to predict but many people claim that there has been and will continue to be continued high variation in climate in the short term – droughts, monsoons, wide temperature swings. If so, identifying options for adapting to increased variability or temperatures might then attract higher priority within NARO. In the longer term, if conditions do improve in Uganda relative to other regions, its agriculture sector could become an even greater prized asset.

Resource degradation and crop disease. The late 20th century saw major shocks to the agricultural production systems of Uganda due to natural phenomena. Some of the major banana growing regions were no longer productive by the end of the century and new areas were opened up to compensate for this. Highly degraded soils were the proximate cause. There were also major outbreaks of disease, the coffee wilt virus and the cassava mosaic. These had devastating effects on plant health and production levels and prompted researchers to rapidly reorient their research efforts to develop new varieties. Such attacks may continue in the future until the underlying causes are better understood. The introduction of Nile perch has also had huge impacts on other fish species in Lake Victoria (Okaronon et al 2004). Climate change may also increase the risks of such catastrophic events. This could be an area for more INRM research.

Demographic change

There are several demographic processes of importance. First, the number of births per household remains high and this will lead to ever increasing absolute numbers of rural and urban people. At the same time, there is continued movement from rural to urban areas so that growth rates are much higher in cities and towns. The food tastes of urban consumers normally differ somewhat from those in rural areas, especially if accompanied by higher incomes. HIV/AIDS and some other diseases are having effects on the overall population growth rate, but absolute numbers are still growing meaning that farm sizes continue to shrink. HIV/AIDS has other debilitating effects such as on the labour force and on funds for investment and certainly the identification of INRM practices or enterprises that do not require much labour or cash, will be of priority for this group of households (Yamano and Jayne 2004). To prevent HIV/AIDS or other shocks from derailing the development plans of households, it will also be important to identify ways for households to build up their assets (such as in livestock or trees).

Market development. The Plan for the Modernization of Agriculture calls for increased commerialisation of agriculture on the input and output side. Fortunately, Uganda's economy has grown at respectable levels and this has expanded opportunities for higher value commodities such as milk, vegetables, fruits, and meats. But this demand has been quickly met by farmers and gluts of products have emerged (Foodnet 2002.). Researchers need to keep abreast of opportunities for value added processing and even export markets (e.g. to the huge and expanding urban areas in China and India). The link between markets and INRM is strong; investments in soil conservation and fertility and water harvesting have been found to be much greater on high value market oriented enterprises (Place et al. 2003).

Biotechnology

This is a controversial topic, with some countries wholly embracing a wide range of biotechnology including genetically-modified organisms while others have completely eschewed them. At an international level, there may be reasons to use GMOs in agriculture or not to (e.g. there may be markets that favour and disfavour them). Irrespective of where different civil groups stand on the issue, it may be wise for research institutes to learn more about them, their potential benefits, and their potential adverse consequences. Researchers need to play a vital role in shaping public debates on the topic.

Agricultural technology generation and delivery systems

In Uganda, the main agricultural research and development organizations may be classified as the national agricultural research institutes under NARO, the universities and colleges, the international research centres and other foreign entities (such as universities), the national extension system (NAADS) and other governmental technical branches, and non-governmental organizations (both large and small and inclusive of projects).

All of the above are worth mentioning in this synthesis, because they can all generate "international developments," or contribute to "best bet techniques" or "state of the art" methods. Moreover, all are very active in Uganda. The lines between research and development have become more blurred as research institutes are being challenged to show impact and development organizations are asked to understand what interventions work best for different farmers or in different environments. For example, much good research on soil management has been undertaken by NGOs in east Africa, including Sasakawa Global 2000 (Uganda, Ethiopia), SOS-Sahel (Ethiopia), and SacredAfrica (Kenya). It is sometimes difficult to clearly demarcate the research or development boundaries between the different organizations. However, considering that overall funding for agriculture is low, it is important that the different organizations communicate well one another, understand each others' strengths, and invest more human and financial resources in sharing information with one another.

A Review of the Literature

In this section, we address separately the state-of-the-art in soils, water, trees and forests, and fisheries as such a structure is most amenable to the papers that were received. However, the integrated nature of NRM, even within a given

natural resource (e.g. integrated soil conservation and fertility practices) is highlighted. We follow these resource-based discussions with a broader overview of the natural resource management that addresses issues of integration across resources, property rights, and conflict resolution.

Soil management

It has been forcefully argued that soil depletion is one of the key causes of low agricultural productivity, itself a cause of rural poverty in Africa (Sanchez et al. 1997; NEPAD 2003; FARA 2004). Soil depletion is created by poor land conservation practices coupled with very low levels of nutrient inputs by African farmers. In looking at a research agenda whose goal it is to overcome such problems, this section discusses all aspects of soil health, its conservation, physical structure, chemical composition, and biological life.

Achievements in approaches/methods

There are *in situ* and ex situ soil management techniques that can benefit agricultural production. *Ex situ* techniques are largely related to erosion control and would constitute an important component of watershed protection strategies. To manage problems at watershed scales it is necessary of course to engage with a wide set of communities and individual households. Decades of watershed work in India has revealed that important success factors are: work on the most critical problems (often water in the dry areas), devise means to overcoming externalities inherent with managing watersheds, and identify mechanisms to work out sharing of costs and benefits between different groups of society (Kerr 2002). As for farm level management, there may be some efficiency gains from working with communities, but a large number of research and development projects have also worked with individual farmers. Because many SFM options are knowledge intensive, it is not apparent that either approach is superior in all aspects.

The starting point for working with communities or farmers is to understand specific soil constraints in the overall context of the rural economy and agro-ecology. There are many useful approaches for understanding the linkages between soil management and the local context. Delve and Rootheart (2004) argue that for improved soil management (or natural resource management in general) there needs to be monetary incentives through much tighter linkages to market opportunities. Chhetri (2004) adds to this by highlighting the importance of capacity building of farmer organizations in forming business plans. Semalulu et al. (2004) similarly present an integrated approach to NRM and describe several examples from projects in Uganda. They also provide good examples of how useful tools such as decision trees can be in uncovering critical constraints and opportunities within a community. Chovweri et al. (2004) describe a method used to engage with communities for improved technology development in Nigeria. The paper provides good examples of the types of information that can be collected through different participatory tools.

It is important to investigate the particular nature of soil problems because they are wide ranging from different nutrient deficiencies, acidity, low organic matter, poor water holding capacity, low clay matter, soil crusting, to shallow top soil. These can easily be detected by laboratory analysis, but only recently have new methods been developed to be implemented in a practical way across wide areas. One is the use of spectral analysis of soils that can be used to provide laboratory quality measurements of a number of soil characteristics (e.g. phosphorus, nitrogen, carbon) (Shepherd and Walsh 2002). These must be done centrally and thus are of more practical use to researchers and other service providers. A second thrust has been to develop simple tools for farmers to use to detect limiting soil constraints. These have been developed with farmers using their indigenous knowledge and include detection factors such as crop plant appearance, prevalence of certain weed species, and soil colour.

In the design of soil management practices, a large body of evidence has demonstrated the importance of involving farmers throughout the research and development phases. Reasons for this include the fact that the soil management systems are knowledge intensive and often new to farmers, soils are heterogeneous and there is no single "blanket" option that is most efficient even across a single farm, and it is obvious that previous approaches have not worked to lead to high levels of adoption. Within this participatory process, farmer designed experimentation must be encouraged from the outset to speed up learning processes. It is also critical to involve the poor and women farmers in technology development activities. If not, the innovations made by the better off farmers may be inappropriate for them (Defoer 2002).

Because soil management options are knowledge intensive, one cannot expect to disseminate information about them at a single event. There needs to be sustained interaction with farmer-testers. This is all the more so for the poor and women who often miss chances to attend dissemination events because of poor health, obligations to work to earn income, or because women generally have many competing responsibilities. But systems for monitoring and communication are weak throughout the agricultural research and development community. Similarly, given the number of rural development projects, there are very few well-designed impact assessment projects (see Mathur and Pachico 2003 for CIAT conference proceedings on the impact of agricultural research). Neupane (2004) reports on one assessment carried out in Nepal in which quantitative household baselines were later followed up. Other studies have engaged in qualitative assessments or have tried to integrate the two (see Meinzen-Dick et al. 2003 for a review of several integrated impact assessments).

Achievements in knowledge, technology or strategy

Soil processes

There continues to be more and more knowledge and understanding about soil constraints and their causes. For example, there is greater understanding of the role of soil carbon in soil health, nutrient cycling processes, biological nitrogen fixation, the relationships between soil degradation and nutrient status, leaching processes, mineralization processes, and nutrient balance inflows and outflows.

Even without systematic analysis and classification, there is no doubt as to the high variation in soil quality and soil constraints across a nation, a region, a community, and even a farm. The notion of developing a discrete set of management options that would apply to wide areas has been dismissed as a misguided strategy of the past. Given limited human and financial resources, research systems will never be able to conduct soil experimentation on all significant types. This has led to the growing support for the strengthening of local innovation processes in which farmers are equipped with the proper tools for analyzing soil constraints and the principles for dealing with them (Pretty 1995).

There is greater knowledge about how different soil and nutrient dynamics function. For example, there is much more known about the biological nitrogen fixation (BNF) capability of different plant species as well as the contribution of BNF to the total amount of nitrogen they added by the plant (Jama et al. 2003; Giller 2001). Similarly, cycling, mineralization, leaching, synchrony, and gaseous emissions have also been measured for certain plant species and certain soil types. Certainly, much more is unknown, but some general patterns are emerging. This holds true for some of the other macro nutrients as well. The potential for green or brown manures to facilitate the availability of other soil pools is also being studied in ISFM systems. Lastly, the roles of organic matter, macrofauna, and micro-organisms in soil health regulation are beginning to be uncovered and Baaru et al. (2004) show that organic resources increase the level of soil microbial biomass.

In sum, while there is more research to be done to be able to fully understand why certain interventions work in some circumstances but not others, we are at a point where there is confidence in the technical effectiveness of a range of soil management options, which we describe below.

Technical options

A wide range of technological options for soil conservation and soil fertility improvement have been developed and tested and shown to be technically effective in raising short term yields and in protecting or improving the longer term health of the soil. For many of these, social and economic analyses have also been done to determine that they are profitable and adoptable.

There are now a large number of soil conservation technologies that have been found to be effective. It has been long understood how to erect effective structures in terms of techniques, location along the contour, spacing between barriers, etc. A key issue has been that these are rarely practiced as recommended. There are an increasing number of adoption studies however (Gebremedhin and Swinton 2002 for Ethiopia; Hatibu et al. 2002 for Tanzania) and Katwijukye and Doppler (2004) analyze adoption of soil conservation practices in central and western Uganda. They find that adoption is more likely the greater is the farm and cultivated area, the degraded land area, and diversification into non-staple foods. This shows that household are motivated both by positive incentives of higher returns and to negative consequences of degradation.

Recent research has attempted to increase the adoptability of conservation measures by reducing labour investments (e.g. through the use of naturally growing vegetation to form bunds) or to increase the value of the structure by planting species that also have other uses. A promising strategy for farmers with cattle is the planting of fodder species, such as napier or calliandra, on conservation bunds. This is popular in the smallholder dairy systems in Kenya. It is also possible to integrate high value trees into bunds that may have been formed by grasses or physical landscaping. In the Philippines, for example, farmers find that herbaceous contour bunds are attractive niches for upper storey timber trees (Bertomeu 2003). Another method for increasing interest in soil conservation appears to be with linking it to improved soil nutrient management, which can generate visible short-term benefits (Jones 2002). Katwijukye and Doppler (2004) found in a study across two distinct sites in Uganda that there is a strong association between the use of conservation methods and income levels. Conservation tillage techniques are yet another means for conserving soil and improving water use efficiency. The technical performance of conservation tillage systems has been clearly demonstrated on-station and on large farms. This has led to the interest of Zambia to promote the technology. But capital and herbicide costs, along with an ability to find sufficient biomass cover are constraints that have prevented significant use by smallholder farmers (Haggblade and Tembo 2003).

A growing body of research has analysed green manure systems. Examples are: herbaceous cover crops, dual purpose (e.g. grain) legume fallows, woody leguminous fallows, permanent intercrops (including scattered trees), biomass transfer systems, composting, and crop residue management. Areas of investigation include the types of species that can perform well under different conditions (i.e. for different soil constraints and agro-climatic conditions), the potential of species that have alternative products such as grain legumes, the integration of multiple organic nutrient sources and with mineral fertilizers, and the performance of these systems over time. Pali et al. (2004) use a farm level linear programming model to compare several different management systems for maize using farm data from eastern Uganda. They found that improved fallow and biomass transfer systems were much more profitable than no input or natural fallow systems and

that given existing resource constraints would be important components of integrated soil management strategies. A good overview of the profitability of organic and inorganic nutrient management options for southern African maize systems can be found in Waddington et al. (1998). There have also been some studies of soil health and vegetative productivity of pastures and rangelands. Sharma (2004) reports on research indicating that there are several options using woody (e.g. acacia spp.) and herbaceous (e.g. stylo) legumes resulting in dramatically improved feed production and soil health. Pathak et al. (2004) addresses a similar issue but through the description of what is considered a successful indigenous practice in India.

In general, many studies have found that despite the high labour needed for some systems (biomass transfer) or the foregone production involved for others (when land is under a fallow), organic manuring systems often perform better than continuous low input systems or natural fallow systems in terms of total production and net economic returns (Place et al. 2002). In addition, performance is often superior when there is integration of organic nutrients with soil conservation (Shapiro and Sanders 2002; Gebremedhin and Swinton 2002) with improved water management (Bationo et al. 1998) or with mineral fertilizers (Mekuria and Waddington 2002; Freeman and Coe 2002).

Nonetheless, there may be specific target niches for organics, mineral fertilizers and integrated systems. The use of all of them seem to be promoted by high value crop production – plots are often smaller, reducing the quantity of nutrients needed, and expected returns are higher (Place et al 2003). This has helped to support the paradigm shift of agricultural and NRM research and development towards a "market-led" approach. Good examples of how this is put into practice are contained in Delve and Rootheart (2004). They describe three different examples from Uganda in which a resource to consumption (through markets) approach has enhanced the investment in natural resources. Green manure transfer systems are mainly applicable to small plots because of their limited quantities both on farm and off farm. Green manures grown on a field can potentially cover wider areas (such as staple crops) but their size will be smaller, the smaller the overall farm size. In addition, many organic systems are untested for some crops. Mineral fertilizers have been shown to perform well for a large number of crops (of course with different compositions of nutrients) but are limited by cash constraints of households (or in some cases by credit constraints). Finally, while the problem of poor soil health among smallholders is well known (especially in Africa), there is less agreement on the first steps or entry points. Must output prices and market opportunities improve before one can expect significantly improved soil management?

Gaps

Though there is an improved understanding of soil physical and chemical processes in response to climatic events and investments, there is much less understanding of soil biology and the role that microbial populations play in short-term and long-term soil health (Swift et al. 2004). In fact, as Byarugaba (2004) indicates, almost 95% of microbial diversity is yet to be discovered and properly identified. It is known that micro-organisms play a vital role in biological nitrogen fixation, mineralization processes, and carbon stocks and thus there is good reason to believe that research to improve management of soil biology could have large payoffs (e.g. Baaru et al. 2004).

Although it is impractical for scientists to attempt to formally analyze all soils, it is still important for land users to know what types of soil problems are present on their farms in order to select options that will be effective. This requires developing simple and affordable tools that farmers can use to test for different constraints. This could include test kits or pictorial guides can show how different constraints manifest themselves in various soil or plant appearances. Some of these have been developed, but only on a limited basis. There is also need to be able to determine estimates of the prevalence of different soil constraints at the landscape and macro levels so that development practitioners from government or development organizations can properly plan their intervention strategies or programmes. For example, it will be vitally important to know whether or not phosphorus is a limiting nutrient that might render organic-based systems ineffective without corresponding complementary imports of phosphorus sources into the project area.

While a large volume of nutrient response trials have been undertaken, they have been rather limited in their geographical and crop variety scope. In eastern and southern Africa, by far the most widely used crop in trials is maize. Further, in order to have consistency across treatments, most trials use hybrid maize. Therefore, a significant amount of researcher designed soil fertility research that is not directly comparable to smallholder farmer practices. This is not to say it is irrelevant, for it is certainly not. However, it should not be seen as the pinnacle that it currently is and should instead lead to a large number of hypotheses that could be tested in a more complex farming system. Related to the limitations in terms of complexity of farming system, there has been much less research on integrated nutrient management systems than there has been on individual options (often phosphorus is added to organic manure trials, but that is mainly to remove phosphorus differences across plots and the amounts applied are well above affordable amounts for smallholders). As such, our knowledge of the potential synergies between small doses of organic and mineral fertilizers is limited to just a few studies.

Similar to the lack of wide area knowledge of soil problems, there is also a lack of understanding of what systems and species can work under different conditions (or which ones do not perform well under certain conditions) and for how long (residuals and sustainability). Again, the purpose is not to create detailed high resolution land use plans, but rather to guide the subsequent testing of locally relevant

options by extension and development organizations so that likely failures can be avoided and efforts can instead focus on more promising or best-bet options. The past two paragraphs point towards research avenues highlighted by a recent workshop (Palm et al. 2001): tradeoffs between alternative uses and management of nutrient sources, farm level systems modelling for evaluation of different soil management practices,

It is worthwhile to highlight the particular problem of low fertilizer use in Uganda, one of the lowest in the whole world (FAO 2004). From a technical point of view, nutrient additions could increase productivity of many of Uganda's agricultural commodities. Fertilizer is rarely used for a number of reasons including lack of information and high prices relative to returns (see Jayne et al. 2003 for an analysis of the fertilizer sector in Kenya). Both of these problems need to be solved if agriculture productivity is to progress beyond some modest increases from other types of interventions.

Lastly, there are environmental effects stemming from different nutrient sources and management practices. For instance, mineral nitrogen fertilizer can be leached through the soil and reach groundwater. The nitrogen from green legumes can become transformed into nitrous oxide emissions. All types of nutrients, organic or mineral, can be washed downstream if proper conservation techniques are absent. These are currently being studied on a limited basis (e.g. Millar et al. 2004) but more work needs to be done to be able to provide a proper environmental impact assessment and incorporate the results into recommendations.

Water management

It is estimated that in order to produce the anticipated increases in food production required by 2015, a 20% increase in water availability will be needed (IWMI 2002). However, rather than witnessing positive movements in this direction, there is a pronounced deterioration of water resources throughout Africa. Major problems include:

- unreliable rainfall
- little irrigation
- overuse of water upstream
- droughts
- waterlogging and salinization
- water pollution and soil loss
- poor groundwater management
- poor land management near waterways

Not all of these apply equally to Uganda. Uganda is fortunate to enjoy relatively plentiful and consistent rains compared to many of her neighbours. But the utilisation of this water has not been nearly as efficient as possible. Investments, in conservation, harvesting, storage, irrigation, and drainage have been very low. For example, only about 10% of irrigable land is estimated to be currently under irrigation (IPTRID 1998). Yet there is considerable knowledge about effective and even low cost technologies that are being practiced in other developing countries.

Achievements in approaches and methods

Emanating from a large number of recent participatory rural appraisals and other diagnostics has been the realisation that water problems are often mentioned as the primary concern of communities – both for domestic and agricultural uses (see the list above for a partial list). This has therefore led to the wide use of a watershed approach to natural resource management, indeed rural development, by projects and programmes. These are usually integrative projects, but they nonetheless place water problems as priorities and it is now commonplace for interventions to include an array of water management techniques as well as institutions.

In fact, major water problems, such as run-off, dried up streams, and flooding are often large area problems requiring collaboration across many villages. Thus, there has been more attention paid to the scale of intervention. Solving large spatial problems requires institutions that can bring together the relevant stakeholders from the wide areas (e.g. upstream and downstream communities). There are several good examples of this from Costa Rica, Peru, India, and Indonesia (Suyanto and Leimona 2004; Kerr et al. 2003).

Achievements in knowledge, technology and strategy

There is much more known about how hydrological systems function at plots and landscapes and how they are affected by different management practices. For example, the influence of different mosaics of vegetation as well as different types of vegetation on water infiltration and surface flows is better understood. The availability of digital elevation models, information on soil physical properties, and a variety of experimental results on water flows has enabled the development of reliable predictive models.

The concept of "crop per drop" has gained more and more importance and indeed water use efficiency measures for a number of crops, livestock products, and trees have been calculated. This has led to reconsideration of the promotion of relatively high water demanding crops (e.g. maize) or trees (e.g. eucalyptus) in drier areas.

With the need to use water more effectively and efficiently, a number of water management techniques have been tested in smallholder situations. For water capture (or "harvesting") at the plot or farm level, there are several proven technologies such as roof collection, roadsize harvesting, the establishment of water pans and ponds, the digging of shallow wells and various earth formations such as zai pits. At a community level, water ponds can also be used, as can be dams on natural waterways, shallow or deeper wells, and the protection or rejuvenation of natural springs. The use of these techniques has been illustrated for eastern Ethiopia by Gebre Michael (2004) and in Sri

Lanka by Chhetri (2004). Gebre Michael assesses different types of water harvesting technologies from the viewpoint of the community and finds that in a community setting, small dams, in-ground tanks, and natural ponds all have a role to play in fulfilling specific water functions.

Related to these measures would be water control measures – more than simple collection, these are required in some cases to divert water flows to prevent damage to land and other assets. These measures include drainage ditches, contour bunds, check dams, silt traps, gully fields, and a variety of permanent vegetative covers.

In terms of using stored or surface water more effectively, there are a number of gravity or power methods to bring water to fields or stalls where it is needed. Bringing up water from streams or shallow wells can be powered by diesel motor, by pedal or foot power, or by container with human or animal power. A range of field based irrigation systems have also been tested – including several precision irrigation techniques (bottle, drum, and drip methods).

Many of the water management techniques are also soil conservation measures. Further, like soil conservation measures, they both display strong synergistic interactions with soil fertility practices.

While the techniques themselves may be straightforward to implement, more challenging aspects have to do with distributional and ownership issues. Kerr (2002) notes that for India, these challenges proved to be insurmountable in a number of cases due to divergent interests and limited supplies of water.

Gaps

Water management at the community or larger levels is still problematic. This is partly to do with remaining uncertainty about the best vegetation mixes and mosaics for watershed protection and water productivity. But more importantly is the difficulty of identifying institutional approaches that can harmonize the different stakeholder objectives and can find compensation mechanisms to reward positive externalities and penalize negative ones. Property rights and collective action research are particularly needed for this.

There are many public works, such as dams and ambitious motorized pumping systems, that have collapsed after short lives. It is very important to study these failures and extract lessons from them, before embarking on more large scale investments.

At the farm level, investment in water management technology is costly. Evidence shows that the lion's share of farmer investment in water is for high value crops, such as vegetables. This is because the higher returns and because the availability of irrigated water is limited and normally insufficient for the larger cereal crop fields. If this pattern endures in the future, then further irrigation development will be limited greatly by the development of markets for high value crops. A big challenge is to develop very low cost irrigation methods that could be used judiciously to on cereal fields, for example to overcome dry spells during the growing season.

Tree and forest management

Two major trends have occurred that have increased the importance of trees in farming systems. The first has been partly revealed above, that scientific research has broadened the types of services that trees can provide to farmers (e.g. soil fertility, soil conservation, and livestock fodder). Second, particularly in Africa, the conversion of natural forests and woodlands into agriculture coupled with the stagnation in plantation forestry, has increased the importance of tree product supply from farms. Indeed, in many areas, there is more standing woody biomass on farms than there is off-farm, including Uganda (Place et al. 2001). Tree planting is also gaining increased attention by farmers with degraded lands (e.g. for woodlots) and where labour shortages occur (tree systems are normally much less labour demanding than crop or livestock systems).

Achievements in approaches and methods

Research methods for tree growth, production, and competition for resources are now well established, for station and on-farm conditions. Models have been developed to aid researchers with ex ante analysis, especially concerning system interactions (FALLOW, WaNuCLAS). An example is Hai et al. (2004) who developed a model to assess the productivity and soil health impacts from diversified agroforestry farms in southern China. The models help to understand the limits and potentials of alternative options and therefore can be a springboard for testing new land management options. Methods for identifying priority species, screening of species and provenances, collecting seed and managing nurseries are among the methods that have been tested across a number of sites. Training tools for development organizations have also been developed.

In forested areas, significant improvements have been made from the traditional "protection" paradigm and forestry officers as "policing" agents to one where the management and benefits are done in collaboration with the community. Uganda has been very progressive on this, developing management plans for its major forests and identifying areas for co-management and production activities. Good scientific and participatory research has underpinned this effort. However, implementation strategies are still to be realized in many communities. There are great capacity building and information dissemination requirements for such a policy change to become effected.

Achievements in knowledge, technology and strategy

There has been some progress made in screening a number of fruits and timber trees for different conditions throughout Africa. Decision support aids for trees are now rich with information about the potential performance of a species in different environments (e.g. ICRAF Tree Database). Further, there is increased understanding of how to select, collect, and store tree seed, how to more effectively propagate tree germplasm, how to establish trees on farms simply but effectively, and how to manage trees to optimize the yield of different products. Much of this has come from researcher managed trials in the region, but insights have been gained from studies of local management practices and knowledge (e.g. Boffa (1999) for the Sahelian parkland species). Okullo et al. (2004) describe local knowledge of the shea butter tree and how farmers can predict fruit production of individual trees prior to the fruiting season. Such indicators are valuable for devising management techniques. Similarly, Sekatuba et al. (2004) surveyed farmers about their utilisation of indigenous trees for fodder and described the farmers' knowledge about different properties of the trees. They show that the two most preferred indigenous fodder species are rarely planted or managed intensively indicating that there is huge potential for impact if researchers and farmers could continue experimentation with these species.

Thus, there is a range of trees that Ugandans could potentially grow (or manage, if off farm) with minimal technical support. However, there are three key questions to answer for potential smallholder tree growers: what niches can be found for the trees on the farm (i.e. aside from a devoted woodlot area), how long will it take for the tree products to mature, and will there be a favourable market for the products? There have indeed been considerable research efforts to look at potential niches for trees. It was early mentioned that contour bunds is often an attractive area and a number of species have been found to perform well in intercropped fields, with cereals, with bananas, and with tree crops such as coffee without having adverse effects on the intercrop. In many cases, the integration of trees can increase overall plot productivity (examples include markhamia, calliandra, grevillea, croton, acacia, papaya). Particular attention should be paid to the coffee systems of Uganda that are under threat from poor world markets and diversifying the income producing enterprises on the plot could encourage farmers to sustain these perennial systems.

In terms of reducing the length till maturity, the most obvious advancements have taken place with fruit trees where successful grafting techniques have been demonstrated for a wide variety of tropical and temperate fruits (e.g. in Kenya, Cooper et al. 2003). When used with scions from productive individuals, time to bearing good yields of fruit can be cut from 5-7 years down to 3 years. In addition, there is much less uncertainty as to the quality of the fruit from known scion parent. There have been other advances in the quality and growth rates of trees from natural selection and sometimes molecular engineering (e.g. Australian eucalyptus and acacia). For fertilizer tree systems, research has helped to shorten payback periods by selection of good species and by management techniques such as establishing the trees into an existing crop toward the end of the rainy season (which can reduce the number of seasons under fallow by one).

The value of tree products to farmers or communities will nonetheless be limited unless there are good market opportunities. Farmers throughout east Africa supply the construction industry with poles and in some places it is one of the more profitable enterprises for farmers (in Ethiopia, Jagger and Pender 2000). There are possibilities for farmers to supply large scale tea (as they do already in Uganda, Raussen et al. 2002) and paper and pulp industries. In India, smallholders supply an overwhelming amount of domestic pulpwood from poplar woodlots and intercrops small farmers (Puri and Nair 2004). Uganda offers a great climate for the production of hardwoods, but whether small farmers are willing to produce such long-rotation trees is doubtful. These will need to be grown in off-farm settings, either in plantations by single farmers, the forestry department, or by groups of smaller farmers (e.g. in productive zones of forests). Forestry researchers in Uganda and elsewhere have already developed techniques for propagation, establishment, and management of a number of good timber species.

There have been several studies of fruit markets and potential in Uganda. These conclude that there is some potential for expanded production both to satisfy domestic demand (sometimes substituting for imports) as well as increasing share of export markets (USAID 2002). On the other hand, there is keen competition from many countries in both tropical and temperate fruits. In general, there is a lack of market analysis and especially trend analysis for all types of tree products at the national level.

Gaps

One major research gap would appear to be market analysis for tree products. Like many other crops, there are countless examples from around the world showing how easily tree product markets can become saturated (eucalypts in India, gmelina in Philippines). Because tree growing is a long term proposition, farmers will need some degree of confidence about future markets and sales value. Related to this, research is also needed to find mechanisms that can better link smallholders with market opportunities, for example through contract farming. Expanding demand through increasing value added processing of tree products is similarly needed.

Another major area of research concerns germplasm supply and distribution systems. Traditionally, tree seed has been in the domain of highly centralized forestry departments and NGOs, both of which have tended to

distribute seed without charge. But there is great need to create a decentralized system that will involve payments for germplasm involving the private sector where sensible. There needs to be greater understanding of which cases require high quality germplasm and perhaps standards and regulation (e.g. with fruits) and those cases where decentralized and relatively little supervised are preferred (e.g. for fertilizer or fodder trees, where the numbers required are high).

Of particular interest for forests and woodlands are the potential opportunities for commercialising non-timber forest products such as medicines, resins, mushrooms, thatch, charcoal, and ecotourism. A range of natural medicinal products have been or could be produced from a number of plants, but legal obstacles have prevented them from formal marketing within the country. There are a number of other locally important products such as shea butter and gum arabic from the northern parts of the country. While it is clear that many people do obtain vital subsistence commodities from the woodlands and forests (Cavendish 2000), the potential for larger scale commercialisation of many such products has been questioned (Arnold 1994). Of concern is not only whether communities may actually generate income from these products or services, but whether the relatively poor will benefit and who (or what rules/incentives) will protect the long-run sustainability of the resource. More research on profitable wood product industries and the necessary institutions and policies that would support them is needed to ensure domestic growth in these opportunities.

Natural and Man-Made Fishing Resources

With Lakes Victoria, Kyoga, Albert, George, Kachera and others, a large number of communities are engaged in fishing for subsistence and income. Fish provide a percentage of protein and in Africa is often a cheaper source of protein than livestock or milk. The annual catch from Lake Victoria is estimated to earn Ugandans about $80 million (Okaronon et al. 2004). Developing countries as whole provide two-thirds of the fishing volume consumed globally, about half of this supplied by China (Delgado et al 2003). Of this amount, just under a third comes from farmed fishing or aquaculture. Global demand for fish has bee rising sharply and is expected to increase from 93 million metric tons in 1997 to 130 million metric tons by 2020 (Delgado et al 2003). Furthermore, this increased demand is expected to be accompanied by a rise in price, because of the decline in catch from traditional fishing waters.

Fish consumption is also strong among Ugandans in many parts of the country. Aquaculture was once popular among Ugandan farmers in the 1950s and 1960's, only to be abandoned during the civil strife of the 1970's (Jagger and Pender 2001). However, the sector is growing once again with around 8,000 fishponds in operation. Yet, the production of fish from aquaculture amounts to less than 0.1% of the total catch from lakes and rivers.

Achievements in Approaches and Methods

Advanced scientific methods have enabled scientists to understand wider aspects of aquatic ecosystems through sampling of its components, such as reefs, plants, or fish. Sampling methods are available to be able to extrapolate samples of fish to larger populations of lakes (e.g. Okaronon et al. 2004) and other aquatic species such as invertebrates (Sekiranda et al. 2004). By using isotope methods on fish samples, it is possible to identify the various sources of food intake, with a sufficient level or reliability (Mbabazi et al. 2004). Other methods are being applied to study nutrient flows and into and out of water ecosystems as well as the decomposition and release processes within the systems (e.g. Masifwa et al. 2004).

Achievements in knowledge, technology and strategy

There have been a number of empirical findings of relevance to fisheries in Uganda. First, there is good global level information about the potential demand for fish, suggesting that Uganda may be well placed to profit from continued increases in demand. Second, progress is being made on techniques of fish farming (e.g. structures, fish varieties, feeding systems, maintenance, offtake), and this practice is expanding worldwide, including in Uganda. With it many wetlands and lowlands, Uganda is once again in a good position to expand output.

The submitted papers to the conference focused on natural fishing grounds, especially the lakes. The papers have demonstrated that these aquatic ecosystems can be described whether large or small (e.g. Mbabazi 2004; Okaronon et al. 2004), that we can begin to understand more about the relationships between the plants, macrofauna, water quality, and fish components (Masifwa et al. 2004; Sekiranda et al. 2004), that we can assess and monitor the composition of fish populations (e.g. Okaronon et al. 2004), and that we can characterize the feeding needs of fish and indeed the food chains (Mbabazi et al. 2004).

All of this enables progress to be made in terms of maintaining ecosystem balance, influencing changes in fish species composition, and providing some guidelines for sustaining specific fish species.

Gaps

The link between nutrient loads and other pollutants on fish composition, diversity, and quantities continues to require further study. The understanding of general principles requires the study of processes in a number of sites because these processes depend on the existing composition of fish, water inflow and outflow sources, water depth/volume, among others.

In aquaculture, both carnivorous and herbivorous fish are being raised. For carnivorous fish, a continuing worry has been with the high and volatile costs of fish feed (because of competition for use in livestock production systems). Research on reducing the costs of these feeding systems is needed. a large

Other resources

Communities manage a series of other resources not formally covered here, including rangelands, woodlands, forests, roadsides, hilltops, etc... We have tried to mention them in the previous sections where relevant and where information was available. The lack of attention to them does not imply that they are unimportant. It is only due to space considerations as well as the ability of the author(s) to review and synthesize across such a wide scope.

Fauna resources have not been discussed in any detail here. We have not discussed the role of livestock in natural resource management mainly because all the contributed papers on that topic went to theme 4, where indeed livestock technology is housed. But it goes without saying that livestock play an important role in natural resource management, positively, for example, through recycling of nutrients as manure. Livestock may also have negative consequences on natural resources if densities become too high. This may result in hardsetting of soils, in degradation of vegetative cover, in destruction of seedlings and saplings, and in consumption of high shares of water resources. Such effects must always be considered in the promotion of livestock production systems.

A second important area of fauna management concerns pests. Again, this was not discussed because of its link to crop technologies in theme 4. But pests can be influenced by different soil and vegetative management options. Organic nutrients can increase soil microbial populations as well as those of key soil engineers. On the other hand, the introduction of new species, for example trees, may also introduce pests that are harmful to other agricultural enterprises. Again, the environmental consequences of new technologies, practices, or species must always be assessed prior to widespread recommendation.

Broader issues related to integrated natural resource management

Two issues of concern to each of the natural resources are property rights and conflicts. Natural resources are often governed by a multitude of formal and informal law and regulations. For example, land use and management is affected by ministries of land, agriculture, environment, and energy as well as by local customs as established by traditional rulers or judicial systems. Furthermore, across many landscapes it is possible to identify land (and other) resources that are legally owned by the government, by social groups, by private enterprises, and by households or individuals. Thus, the management of larger natural resource management problems is complex. Nonetheless, it is possible to devise property rights systems that can provide proper incentives so that society's interests are met as best as possible.

The fact is, however, that property rights systems are often unclear or poorly aligned with improved natural resource management. The case of Uganda offers several such examples. Prior to the 1998 land reform, there was conflict between the formal tenure law and the customary practice. Essentially, the legal policy was only on the books and not enforced. But even after the land reform, some tenure problems exist. One example is on farms in the mailo areas where strong rights are held by more than one household to the same piece of land. The authority over non-gazetted forested land remains unclear as the central and local governments both claim some decision-making power. How much powers local communities may exercise vis a vis the forest department on the management of forest production zones is also not yet tested. All this will require considerable attention and monitoring.

Conflicts over resource use and benefits are inevitable. Much of the reason of their inevitability is that property rights systems are rarely satisfying to all parties. It is very difficult to devise and enforce rules of resource use that do not give rise to conflict. That is because one particular use of a resource may preclude another use. For example, if one person uses a tree for firewood, another user cannot use it for resin or fruit. More water harvesting upstream can mean less harvesting downstream. The likelihood of such competition for resources increases with population pressure. A second major reason for conflict is that the effects of resource use/management may spill over to other resources or landscape areas. A farmer or logger who removes vegetation on a hillside may cause increased water and soil runoff on plots further down the hillside. They may also increase sedimentation of waterways and harm fishing areas. They may also reduce the numbers of key pollinator species. The simple planting of a tree near a farm boundary may lead to conflict with the neighbour over competition for water, light, and nutrients. As a result, conflict resolution is a key area of natural resource management research and development. Systems for resolving conflicts need to be developed at various levels including international levels. As we repeatedly read in the press, conflicts over fishing rights in Lake Victoria and about water offtake on the Nile Basin are high profile areas of contention between Uganda and other African countries.

There have been several major initiatives to develop sustainable INRM projects or programmes at both watershed and community scales. A good example of a partnership between international researchers, national researchers, governments, NGOs, and local communities is the Mashreq and Maghreb project (Thomas et al. 2003). Through participatory approaches, researchers have been able to assist communities with technological and capacity strengthening interventions. But the key has been the development of a process that can be sustained by the community as external support reduces over time.

Principles for developing successful INRM have been developed and discussed in Harwood and Kassam (2003). These are:

- Creation of short-term interest and commitment
- Clear partnerships built on trust
- Cross-disciplinary teams of research and development
- Enabling governance and policy
- Local organizational capacity for collective ation
- Innovation and feedback processes
- Access to information
- Effective research design
- Shared problem and opportunity focus
- Effective facilitation and coordination
- Explicit strategy to scale up and out

Summary and Recommendations

Summary of Main Progress

Progress in the area of INRM research can be grouped into the following areas:

- Advancement of tools for studying natural resources
- Integration of indigenous knowledge into NRM research
- Improved empirical knowledge of how natural resource systems work, how they are related to each other, and how they respond to management
- Improved understanding of how natural resources are used by different users
- Development of practical NRM techniques

These advances have taken place with respect to all the focal resources of NARO as well as their integration. These provide an adequate foundation from which to proceed with an adaptive and applied research agenda.

Priority Directions

Obviously, the research gaps identified are huge in scope and number. There will be need to prioritize: across themes and within themes. The first recommendation is to develop and practice an ex ante impact assessment system. A sound framework will subject all major research directions and possibly individual projects to the test of generating productivity, income, or environmental impacts. As such, the ex ante impact assessment needs to embrace the notion of market oriented research, as recommended by several of the papers.

Without such analysis it is difficult to transform the "global research gaps" indicated in this paper into a sensible agenda for Uganda. Certainly, much can be learned from analysing research conducted in other countries. But there will be a certain amount of research required to develop a good ex ante impact assessment process. For instance, to be able to predict income impacts, there needs to be some basis on which to select reasonable prices, quantities of output that can be absorbed in the market, and the extent of adoption of innovations. If these are not available, some research would be implied. Similarly, there needs to be some basic information available on likely productivity or environmental impacts of certain types of interventions. Clearly all of this iterative – ex ante impact assessment research is meant to be "lean" in the sense of being not overly cumbersome or lengthy so that it does not bring other research activities to a halt. Over time, almost all research results will feed into and help to improve impact assessment analyses.

The fundamental questions for this theme will revolve around "what are the key natural resource problems and opportunities to work on," "what interventions work under which situations," and "what processes will enable the greatest impact to occur?" Several gaps have been identified under each of these major questions, including lack of basic information about the state of the resource base (e.g. biodiversity measures), how various NRM practices lead to positive or negative externalities, and how to engage in meaningful collaboration with a significant number of communities.

Independent of the research direction, it will be necessary to identify clearly the clients for the research results. Most likely, there will be many, such as fellow scientists, extension professionals, the private sector, and policy makers. Strategies for translating research results into useful materials for these groups will be important to plan for.

Challenges for Research

When priority research directions are identified, it will be important to make the most efficient use of the research undertaken – that is to be able to link results from different pieces of research and to generalize results to beyond site specificity. So careful consideration must be given to research questions, hypotheses, site selection, research methodologies, and data collected. In the submitted papers, several of these aspects were often missing. There were several papers that provided interesting descriptions, but without hypotheses or how the research builds on previous work or would fit into future work. Also, though much of the research is conducted in communities or farmer fields, the contextual description was generally insufficient to be able to draw lessons for how results depended on specific criteria.

An example is that scale effects were neglected in a number of papers – that is the analysis of whether specific interventions in a plot, farm, or community can be replicated. For example, can local successes be replicated across other sites? Where are the agroecologies similar? Can much additional production be sold on the market? Can plot erosion estimates be linearly extrapolated to surrounding plots?

An important driver of NAROs research agenda is market orientation and income generation. How market orientation is to be integrated into the research agenda needs careful attention. A project working in a small community might, with nothing more than better information, be able to improve incomes through increased commercial activity.

But if the intervention area is now a region, the possible gains from simple information improvement will have limitations. At some point, efforts in developing new value added activities, reducing inefficiencies, or expanding market reach would be necessary. This requires careful research planning by NARO at a national scale.

The allocation of researcher time between intensive involvement with relatively few communities over a period of time versus wider more extensive coverage is a tradeoff to be evaluated. It is difficult to understand how social or natural resource processes work without committed long-term research. On the other hand, the cost of that might be lost opportunities to work with a larger number of communities and farmers which may reduce the ability to extrapolate research results. It is likely going to be optimal to strike a balance between the two. In either case, participatory research processes have become mainstreamed and will be used. This is a very positive paradigm shift, but it has also been found to lead to a blurring of the comparative advantages of researchers and development specialists. It is important that researchers clearly identify their value added in such participatory research processes so that they are able to have the impacts nationwide that NARO is expected to deliver.

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