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Technological options that respond to demands and market opportunities with focus on crops and livestock

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Abstract

Technology development is a core area of agricultural research, and the increasing global focus on client-demand and market opportunities is intended to increase its relevance and effectiveness. This theme focuses on the achievements of and lessons learnt from technological options developed for crop and livestock systems including breeding, management practices and processing and appropriate technologies, knowledge, information and methods that enhance productivity, value addition and the competitiveness of the products in both national and international markets. A number of research providers as well as public sector bodies such as national agricultural systems and universities, non-governmental organisations which have links to broad farmer networks have become increasingly involved in research activities. Consequently, agricultural researchers have and are continually developing a broad range of technological options to secure the production of safe food and non food cash crops and to achieve the most efficient and ecologically sound use of natural resources; soil, water and energy. It is however apparent that farmers prefer packages of information-not just pest management strategies alone but a total package including other aspects such as soil and weed management options.

Key words: Crop and livestock systems, market opportunities, technological options

Introduction

In Uganda, a new national agricultural research policy (NARS Policy, 2003) has been formulated and is under implementation. This policy is based on a new, modified vision, mission and objective. Five research themes are identified within the framework of the National Agricultural Research Organisation (NARO's) research strategies, of which the fourth carries the title 'Technological options that respond to demands and market opportunities'. Technology development is a core area of NARO, and the technological options developed under this theme seek to enhance food security, enterprise profitability and sustainable natural resource base. This review focuses on the achievements of and lessons learnt from technological options developed for crop and livestock systems including breeding, management practices and processing with the aim of contributing to the development of NARO's and NARS strategic agricultural research plans. Where other themes focus primarily on the technology development process, in this theme, the outputs focus on appropriate technologies, knowledge, information and methods that enhance productivity, increase value and the competitiveness of the products in both national and international markets (Box 1). The technologies both cover techniques, which optimise quality, broaden utilization base and enhance the marketability, as well as tools and equipment. In other words the outputs indicate that agricultural research for development must improve crop and animal production qualitatively as well as quantitatively. Cross cutting issues and gaps are also described.

Box 1. Outputs expected from the synthesis of Theme 4

Expected outputs for Theme 4
Technological options that increase productivity of crops, livestock, fisheries and forestry resources developed and promoted.
Technological options that optimise quality, broaden utilization base and enhance marketability of agricultural products developed and promoted.
Appropriate farm power, tools and equipment that optimise production and processing developed and promoted.

Material

This review is based on of 52 papers (36 on crop/soil resource papers and 16 livestock papers) submitted under Theme 4 at the international conference. The review identifies achievements, best practices, key lessons learnt and gaps or options which are not represented.

In this paper the achievements of the crop and livestock contributions are discussed separately, but lessons learnt are brought together. In the crop sector the diversity of commodities in the 36 papers (fodder shrubs to mushroom cultivation), as well as a relatively large number of papers on banana research, makes it difficult to provide a balanced summary of achievements using a commodity focus. There were, however, clear distinctions in the approaches used to investigate technical options to improve crop productivity and therefore this grouping was selected for the crop science review. The 16 livestock papers, however, could be clearly ordered into six main topics, covering goats, poultry, pigs and cattle. Besides, the two topics 'disease control' and 'animal herds as part of farming systems' were included.

Achievements in crop/soil resource research

Generally the submitted papers demonstrate the broad range of achievements in crop research, largely in Uganda although papers were also received from Kenya, Malawi, Ethiopia and Benin. New technological advances in crop production such as biotechnology were not represented.

The papers also demonstrate that agricultural researchers have and are continually developing a broad range of technological options to secure the production of safe food and non food cash crops and to achieve the most efficient and ecologically sound use of natural resources; soil, water and energy. In the crop sector these options include plant breeding, seed technology, biological control and cultural practices, etc.. It was interesting to note that many of the papers addressed productivity increases and described participatory research and on-farm trials as opposed to laboratory based or on-station based work. In particular they described methods for assessing production constraints as well as the demands for and the feasibility of options to improve productivity. In all cases the target users were risk adverse farmers who have scarce resources in terms of time, labour or cash or access to markets. Few papers, however, made any specific reference to gender considerations and little attempt was made to disaggregate information by gender or by age, size of landholding, etc. Some exceptions are outlined in the review. In addition a few authors produced policy recommendations as key outputs from their research.

Participatory research and technological options that improve crop productivity

Many papers submitted under Theme 4 document participatory research processes to understand production constraints and identify gaps in knowledge on crop and soil management which require further research. Table 1 summarises participatory method which describe a range of technologies and research methods used to provide insights into farmers' perceptions and indigenous knowledge into these issues. In some examples, technologies were also evaluated with farmers. In addition to pre and post harvest crop production constraints, a number of papers describe approaches used to manage soil productivity, a major issue across sub Saharan Africa. In some instances the participatory approach was required because researchers found that many of the "recommended technologies" developed in the past were performing poorly on farms. To address this, research-farmer groups refined technical options to meet site specific needs and monitored the trials to understand the economic benefits of different regimes.

Seed delivery is the third area featured under Theme 4. Seed is one of the most important inputs in crop production and yet is relatively neglected especially with respect to legume and vegetable crops which can provide income and or nutrients. One of the significant features of the research findings reported in the seed delivery papers concerns the level of monitoring which has taken place and the existence of essential baseline information which will ensure that future impact assessments will have firm foundations. There are also examples where participating farmers have recognised the benefit of working as a group and in the potato project the primary seed multipliers registered themselves as a farmers association which is recognised by a national advisory service. All the examples in Table 1 demonstrate how viable frameworks can be created for farmer-research interactions which result in the development of relevant technology options for smallholder farmers. A number of lessons learnt are described in these papers but a major one emphasised by Woomer and Mukhewana (2004) is that special effort may be needed to ensure that participatory approaches are as inclusive as possible because some groups can be excluded for a number of reasons including illiteracy or lack of access to land, capital or time.

The participatory projects also provide some important lessons on demand articulation for technical options. Demand is a complex issue and consideration has to be given as to how is demand extracted/ articulated, whose demand are we talking about and dangers of misinterpreting demand (or extrapolating a single voice). In addition different socio-economic groups e.g., rich, poor, young, old, men, women will have different needs and will be able to exploit different opportunities. Some of the papers presented findings that described the processes involved in demand articulation. For example surveys have been used by teams to determine the status, management practices and socio-economic factors relating to crops. This allows researchers to asses and identify farmers' demands from research e.g., it records farmers' explicit demands, such as requirements for higher yields or improved seed, but, just as importantly, it also provides researchers an opportunity to capture implicit demands. These are other demands that farmers do not express often because they either confuse the causal agent/ pest or disease with something else (this is especially common with pests that are difficult to observe such as soil pests e.g., plant parasitic nematodes or tree pests) or because they are unaware of new opportunities. There are some

Table 1 Different participatory methods used for development and assessment of crops and cultivation techniques

Crop and theme	Research questions: technique developed/tested	Agroecological zone(s) or region(s)	Research method, degree of participation	Authors
Mushroom cultivation	Potential of high value crops (mushrooms), improving land use, providing income and food for rural communities	Kabale District, Uganda	Farmer surveys, indigenous knowledge recorded. Responses disaggregated by gender. Farmers tried varieties provided by researchers and improved access to urban markets identified.	Obaa *et al.* (2004)
Callindra calothyrus, pest management	Fodder production improved through pest and disease management	Lake Victoria crescent, Southern Drylands and Southern Highlands, Uganda.	Pre tested questionnaire; opened questions, local languages used. Responses cross checked with field observations.	Nyeko *et al.* (2004)
Mango and citrus cultivation	Improved varieties provided with technical information on crop management	Soroti	Surveys of farmers perceptions, trials of new cultivars in nurseries. New constraints identified e.g. water management, lack of participation by women, need to improve group management skills.	Sengooba *et al.* (2004)
Yield stability/acceptability of Irish potato	Client driven variety selection	Four contrasting sites in Uganda	Yield stability analysis and user acceptability during agronomic evaluation before release	Kakuhenzire *et al.* (2004)
Soil improvement	Understanding farmers' choices for selecting crops which can improve soil fertility	Chisepo district, Malawi	'Mother-baby' approach allows quantitative data from researcher managed on-farm 'mother trials' to be systematically cross checked with farmer-managed 'baby trials' with similar themes.	Kabuli and Kamoto (2004)
Maize production, Soil improvement and improved marketing	Working with self-help farmers groups to refine technological options	Western Kenya	NGO alliance comparing recommendations on intercropping, soil fertility management and marketing	Woomer and Muhwana (2004)
Seed delivery by farmers 1	Comparing delivery of seed by two groups: individual farmers and farmers groups	Lango farmin systems, Uganda	Baseline survey and monitoring of seed delivery over season	Obuo *et al.* (2004)
Seed delivery by farmers 2	Evaluating farmer led multiplication of groundnut	Eastern Uganda	Baseline survey.T raining on production technologies. Local leadership structures developed; group distribution plans	Tino *et al.* (2004)
Development of quality seed multiplication system	Irish potato; locally driven and monitored quality assured production methods to scale up clean potato seed	Kapchorwa eastern Uganda	Fairly prescriptive but simple technologies to assess and manage a major disease, bacterial wilt. Primary producers have formed an association which is recognised by the National Agricultural Advisory and Development Service	Namisi and Smith (2004)

interesting examples reported in the findings of the papers presented where opportunities are being explored with farmers. Obaa *et al.* (2004) and Sengooba *et al.* (2004) demonstrate the iterative nature of action research in that it can identify important research needs which are essential to underpin a potentially lucrative enterprise as well as providing technical solutions to production constraints. The farmers were unaware of improved varieties or market opportunities before the researchers explained their existence but gained interest when exposed to them. Farmers wish to continue with the programme but will need technical support once the research project expires.

These papers also demonstrate the diversity of research providers. As well as public sector bodies such as national agricultural systems and universities, non-governmental organisations which have links to broad farmer networks have become increasingly involved in research activities. Those organisations with a network can test options under a wide range of conditions and where promising recommendations emerge, their linkages can permit research recommendations to be rapidly scaled up. It is also apparent from these papers that farmers want packages of information- not just pest management but soil and weed management. Researchers are frequently addressing a combination of factors -not just yield, quality and user acceptability because they recognise that this improves the relevance and adoption of their recommendations. The paper on integrated rice crop management options in The Sahel by Kebbeh *et al.* 2004 emphasises this point. The final sub set of papers which involve elements of participatory research describe researcher-managed, on-farm trials supported by research in the laboratory, glasshouse and experimental station to explore the nature and behaviour of agricultural systems or their components in controlled conditions. Plant breeders for example use on-farm trials to select promising lines for release in combination with on-station trials. Busolo-Bulafo describes the evaluation of groundnut rosette disease resistant materials largely through on station trials although the use of participatory on-farm trials are briefly mentioned. Adugna *et al.* 2004 screened sorghum varieties for dryland conditions and three were selected by farmers. The names suggest that they had qualities which were appreciated by farmers "community survivor" " life save" and " hunger fighter". However, despite their efforts the team report that the improved varieties are still not well assimilated into the farming community because the varieties are sensitive to local conditions, including sowing depth, soil crusts resulting in poor stand establishment and a continued farmer preference for their own local cultivars. It is possible that these factors could have been identified earlier if the trials had been moved out of the station and into farms more quickly.

Gaps identified from the participatory research projects into technological options that increase productivity and optimise quality

Some major issues concerning impact indicators and sustainability need further discussion because they are not really addressed in th papers received. All the current indicators in the presented papers papers describe the benefits or outcomes of research as enhanced productivity or improved incomes. However, some of the dimensions identified by the poor include voicelessness, isolation and vulnerability, the eradication of which requires more of institutional change than just increases in income. In many cases, research can empower the poor through increasing their access to decision-making processes and reducing their vulnerability to economic shocks via asset accumulation. Agricultural research that leads to improved technologies can also benefit the poor through greater physical and economic access to crops that are high in nutrients and crucial to the well-being of the poor- particularly poor women. Should development of more nutritious and safer foods therefore be a key part of the modernisation of agriculture? Should we therefore be thinking of amending the stated indicators to reflect some of these more 'intangible' impacts such as improved health or greater participation in decision-making due to agricultural technology development? Additionally the impacts stated in many of the papers will only occur once the projects are completed. It would be a useful exercise to assess the outcomes of these projects 3-5 years after the projects end to really explore the advantages of these approaches. Given researchers perceptions that participatory approaches are expensive and labour intensive this must be a priority in the future if lessons are really to be learnt from them. Although it was not noted in the papers received it should also be remembered that participatory methodologies aren't necessarily a panacea for all development research. A DFID funded Crop Protection Programme project on beans in Tanzania found that the poorest women farmers in the selected communities preferred demonstration plots because they didn't have time to get involved in participatory research development. There is also the danger of particpatory rural appraisal fatigue especially amongst poorer groups who must sell their labour to make a living.

Basic research into technological options that increase productivity and optimise quality

The second major grouping of papers receivedunder Theme 4 concerns basic research into technological options. Basic research which largely occurs in laboratory or glasshouse conditions was reported in the papers on the early screening of cassava for resistance to root knot nematodes, use of starter cultures in the fermentation of bushera and seed transmission of *Fusarium xylaroides* in robusta coffee. They

provide essential baseline quantitative information on variety and or economic performance. Additionally the importance of detailed technical surveys to obtain valuable information on soil resources is recognied. These studies should underpin on-farm research because there is no point in testing completely unsuitable materials or varieties with farmers. Unless the resource base is described and/or the characteristics and nature of pests and diseases are understood, effective management strategies cannot be developed and rolled out to on farm trials. For example sweetpotato lines genetically modified to be virus resistant have not performed well in recent field tests in E.Africa because the researchers did not appreciate the etiology or epidemiology of the host-disease complex. These are expensive mistakes which cannot be supported by national or international research programmes. The challenge for research agencies and managers in the future will be the balance between the strategic and the adaptive research activities in a national or regional programme which will deliver outcomes required by policy makers and citizens.

Research findings from the National Banana Programme of Uganda and IITA (Table 2) reflects the importance of this banana in Uganda and the results relating largely to biological control and improved cultural practices elements awareness of the complexities surrounding the pests and the cropping system. The latter were outlined by Okech *et al.* (2004) who indicated that poor crop management in these systems is a consequence of land scarcity, poor marketing options and lack of assets which can be readily turned into cash. Farmers therefore, have little power to implement soil and pest management strategies in their banana crops and both are contributing to serious yield declines. The biocontrol options against two major pests, the banana weevil and parasitic nematodes, however, are being explored with the aim of developing an area wide management strategy which can keep populations levels to bellow economic injury and reduce the rate of yield decline. This technology requires detailed knowledge of the interactions between the pests and the control agents. In terms of biological control, *Beauveria bassiana* holds promise for the control of weevil borer (*Cosmopolites sordidus*) and enhanced trapping technologies for weevils may make the delivery systems for biocontrol agents more effective. Additionally biologically-enhanced and clean planting material which incorporate endophytes are being evaluated. Farmers may not need to know how these agents work in the development phase, but they will need to know if they are to be used on farm. The banana group are developing improved formulations and have undertaken adaptive trials on farm, but it is not clear whether the policy and biosafety frameworks exist to exploit the most promising biocontrol technologies? This was not highlighted in any of the papers revied yet it is an important issue since these agents are not chemicals like synthetic pesticides so testing and registration may require different protocols. Perhaps the team should put some effort into influencing the policy environment to improve access to the most promising technologies as well as refining and optimising the technologies.

Table 2. Papers submitted on the development and utilisation of biocontrol agents for the management of banana pests

Selection of assessment methods for evaluating banana weevil Cosmopolites sordidus (Germar) (Coleoptera: Curculionidae) damage on highland cooking banana (Musa spp., genome group AAA-EA)	*C.S. Gold, P.E. Ragama, R. Coe and N.D.T.M. Rukazambuga*
Use of crop sanitation for the management of the banana weevil Cosmopolites sordidus (Germar) in Uganda	*M. Masanza, C.S. Gold, A. van Huis and P.E. Ragama*
Effects of potassium deficiency, drought and weevils on banana yield and economic performance in Mbarara, Uganda	*S.H. Okech, P.J.A. van Asten, C.S. Gold and H. Ssali*
Integration of pheromones and the entomopathogenic fungus Beauveria bassiana for the management of the banana weevil.	*W Tinzaara C S. Gold, C Nankinga, M Dicke, A van Huis, P E. Ragama and G.H. Kagezi*
Kairomone trapping system for delivery of Beauveria bassiana to control the banana weevil	*V. Tumuhaise C.M. Nankinga C.S. Gold, S. Kyamanywa, P. Ragama, W.K. Tushemereirwe*
Evaluation of conidia production and infectivity of selected Beauveria bassiana substrates and formulations for the control of Banana weevil	*E. Magara, C.M. K. Nankinga, C.S. Gold, S. Kyamanywa, P. Ragama, W.K. Tushemereirwe, D. Moore, and S.R. Gowen.*
Merging biotechnology with biological control: Musa tissue culture plants enhanced by endophytic fungi	*T. Dubois, C. S. Gold, D. Coyne, P. Paparu, E. Mukwaba, S. Athman, S. Kapindu and E. Adipala*
Inoculation, colonization and distribution of fungal endophytes in Musa tissue culture plants	*P. Paparu, T. Dubois, C.S. Gold, E. Adipala, B. Niere and D. Coyne*

Technologies and tools that Optimise quality, broaden utilization base and enhance marketability

suprisingly a few of crop related papers submitted to Theme 4 concerned technologies to improve post harvest processing and to develop appropriate farm power, tools and equipment that optimise production and processing. These are critical areas of research since post harvest processing can add value to produce and therefore enhance marketability. Moncho and Fagbohoun (2004) compared two tomato pulping technologies for producing puree. The technology that uses common milling machines used in maize processing gave higher yield of puree than an expensive dedicated machine and the team believe that this was due to the contribution of manual processing of the tomatoes before they are placed in the milling machine. However, they recognise that the manual removal of seeds is time consuming and they inferred that this may not be cost-effective. A socio-economic comparison of the new and old technologies would have been useful in this study since it would provide for a cost benefit analysis of the technology but also a social survey on labour requirements and opportunities for marginalised groups. In the example of the motorised sheller provided by candia *et al.* (2004) a detailed economic evaluation was also absent, although a comparison of running costs in terms of fuel used per unit of grain milled was provided. This was one of the few papers in Theme 4 linked to the commercial sector. However, a comparison of the cost of the machine with the existing models and economic analyses would have helped in understanding the benefits of the technology to commercial millers and would appear to be critical before additional investments are made into new machinery. The paper on developing par-boiling equipment for paddy rice by Housson and Amonsou acknowledge economic evaluation as a next step in their research. The major question remains as to why so few papers on technologies to improve post harvest processing or to develop appropriate farm power, tools and equipment that optimise production and processing were submitted? Does the number and distribution of crop related papers submitted under Theme 4 reflect the balance of funding available in research agencies?.

Results from the livestock sector

General points

The findings reported in the submitted papers covered the four different animal species cattle, pigs, poultry and goat production. Four papers deal with livestock as a part of the farm, and five papers concentrate on disease control. The majority of papers present research conducted in Uganda, and one is a tudy conducted Nepal. Researchers, NGOs, farmers and institutions are represented, but the private sector is not really involved in research of this kind.

The papers discuss a range of technological options available within the livestock farming, such as breeding, feeding, daily herd and animal management strategies (including medicine management). Some papers opened questions as to which role, animals and the different animal species have in the whole farm, giving the technological option of utilising farm resources in the most optimal way through e.g., the choice of different animal species and numbers of animals. The focus of the technological options presented and discussed was primarily to increase yield and efficiency, or to improve quality of the animal products. Some of the papers dealing with medicine use and disease management aimed at minimising risk for disease and consequences of disease or disease treatments. Food safety issues were mainly described through this (the use and mis-use of medicine', and not in terms of e.g., zoonoses or residues of e.g., heavy metals.

It must be noted that no really new technologies were explored or discussed, and that only few of the papers included e.g., economically evaluations or described relations to markets or the surrounding society. All studies presented were carried through on-farm or in farming communities, and with the main aim to identify, develop and assess technologies. The actual use of participatory methods was generally not clear, and was given limited attention in all the research undretakings presented. Farmers were involved to some extent, but whether they had been involved in the problem identification or how the so-called 'sensitising' had taken place is generally not well described. The research teams seem to have identified the problem areas in details, and have planned the studies.

Gender issues – not understood only as 'women' but also e.g. children and disabled – are not apparent in all the studies. This does not necessarily reflect the nature of the projects, but only what the author groups have judged as relevant in this context. The same can be the case with the complexity, of which the presented results are a part of, but which are not discussed explicitly in relation to the results.

Goat production

Oluka *et al.* (2004) reports on the growth performance of indigenous and crossbred goats at Serere, while Ssewannyana *et al.* (2004) reports on theeffect of management systems on body weight raised under on-farm conditions. Indigenous goats are participating in both studies. There is generally not appropriate material for making good breeding plans and developing selection criteria. Different crossbreeds (Teso x Boer, Mubende x boer and pure indigenous breeds) were tested (Oluka *et al.*, 2004). Breed influenced the pre-weaning growth rate significantly. The Teso crossbred kids generally had higher body weights and growth rates than the Mubende crosses. The pure Mubende kids had a higher birth weight, but the growth

rate and growth characteristics generally were better in the crossbreeds, and in the Teso crosses in particular. Other factors also influenced the birth weight, and the different performance in growth rate was also interpreted as due to good adaptation to the local environment. The relations between management systems and body weight in indigenous Mubende goats were investigated (Ssewannyana *et al.*, 2004). The sex of the farmer was the most dominant influential factor through the pre- and post-natal period, and in the critical period of weaning. Kids raised by female farmers had constantly a higher weight than those raised by male farmers. The maternal factors, which are also partly influenced by the goat owner, also have a significant influence on the peri-natal period. Higher age and weight of the dam influenced the growth positively. Under free-grazing conditions there was a tendency that the growth was lowest in the beginning, but the weight was highest at the later post-weaning period, where the kid could use its own efforts to find and select good quality forages. In older kids, males had the highest body weight. Different sizes of does and bucks were mated (Oluka *et al.*, 2004b). The outcome is partly inconclusive because of an un-equal distribution of groups. Kids from large dams were significantly heavier than kids from ordinary dams, and the overall development indicated that doe size has lasting effect from birth to yearling weights. The effect could not be separated into genetic or non-genetic maternal effects.

Poultry production

Strategies for having improved the poultry production in Kumi and Apac districts are investigated (Ssewannyana *et al.*, 2004b). The two strategies were cross-breeding with Bowan Browns cocks and monthly vaccination against Newcastle disease. The effects were dramatic, e.g. the flock size per year per household increased with 195,6 % and mortality was reduced by 83%. The overall increase in yearly egg consumption per household was 510,7 %, and the involvement of both man and wife in the caring for poultry and the chicken house construction was improved during the project period.

Pig production

Piggery is explored as an enterprise through interviews of groups (8-46 people) of farmers, stakeholders and agricultural professionals (Sewannyana and Mukasa, 2004). Even though good market opportunities were identified for pork, the owners did not seem to fully appreciate their role in the agricultural system, and poor management mostly due to lack of knowledge seemed to be a major constraint to the production. In this paper it was concluded that the results from this production was better than for any other animal enterprise. In combination with the good market opportunities, more reasons for promotion of the pig production systems reported are raised. It was, however, pointed to the fact that more knowledge and better breeds are needed in order to improve. The types of pig production systems in this paper are systems where 1-15 pigs were kept for cash, food, marriage and financial security. Most sows had an average litter size of 7 piglets, and farrow twice every year. They were not housed, but lived mostly in tethered systems and lived from kitchen leftovers and mainly purchased from neighbours.

Results from a Nepalese study of the 'synthetic' breed Pakhribas are presented (Shrestha and Edwards, 2004). The authors concluded that restricted suckling in pig production systems, meaning restricted access for the piglets to suckle only at nights from 6 weeks of age (in the most restricted system) had a significant effect on the sow rebreeding interval. There was not any effect on the live weight of piglets or the body condition of the sows.

Cattle production

In a Kenyan study, Bebe had investigated smallholders' feeding systems based on data from an almost two-year period. He found that there was no significant difference between the *Bos Taurus* breeds with regard to milk production, although Friesians were fed almost 1,4 times more concentrate than Ayrshire and Guernsey/Jersey. In general, 4 times more was spent on purchased concentrate than on other sources of feed. It was concluded that milk production as well as reproductive performance reflect the low level of feeding due to limited cash flow. The author of this paper points to the possibility for membership of co-operative societies, which may help the access to better feed through credit arrangements.

Disease control

Improvement of diagnostic services is the focus in paper 8, where endemic livestock diseases are subject to the development of decision support tools. The value of a decision support card which focus on the diseases anaplasmosis, babesiosis, cowdriosis, fasciolosis, parasitic gastroenteritis, schistosomosis, theileriosis and trypanosomosis were tested through a Delphi expert panel. At the same time, the handheld hemoglobinometer HemoCue was tested on animals on 7302 cattle in Tororo and Busia districts, where it was concluded that it could improve the diagnosis significantly.

The results of spraying for ticks and tsetse flies with deltamethrin in Serere County, Soroti district, are presented (Ocaido *et al.*, 2004). Spraying every second week or every month improved body weight, body condition and packed cell volume. The mean tsetse catches per trap was also reduced dramatically. In this study it was concluded that fortnightly sprayings was a sustainable solution also from an economic point of view.

Okello-Onen *et al.* (2004) investigated tick and tick borne disease control practices countrywide in Uganda and identified 6 types of malpractices associated to the use of acaricides. The quality of the acaricides was found to be affected by the long transition period from import through drug shops and to the farmer. Farmers are not well guided on how to use these products. The products are often not labelled in the local language, and there are at least 15 types in three main groups on the market, which should be handled slightly differently. For instance, they are often diluted in a wrong way, which can cause acaricide resistance in ticks. Furthermore, it was found that it was very often not used appropriate, e.g., the spraying did not include any attention to the preference sites of the ticks. Besides, spraying was often done close to the water points causing pollution. The way dip content was handled seemed far more risky and should raise concern. Finally, the frequency of application was far from met, and should normally be influenced by the level of the tick-challenge and season.

The catches of *G. fuscipes fuscipes* in monoscreen traps were compared under high tsetse challenge conditions on Buvuma Island, Lake Victoria (Okello-Onen *et al.*, 2004b). Approximately 73% of the catches were females, and the difference between 4 different blue shades were not significant for the catches of female flies, where there were significantly more male flies being caught in the standard blue material. This shows that the locally-available material can be used instead of importing more expensive material.

The role of antibiotics in relation to the Contagious Bovine Pleuropneumonie is evaluated (Twinamasiko *et al.*, 2004). Antibiotics is claimed to encourage the development of carriers of the disease, but this is disregarded by many pastoralists. The study was carried out through cross-sectional and longitudinal observations in pastoralist environments, and analyses based on these observations which included treatment regimens. In fresh outbreaks, antibiotics reduced morbidity and mortality. In chronic outbreaks, only approx. a quarter of the treated cases (35 of 121) led to recovery, and in 17% of cases, the treatment had to be repeated before the severity of the symptoms decreased. The author groups also points to some disadvantages such as risk of under-dose because consistently high doses are needed to really control the disease, and therefore the risk of antibiotic resistance. Antibiotics should not be used as the only control.

Animal herds as part of farming systems

Leguminous forages like cereal or elephant grass supplemented with lablab hay or calliandra leaf hay was tested under on-farm conditions (Kabirizi *et al.*, 2004). Major benefits were improved milk yield and household food security. Major constraints were higher costs. Farmers' expertise and ability was supported through workshops, e.g. feedback workshops and cross-visits. Farmers collaboration was good, and the farmers identified benefits and constraints for including leguminous forages. Intercropping seemed more beneficial and efficient. Majority of farmers experienced increased milk yield, and more men than women increased household income from sale of milk. Many farmers expressed that this success attracted other farmers outside the district, and study tours were highly appreciated by the participating farmers. Among constraints, chopping the fodder was dominating and time consuming, and not many farmers had choppers. Land shortage was another serious constraint. Many positive experiences were accumulated with regard to the use of on-farm research and development methods.

A similar conclusion was reached where the restoration of degraded natural grasslands was investigated (Sabiiti *et al.*, 2004). One of the backgrounds for doing this was severe mismanagement of many natural grassland areas, in terms of weed and overgrazing. Increased milk yield on areas with improved pastures and bush cleaning was obtained. The nutrient status of the animals was clearly improved, and there was much more herbal growth on the areas.

The development of mixed game and livestock production in a national park is discussed (Ocaido *et al.*, 2004) where impala, zebra, Ankole-Sanga cattle and goats were communally grazing. The development of such systems were beneficial for the cattle ranchers, but not with pastoral households. The financial performance greatly improved by involving goat into the cattle-wildlife grazing scene. A major constraint, however, is ticks and tick-borne diseases. In the ranches, the costs of control of these diseases can still meet the benefit, where this is not the case in the pastoral systems: the use of wild animals in these mixed systems would only meet approx. 70% of the costs for control of mastitis.

A study was made to define constraints, causes, effects, gaps and opportunities on draft animal power (DAP) (Okurat *et al.*, 2004). Draft animals have been used since 1909 for opening land. Through participatory interview and group work methods of 90 DAP experts the 5 most important crops were ranked, as well as constraints in their production. Even though many procedures could have been performed by the use of animals, only land opening involved animals in current practice. Many diverse constraints within the areas of technical, animal health and nutrition, economic, social and environmental constraints were identified, and systematic training as well as a range of implemental strategies are now being redressed by the NARS.

Lessons learned in the crop and livestock sectors

The most apparent lesson learnt from the findings presented in the submitted papers and the discussions during the conference is that participatory research methods are being widely used in agricultural research for development in the crops and soil science sectors. The key lesions learnt are presented in Boxes 2 and 3. Based on the reviews it is clear that resource allocation technical support must be available for a number of years especially for perennial crops because outcomes and indications of sustainability will not be

Box 2. Achievements, gaps and lessons learned from the papers in Theme 4

Achievements

- Many technologies are available, which farmers can choose, and some of which can help the poor.
- Research has been moved nearer to end users, and researchers are responding to market demands. Increasing quality of the products because of market linkage (especially for the crop sector).
- There is increasing evidence of participatory approach at the planning stage, where target groups are involved.
- Increasing trend to integrate gender and poverty issues
- Increasing multidisciplinary approach is being used, much willingness from stakeholders and a wide partnership involved. Increasing numbers and capacity of stakeholders, and farmers becoming increasingly organised.
- Capacity building has been achieved at various level
- Major constraints to crop and livestock production have been identified and are continually being addressed

Gaps

- The poorest communities or members of communities appear to have limited access to current technologies. The dissemination process does not allow the poor to access them. Some are too expensive.
- The reaction time to farmers' demands are too slow, and there is little acknowledgement of the fact that farmers' and market's needs are very dynamic. Insufficient capacity in human resources and infrastructure to effectively respond to emerging issues, and long time lag before information, technological generation and publicity.
- Market linkage research is inadequate, and there is limited participation of the private sector in technology development. In some technical areas the number of researchers are inadequate.
- The demand system of the farmer is weak; the farmers are often not organised and do not speak with one voice. They are not properly empowered, and there is inadequate capacity for demand articulation.
- Poor management of research dissemination, ineffective scaling up of technologies
- More need to learn about gender – not only man/female issues.
- Indigenous technologies poorly researched.
- Need for socio-economic inputs to technological research.
- Measurement of impact of processes and partnerships are missing.

Lessons learnt

- Adoption is increased by market research, smallholder consultation, use of better pathways e.g. schools, and when working with the end users.
- Need to understand people before generating and disseminating technologies; underlying demands are not always understood or interpreted correctly.
- Technologies must be affordable, and working in groups may help the poor to access expensive technologies.
- The output of research is sometimes misinterpreted or misunderstood.
- Basket of options should be increased, and technologies should be appropriately packaged.
- Quality standards should be maintained.
- Policy development is slow, and there is a need to review policy on certification of technologies.

Box 3. Best practices and institutional implications / policy markers learnt from the paper submitted in theme 4

Best practices

- Clear definition of roles, and matching expertise with roles. Strong leadership is suggested.
- Responsive partners, and interactive communication.
- Reduction of duplicating activities / efforts.
- Relevant stakeholders should be involved, and NGOs should be facilitating stakeholders.
- Consolidation and strengthening of multidisciplinary approach.
- Proper risk assessment framework of biotechnological products for safety assurance (mostly related to discussion in crop research)
- Resource mobilisation and rational resource utilisation
- Effective communication of research results and technologies to all stakeholders.

Institutional implications / policy markers

- Funding flow should change with structural changes.
- Private sector should be included in research. NARO must institutionalise this as well as the participation of farmers, NGOs and GOU.
- Implementation of policies that promote smallholder investment.
- Infrastructure should be improved in rural areas to ensure effectiveness of technologies.
- Harmonized patenting system is needed. NARO should have a policy to promote incentive for innovation in terms of recognition, not just financial, but also promotion. Champions of innovations could be an idea.
- Better collaboration between partners and research institutions is necessary. There is need for structures that facilitate partnerships. Partnerships should benefit the smallholders.
- Need for domestic policies in order to be able to compete on international markets.
- Capacity building in information and communication, including research outputs to policy makers.
- Need to promote a food chain approach in research programmes which encompasses disciplines e.g. a farm to fork research programme or a fork to farm approach if market issues are critical.

evident over 2-3 year period. Participatory resource management is reported as expensive as farmers appear to require long-term training and monitoring. With regard to demand articulation, demand-led research is not a simply reacting to farmers demands because does not take into account knowledge and technologies of which farmers are unaware. However, demand should not rely solely on researchers assessments because they may not have an adequate understanding of farmer resources (e.g. time, labour or capital) or market requirements.

Therefore, researchers must understand whose demand has to be addressed (this can be from policy makers as well as farmers) and must be able to define and respond to it adequately.

Post harvest processes and technologies

Given the scarcity of papers in this theme, only a few lessons could be gleaned from the post harvest processes and technologies.

- Research to broaden crop utilization base and to enhance marketability should be enhanced in national systems.

- Economic analyses should be integrated into these research projects to assess financial benefits as well as the social and human benefits.
- Linkages to the commercial sector should be explored in greater detail.

Animal breeding strategies

Breeding strategies were discussed in various ways for poultry, goats and cattle, and so-called improved breeds were emphasised as a future relevant strategy for improvement of the animal population. Cross-breeding seems to be an option which definitely should be considered for future development in more animal species. The use of improved genes has been introduced and it is concluded that the implementation of this should be maintained. Among the presented studies, this seems to be the case for goats and poultry. From other studies, it is also relevant to consider for cattle. Such breeding strategies can be implemented in various ways, and more of the studies point to the fact that it demands time and insight into local environment and circumstances, and that some knowledge about animal husbandry must be connected to the implementation. In the presented papers, it was also noted that a thorough analysis on this should always be included in order to clarify whether the basis for using improved genetic material is acceptable, e.g. whether water and feed are accessible, and hygiene and animal husbandry practices are acceptable. Consequences for the demands to management and conditions should also be considered, and changes in disease patterns and susceptibility must be expected.

Using e.g. improved breeds may demand other strategies in general, partly because some hereditary characteristics e.g. concerning production capacity may imply less robustness (reproduction, disease problems). This may demand new feeding strategies, record keeping and a controlled breeding plan, and better strategies for disease prevention. It must be critically evaluated how the resources demanded for an improved effort for this can be used in an optimal way.

Animal feeding

The feeding of different age groups is a specific area of feeding strategies, which should be considered. Feeding of the young animals, e.g. kids and calves, was pointed to as a specific problem area in the LSRP project. The feeding of pregnant animals, animals for fattening and slaughter, dry animals and high yielding animals, as well as draft animals demand different distribution of energy and content of the feed. It has been shown through several on-farm studies that this is not always easy to meet under the different weather and climatic conditions of dry and wet season. It is relevant to develop and disseminate improved knowledge and relatively simple strategies on what is optimal and how can the different demands for different age groups and the shifts through life phases of an animal be met. Priorities between animal species and different age groups must be made and related to available resources on the farm, especially feed resources.

Local resources must be in focus and more consciousness about this may be needed in some areas. This is the case both in research, which should not focus solely on expensive and 'optimized' solutions, and in extension, where local knowledge and local resources should be drawn into any development of solutions and strategies. In some areas of Uganda, farmers may not have been used to keep certain animal species, which are now being introduced or re-introduced. This means that there is a general lack of knowledge. Therefore, simple and resource saving solutions are not being used sufficiently, simply because of lack of knowledge and no inherited knowledge from earlier generations. Optimal use of household left-overs and crop residues for feeding is one of the relevant areas for this and will optimise the production among the poorest farmers.

In the LSRP projects, it was pointed to a need for focusing on ration formulation and feeding strategies for locally available feed for small ruminants as well as poultry. In the presented studies at this conference concerning pigs, this enterprise was concluded to be very beneficial, and that pigs very well can live on residues from household and crops. In the LSRP projects, it was pointed to the need for dissemination, as much knowledge and many technologies are ready, such as fodder bank and feed conservation technologies for e.g. the smallholder dairy sector. What is needed with regard to new and further research within the smallholder dairy sector is thinking the whole area of specific knowledge on feeding into more complex decision making and supporting system, involving land use, farm management and human resources. In the poultry sector, it is likewise pointed to the need for improving the management on free-range chicken, but in particular to think it into the on-farm approach and quantify existing feed resources including the scavenger animals.

Animal husbandry

As indicated above, there is need for improved breeds. At the same time, management is also concluded to be too poor in many farming systems, and knowledge is needed. For all animal species it is important to underline that improved breeds do not compensate for poor rearing conditions and insufficient management practices. In an LSRP-study by Rubaire-Akiiki *et al.* (in press) with focus on ticks, tick borne diseases and helminths, it was concluded after a cross-sectional and a longitudinal study based on both quantitative as well as qualitative analyses that the general management of the animals especially in the lowland in the research area (Mbale district). Based on this, farmer groups for participatory learning was formed in a modified Farmer

Field School approach. This must be pointed to as one core area for future development and extension especially in cases where complex farm situations are involved, and where animal husbandry and daily practices are in focus.

Animal disease control strategies

Some diseases are identified as still being major constraints to the development of animal production, such as helminths in goat production. Some diseases seem to be relatively easily eradicated through vaccination strategies. Among the studies in focus for this paper, Newcastle Disease in poultry seems to be such a disease. Other strategies for controlling diseases should definitely be searched for, and for all major diseases more than one possibility for control should always be included and considered. A wide range of options can be included, from the use of appropriate breeds to vaccination, feeding, hygiene measures and individual care. It is important that the strategy – both for development and research – is based on knowledge on the area, where initiatives are initiated. E.g., in one of the LSRP-projects, initiatives to control tsetse fly in a certain area was taken, and later in the project period it appeared that there were no problems with Tsetse flies in that area at all.

Disease management mostly in terms of disease treatment was a focus area in some papers, touching or describing mismanagement of medicine both in terms of using it when not relevant or appropriate e.g. when the prognosis is poor like in many chronic cases, or using it in a wrong way (e.g. under-dosages). The risk of resistance against various drugs is high, and the risk of residuals have been pointed to in other studies, among others in studies under the LSRP. In many studies, the use of veterinary medicine in sub-therapeutic doses has been pointed to, and this represents a true health hazard for both animals and humans, besides the fact that it is waste of resources. There is an area of disease diagnostics and medicine use, which definitely need further development in order to create a sustainable and safe environment within the livestock production and the veterinary sector. It can be pointed to, as it is in the FAO report 'Guidelines for strengthening animal health services in developing countries', that training and dissemination of information is needed. The context of the problem needs should not be overseen, and should be addressed seriously. Severe disease problems, where action must be taken in combination with poverty and other problems like unavailability of the best drugs and other technologies will often lead to inappropriate handling of the problem, and any solution will be very short termed. These papers open a highly relevant discussion, as problems with medicine residuals and antimicrobial resistance are increasing worldwide. In many cases, medicines are used in order to compensate for bad conditions or management, creating an environment to develop disease. The emphasis on disease prevention and health promotion must urgently be addressed. It furthermore points to a future need to improve diagnostic methods for many diseases on animal, group and population level, in order to enable people to critically choose when the use of medicine is relevant or not. This also raises the question whether the integration of livestock research, veterinary research and farming system approach in relation to animal health research is good enough. This needs to be analysed and a plan for improvement might be necessary. In the extension service, it can also be questioned whether the veterinary sector and the livestock production advisory sector work sufficiently together.

In a section below in this paper, sustainability in relation to livestock production is discussed in a broader perspective. One important strategy in the way forward to a sustainable approach in livestock disease handling is to identify properly where the problems are. One example of this is in the project on ticks, tick borne diseases and helminths in the LSRP smallholder dairy problem, where the problems were identified to exist in the lowlands, and not in the highlands and midlands. It furthermore became evident that the current problems with tick borne diseases to a very high extent could be handled by non-medical technologies. These technologies are not regarded as giving as much status and signalising 'modernity' as much as medical solutions, but as long as they are appropriate in handling problems, this is far the best and most sustainable solutions.

There is a need for indigenous knowledge on disease control to be drawn into analyses of disease control methods. Some of the indigenous knowledge is of great value and built on centuries' experience. In some areas where certain types of livestock production are newly introduced, or where migration of people have led to the formation of new societies and communities, indigenous knowledge may not exist or may come from many different sources and origins. All kinds of this knowledge should be evaluated in a very critical light, and held up against other sources of knowledge, e.g. biomedical scientific knowledge (e.g. the content of some plants), and not just be disseminated in an un-critical or un-systematic way.

Sustainable livestock production systems

Some of the presented studies as well as some conclusion, which can be reached based on the discussion above so far, points to the need for an integrated and holistic approach to the view on livestock production as well as animal health research. In the FAO-report 'Guidelines for the integration of sustainable agriculture and rural development into agricultural policies (FAO agricultural policy and economic development series 4), sustainability is dealt with in relation to the concept of 'Sustainable agriculture and rural development' (SARD). In the policy framework, one of the 5 elements is 'Developing coordinated and consistent policies within the agricultural sector'. In relation to the animal herd, the land-use is pointed to as a potential problem area. Concern is expressed for development into agricultural systems, where land deprivation is taking place. This points

to a more overall evaluation of the relevance of keeping animals in certain areas, and both animal species, breeds and numbers should be evaluated in the light of sustainability. The issue of sustainability should be in focus also in livestock production. This is including the use and possible overloading of land, the work load and available human capital, the considerations concerning diversity and robustness in the overall animal population in a given area, and the accessibility of feed and water. Sustainability implies not only concern about diversity and robustness in the animal population, and a sustainable way of using medicines with minimum risks. It also deals with using as many available resources and low input strategies as possible and whenever relevant in order to reduce poverty. Very few studies include economical analyses of the strategies discussed,or assessments of farmer priorities or decision making revealed by means of qualitative research methods. Scavenger animals, use of kitchen left-over or local feed resources, feed conservation, and draft animals are all possibilities which should be explored in relation to different contexts. Food security and food safety is also expressed as an area for an increased effort. The use and misuse of medical inputs pointed to above raise a sincerely critical voice as to how to handle disease in a sustainable way and direct the development in a sustainable direction.

Research methods in crop and livestock sciences

Based on the papers mainly in the crop sector, but also on some of the livestock oriented papers, lessons learned can be listed with regard to participatory methods, which were used to large extent. In relation to the approaches generally used to target agricultural research, the following can be emphasised:

- Participatory research methodologies (PRM) are useful tools in prioritising research activities across a wide range of sectors and in testing a broad range of technological options.
- PRM needs a flexible approach because unexpected, but related issues may need to be addressed.
- The case studies demonstrate that farmers want packets of information that can address a range of farming constraints and/or provide additional benefits such as additional grain for food, weed suppression, animal feed, fuel wood etc.
- Researchers need to pay more attention to marginalised groups in participatory research activities (male, female, old or young) to ensure they can also benefit from research and are not further excluded from the benefits of new technologies.

This gives the following opportunities for research promotion:

- Participatory research can enable a wide range of research providers, researchers, NGO, extension agents and farmers to work together to identify effective practices for different environments.
- Participatory research provides a good environment for learning and sharing messages between the different stakeholders, but partnerships take effort and commitment by all stakeholders.
- Action research empowers farmers in the decision processes.
- PRM appears to improves the likelihood of technology uptake, but not always.
- PRM can improve the speed of delivering varieties with marketable qualities to farmers.
- A 'non technical' label or brand name for a package of technologies which can be recognised by farmers appears to be a useful mechanism to promote quality or effectiveness.

However, the use of participatory and cross-disciplinary research methods, follow-up strategies in terms of assessment of impact and consequences also needs to be critically questioned, in order to ensure a continuous development in the future towards a more and more dialogue-based development in the research and extension strategies. Participatory and especially action research have the double objective of solving immediate problems for the local stakeholders and create knowledge that can be generalized and may be disseminated to wider groups in society. The emphasis of context analyses and the responsibility to 'translate' research results from one context to another is important and must be included in all research projects. The questions of generalisation of scientific knowledge gained from applied research is important both from the point of view of society (i.e. expensive research should deliver different results than a mainstream rural development project) and from the research community (i.e. researchers need to publish for sustaining their carriers). Roles and responsibilities of agricultural researchers are broader than traditional roles because in participatory research projects, researchers need to manage knowledge, to train, to develop group skills and communicate options to end users as well as to develop technological options.

A number of project level farmer workshops have documented the immediate impact of the applied research and an independent participatory impact assessment (Laker et al, 2004) has confirmed a number of important benefits for the participating farmers. This is off course a positive outcome and demonstrates the viability of the research method in terms of improving the smallholder livestock systems in focus. However, for this to be a truly success

story evaluated from the light of a public research programme, there results will have to be of a more general nature (refer to the two sides of action research mentioned above). Different dimensions of generalisation have been used in LSRP such as:

- Up-scaling and spreading of new inputs (e.g. new poultry breeds and vaccines)
- Up-scaling and dissemination of generic systems (e.g. introducing new zero grazed goat keeping including stables and feed supply strategies)
- Generalising technical solutions for specific types of livestock systems (e.g. the applicability of using maize Stover and lablab feeding in zero-grazed dairy systems) through farmers leaflets etc.
- Generalising working methods and improved daily farm management (e.g. simple ways to observe livestock health status and assessing the needs for treatment),
- Methods for enhancing & facilitating participatory inquiry (e.g. development of FFS methodology for livestock).
- Improving scientific knowledge regarding the biological, technical and socio-economical characteristics of smallholder livestock systems (e.g. the degree of diseases, the profitability of different interventions etc.).

It is thus possible to obtain generalisable results from this type of research, but research funding organisations and directors should be aware that these extra tasks for researchers (transdisciplinarity, participation etc) may reduce or delay the number of classical publications normally used to evaluate research in scientific communities. Moreover, a number of Ph.D. theses have been successfully defended building directly on research within LSRP demonstrating that it is in fact possible to build acceptable research results from on-farm studies. The high degree of involvement from Makerere staff also demonstrates that participatory systems research is increasingly accepted by Academia.

Most studies in the livestock sector – including the ones reviewed in this paper – were not particularly cross-disciplinary and do not involve e.g. socio-economical expertise directly in the process from problem identification to testing and interpretation of different interventions. Increased inter-disciplinarity will necessitate sufficient time allocated for researchers to understand and appreciate each other's methodological contributions and to facilitate the building of a joint understanding of the systems in focus.

The focus on participatory methods and applied research does not mean that basic research is not needed or relevant. A number of lessons were learned from the papers describing the basic research activities in the crop sector, and these studies seem so essential in IAR4D because they underpin technology development and can support client oriented approaches by generating new knowledge on poorly understood problems. Not only do they provide important baseline information for evaluation purposes and good research environments also to support young scientists like master students and Ph.D.students, but they also enable researchers to stay ahead of evolving agricultural threats and challenges, and they provide a relatively controlled environment to

- Develop and test hypotheses
- screen large numbers of genotypes
- enhance local breeding efforts

Extension, development and dissemination

The papers in the livestock sector did not give many new technologies for animal production and management. Based on the studies and what is concluded here and elsewhere, it points to the very important conclusion that many technologies are developed and partly ready to use, but not implemented in practise for various reasons. More research is still necessary – but to a large extent it is the dissemination of already existing strategies which is not working well.

In a number of the livestock sector papers, differences between performance were explained by herd specific factors or management factors, e.g. that females had a different effect on the rearing of animals than men seemed to have. In terms of technology transfer, such results can only be implemented by understanding these management related factors and working with the farmers actions and priorities in a farm specific way. This area links together research, extension and farmers' own on-farm development. It underlines the need to always analyse the context of a study and the context of the systems, in which the technologies are going to be implemented.

Roles and responsibilities of agricultural researchers practicing research in livestock systems are very broad also compared to traditional researcher roles because in participatory research projects, researchers need to manage knowledge, to train, to develop group skills and communicate options to end users as well as to develop technological options. The participatory research methods are reaching into the development and dissemination strategies.

Training and learning through experience exchange among farmers in farmer groups focusing on how to handle animals, prevent diseases and perform good management is a challenging and relevant possibility. This possibility exists and is developed in different farming contexts both in the crop and livestock sector. Certain criteria for these farmer groups are crucial, such as taking the starting point in the true needs, possibilities and circumstances of the farmers, and letting them guide the process and the solutions instead

of basing it on pre-formed ideas of what are 'the right solutions', which can even be quite general and context-independent. Animal husbandry is a complex area, where information must be combined and the effort must be situation and context based, and experience as well as knowledge can be used to the benefit of developing good practices. As explained above, health promotion practices and disease management practices often seem to be managed as two distinct areas, which is not beneficial for the farmer, who has to deal with both areas and will prefer an integrated approach. The approach of farmer learning and training groups based on thoughts and intentions of empowerment and true equity is relevant for learning how to evaluate a complex situation and goal direct the effort for handling it in a relevant way in practice.

Conclusions

The papers in this conference have demonstrated that technological options (Theme 4) only form part, albeit a critical part, of the solutions to poverty reduction. The relatively non-globalised state of African agriculture presents all development stakeholders (scientists, farmers and development agents) with challenges at a number of levels. In this conference Themes 1,-2 and 5 tackle research on the clients of research, partnerships and processes which can improve adoption of new technologies and market opportunities. In addition productivity improvements must take place in cropping systems with degraded soils and which face periodic drought- the main issues covered by Theme 3. By linking the five research themes for the new NARS it is possible that an integrated research approach should be greater than the sum of its parts because it will ensure that research addresses farmers' problems and provides sustainable solutions and opportunities which can be readily taken up by them.

This meeting has provided an excellent opportunity to discuss the components of an integrated research system for development under the five themes and to look at ways for implementing effective integrated systems. It is encouraging that the submitted papers for theme four clearly demonstrate that new research partnerships are developing and that integration between sectors is taking place within agricultural research systems. Furthermore it is hoped that the lessons learnt from the submitted papers can be used to strengthen the effectiveness of existing technological options and to improve the development of new options in the future. However it should be remembered that agricultural biological and biophysical systems are not static and farmers are continually faced with emerging constraints, many of which are poorly understood. Even where some understanding exists, the lack of policies or political will means that research findings may not be acted on. The threats to humankind posed by climate change and the erosion of biodiversity are just two examples which will have global as well as local impacts. In addition the development and adoption of new technological innovations are accepted by the global community as essential instruments for solving resource problems. This must be recognised before suggesting that enough technology has been developed. Research managers and policy makers must be aware, therefore, that although in some cases, further/ better promotion of existing technologies may indeed be necessary to reduce poverty, it is also vital to ensure that further research into new technologies is also funded.

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