INTEGRATED AGRICULTURAL RESEARCH

PROCEEDINGS OF THE SACCAR/WINROCK WORKSHOP, HELD IN LILONGWE, MALAWI, 26 NOVEMBER - 1 DECEMBER 1989

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Proceedings of the SACCAR/WINROCK Workshop
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Editors

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FOREWORD

In sub-Saharan Africa as in most parts of the world agricultural research has been strongly commodity oriented. A great emphasis has been given towards export cash crops in the case of plant research. In livestock and forestry research the emphasis has also been single-commodity oriented. Those efforts responded appropriately to the needs of the commercial sector and large farms in which intensive production systems are practiced. As the interests of many governments, international organizations, and donors shifted towards solving the problems of small farmers, it was realized that the task was quite complex, as a conglomerate of social, economic, and biological factors existed which interacted within the farm and the communities. It was, therefore, found that research approaches needed to be changed as more holistic and multidisciplinary efforts were required.

The evolution of those experiences has been quite variable, but it is leading towards an increasing need to focus research and development efforts more tightly. There is need also to broaden the range of commodities to be studied, the disciplines to be involved, and the institutions that need to collaborate and to emphasize a stronger farmer participation. The preoccupations for the environment, and the sustainability of production systems, linked to the need for equity and increased food production are even broadening the research and development agenda. Interactions need to be studied at the farming system level and at higher hierarchies such as the community, the country, the region, and the world. There is, therefore, need for studies to be also conducted on marketing, policy, and environmental issues. At the same time, resources for research and development are shrinking due to the appearance of other preoccupations in developed countries, as well as signs of donor fatigue. It is within this complex but quite exciting and challenging framework that specific actions need to be conducted, in order to broaden our understanding of the problems and look for feasible solutions in the fastest and more efficient ways.

At the request of the Southern African Development Coordination Conference (SADCC) and Winrock International, IDRC and the Ford Foundation supported a workshop on Integrated Research in Lilongwe, Malawi between 27 and 30 November 1989. Over fifty participants from the SADCC countries, international, non-governmental organizations, and donor agencies attended the workshop. The objectives of the workshop included:

- identifying the needs and priorities for integrated research in the SADCC countries;
- identifying opportunities for regional collaboration among institutions and countries, including involvement of networks; and
- exchanging information on current government and non governmental organization activities in integrated research.

Eleven technical papers were presented apart from two introductory and key-note addresses. Small groups discussions took place in order to identify key issues, and propose conclusions and recommendations.

This publication is a useful source of information for research planners, researchers, educators, and donors interested in the development of the Southern African countries, as it reflects the experiences and aspirations of their researchers and research leaders. It is hoped that the recommendations will be implemented in future endeavours.

Dr Hugo Li Pun
Associate Director
Animal Production Systems
IDRC LARO

WELCOME ADDRESS BY DR M.L. KYOMO

DIRECTOR OF SACCAR

LILONGWE, MALAWI, 27-30 NOVEMBER 1989

Mr Chairman,
Distinguished guest of honour,
Distinguished representatives of IDRC and the Ford Foundation,
Distinguished representative of Winrock International,
Distinguished resource persons,
Distinguished workshop participants and observers,
Ladies and gentlemen.

I wish right at the outset to mention that this workshop which has brought together senior policy makers in research, extension, and training both in government and private organizations in SADCC was planned and organized jointly between the Southern Africa Centre for Cooperation in Agricultural Research and Training (SACCAR) of SADCC and Winrock International Institute for Agricultural Development based in Arkansas in the United States of America. Both organizations aim at strengthening the national research, extension, and training institutions so that they may improve their services to farmers. On behalf of these two organizations, I wish to thank the Malawian Government for allowing us to hold this workshop in this beautiful capital city. The choice for the venue of this workshop was not by chance. It was due to the recognition that while Botswana has a mandate of coordinating the SADCC's sectors of Agricultural Research and Training and Livestock Production and Animal Disease Control, Malawi has the responsibility of coordinating Forestry, Fisheries, and Wildlife. Since, in addition, SACCAR has located the headquarters of its regional Agroforestry Research Project in Malawi, it was logical that the dialogue involving specialists in crop, livestock, and forestry agriculture on how to integrate research in these fields for the benefit of the farmer should take place in Malawi.

I wish also to mention that this workshop would not have taken place if it had not been for the generous financial assistance from both the International Development Research Centre (IDRC) of Canada and the Ford Foundation. On behalf of SACCAR and Winrock International and on behalf of SADCC national participants in this workshop, I wish to thank the two sponsors.

Mr Chairman, the workshop is fortunate to have Professor Bede Okigbo to give the key-note address. Professor Okigbo is an agriculturist who rose from the ranks as one of the founder lecturers of the University of Nigeria at Nsukka to become a professor of agronomy and later Dean of the Faculty of Agriculture of the same University. He later became one of the founders of the International Institute for Tropical Agriculture (IITA) based at Ibadan Nigeria. He served as an Assistant Director General of IITA for over ten years. He is currently on leave of absence from IITA serving as a visiting Professor in Michigan State University's Department of Agronomy and Soil Science. Professor Okigbo has the interest of the African farmer at heart. He has dedicated his life to understanding better the farmer's environment including the plant and animal resources he works with. Professor Okigbo is currently writing a book on plant genetic resources of economic importance and African agriculture in general. We shall look forward to listening to this experienced agriculturist.

Mr Chairman, the workshop has attracted distinguished scientists from international, regional, and national governmental and non-governmental organizations (NGOs). Some of these will be presenting papers while others will be contributing in the discussion groups. We are particularly pleased that some of them have come from SADCC's regional projects or programs. We believe that their participation in such a workshop will encourage them to interact more among themselves and thereby make their research activities more targeted to generating technologies which farmers will use in solving their problems. We have several donor representatives who are listening to what we are discussing. We hope in future they will support our new initiatives in integrating research for sustainability of production.

In SADCC, agricultural research focuses on problems of both the small and large scale farmers. From experience, it has been realized that the small scale farmer has more complex issues to integrate. At present in most SADCC member states we see damage of varying degrees to the natural resource base. Specifically we see examples of soil erosion and the depletion of soil fertility, including an increase in soil acidity and the breakdown of soil physical properties, and the destruction of natural vegetation through shortened fallow cycles, uncontrolled overgrazing, bush clearing, and fuelwood collection. We see environmental pollution through indiscriminate use of agricultural chemicals such as insecticides, herbicides, and inorganic fertilizers.

It is believed that the single discipline approach of agricultural research has emphasized short-and medium-term yields at the expense of long-term productivity; little attention has been given to the management and conservation of natural resources beyond the boundaries of individual farms. A separate focus on the crop, livestock, and tree components of production systems has ignored the important interactions between them, and has failed to fully recognize and exploit the interactions between agricultural technologies, the socioeconomic environment, and the physical production base. The objectives of the workshop include:

- broadening the understanding of the relationship between natural resource management and sustainable agricultural production;

- identifying the needs and priorities for integrating conventional research components to enhance renewable resource management;

- exchanging information on current government and non-government activities related to integrated research and technology transfer;

- identifying opportunities for regional cooperation and institutional collaboration in research networks such as PANESA, AFRENA, ARNAB, etc.;

- examining institutional policy issues which serve as incentives to promote long-term research for sustainable agriculture; and

- establishing recommendations for post-workshop activities.

The workshop will address the issues of sustainable production and management of natural resources through the following themes:

- information exchange within SADCC across research networks;
- community involvement in natural resource management;
- curriculum development and post-graduate training;
- policy issues long-term research, land tenure, commodity pricing, etc.;
- the role of NGOs in research and technology transfer; and
- land and water management issues.

The expected outputs will include the production of workshop proceedings from papers given by resource persons and recommendations of the working groups on the workshop themes. The proceedings will be organized on the need for integrated research, priorities, constraints and opportunities. It will also include a work plan for regional initiatives including an agenda for post-workshop activities and projects.

Finally, Mr Chairman, I hope I have managed in my short address to inform the distinguished guest of honour who we are and why we are here. We are looking forward to receiving his guidance for our workshop.

I thank you for giving me the time.

OPENING ADDRESS

Mr Bester Ndisale, Principal Secretary, Ministry of Agriculture, Malawi

Mr Chairman,
The Director of the Southern African Centre for Cooperation in Agricultural Research,
Representatives of Winrock International,
Distinguished guests and participants,
Ladies and gentlemen.

I am greatly honoured and privileged to have the opportunity this morning to officiate at this inaugural session of the Southern Africa Centre for Cooperation in Agricultural Research and Winrock International Workshop on Integrating Research on the Tree/Crop/Livestock Complex to improve agricultural productivity and natural resource management in Southern Africa.

I have been told that over 70 participants representing the Southern African Development Coordinating Conference (SADCC) member states (Angola, Botswana, Lesotho, Malawi, Mozambique, Swaziland, Tanzania, Zambia, and Zimbabwe) as well as the United States of America, Ethiopia, Kenya, and Nigeria are expected to attend this workshop.

It is pleasing to note that 11 International Agricultural Forestry Research Centres (ILCA; IITA; Winrock; ICRAF; SACCAR; CIMMYT; SADCC/ICRISAT, PANESA, IDRC, SACCAR/ODA) will also be participating in the workshop.

It is indeed an honour for us to host and meet some of Africa's, if not the world's, leading scientists working on the "Integration of Research on the Tree/Crop/Livestock Complex to Improve Agricultural Productivity and Natural Resource Management". You are most welcome here, and please feel at home.

The workshop's topic is especially timely and relevant for a number of reasons. In this regard, I wish first to address the situation and challenges facing Southern Africa today.

It is common knowledge that the ultimate source of all energy and negative entropy is radiation from the sun. Photosynthesis is our only mechanism for capturing solar energy in a form that can be consumed immediately or stored for tomorrow's needs. Thus, we should learn to live on the photosynthetic interest generated by the world's resources instead of consuming its capital.

Agriculture has evolved under population demands to increase production of usable products by changing the mix of organisms and manipulating the environment to favour the new higher-yielding crops and animals. But, along the process, intended as well as unintended consequences have resulted. For example, annual crops are poor substitutes for trees and perennial grasses in controlling soil erosion and recycling plant nutrients from deep soil depths. Similarly, improved livestock breeds are often poorly adapted to the disease, forage, and harsh environmental realities found in many parts of Southern Africa. In the developed world, such problems have been addressed by high-input technologies and services. By contrast, most agriculture in developing countries remains dependent on finding and exploiting previously accumulated soil organic matter and plant nutrients. Based on the dramatic increases achieved in Temperate Zone agriculture, improved germplasm with high levels of external inputs were considered to be the logical fix for low-yielding agriculture around the world.

The validity of this assumption is now in question. The Green Revolution in the tropics appeared successful only where soils were young and fertile such as volcanic regions and river deltas. Moreover, recent estimates show that energy reserves and mineral deposits are being depleted on a global basis, indicating that any system dependent on fossil fuels is ultimately not sustainable. Industries which use fossil fuels or their products are also threatening all life forms by polluting soils, water, and atmosphere, as well as contributing to global warming trends.

Low-input agriculture is the major food producer and major employer of most Southern African countries, and despite its constraints, there is high potential for improvement. But development efforts focusing on modern or high-input farming methods from the Temperate Zone have usually had destabilizing effects. Examples include the decreased productivity of tropical soils under continuous cropping despite supplementary fertilizers, the failures of mechanized farming, and attempts to introduce western concepts of livestock production and range management in communal pastoral lands.

The nature of, the natural and socioeconomic environment in Africa, has hindered progress, while local knowledge has often been ignored or discounted. Soils are often inherently low in fertility because of their extreme age and weathered condition. Rainfall is low and unpredictable in much of the region. Other factors such as communal systems of land tenure, competing interests of farmers and pastoralists, lack of skilled labour and capital, and infrastructural weaknesses limit options for adopting improvements and new technologies. The situation has been aggravated by inadequate investment in agricultural research and development, and approaches that rarely address actual farmer needs.

Most of Africa is now faced with declining agricultural production, deteriorating natural resources, increasing shortages of fuelwood and building materials, escalating costs of fossil fuel based inputs, and deficits in foreign exchange earnings. Reports from scientists throughout the SADCC region indicate that growing human demands on resources are eroding life-support systems. Per capita food production and income, as well as nutritional levels are dropping in most areas. Cereal production, which supplies 65 - 80% of the caloric intake in Africa, has decreased from a peak of 180 kg per capita in 1967 to a low of 120 kg in 1983 and 84. Also during this period, Africa changed from a net exporter of staple foods to a net importer.

In 1986, the value of exports in 22 countries was insufficient to pay for imports. In SADCC countries, cereal imports have increased four-fold in the last decade from 240 000 to 600 000 MT/annum. Although essentially agrarian, Africa is losing the ability to feed itself. In 1984, 140 million of its 531 million people were fed entirely with grain from abroad.

By the year 2000, the demand for food and agricultural products in developing countries is projected to increase by 50%, yet there will be little increase in cultivated land.

Even if population growth slows slightly, as expected, Africa will have tripled its current population in 40 years. Future improvements must, therefore, arise by increasing the productivity of small holder farmers and herders, most of whom raise unimproved crops and animals under marginal conditions. This is perhaps the greatest challenge yet faced by national governments and the international development community.

Fuelwood security is another important issue. Wood is Africa's primary source of fuel, and households use 10 times as much wood as all other commercial fuels combined. By the turn of the century, an estimated 3000 million people in developing countries will face an acute shortage of fuelwood. Energy substitutes, usually in the form of crop residues and animal manure, rob soils of essential nutrients and organic matters, and livestock of valuable feed. Alternative sources of fuel are either too costly or unavailable. But the fuelwood crisis is more than an energy and social issue; it, along with the clearing of land for crops, is the major cause of deforestation. Crops now cover over 120 million hectares in Africa, an increase of 90 million since 1920. Overall, 3.6 million hectares of forest are cleared annually, or about 0.5% of the remaining forests.

Livestock, which are an integral part of farming communities throughout the continent, are also contributing to increased pressures on plant and soil resources. Since 1950, Africa's livestock population of 295 million has almost doubled, yet available rangelands have steadily shrunk with encroaching cultivation. Finally, and perhaps most alarming, is the accumulating evidence that the continental degradation of vegetation and soils is disrupting long-term rainfall patterns, setting in motion adverse changes in agriculture, environment, and climate that are self-reinforcing.

Achieving agricultural sustainability and food security, while preserving the integrity of the natural resource base, are now the predominant goals of all SADCC countries. There is ample evidence today that sustained and improved productivity is dependent on the level of soil organic matter, the type of vegetative cover, and the carrying capacity of the land. Agricultural intensification will, therefore, require greater rather than fewer efforts to maintain and manage the natural resource base. The question is how can increased agricultural production be accomplished in a manner that is ecologically and economically viable as well as socially acceptable to farmers?

That question brings us to the purpose of this workshop. Historically, African agriculture consisted largely of a complex, interactive mixture of crops, livestock, and trees, quite different from the monocultures that have been encouraged over the past years, and upon which most of the world's agricultural research is based. Current attempts to integrate trees with crops and animals in a form that mimics natural systems, offer potential to alleviate many of the problems highlighted earlier. The universal appeal of this approach lies in the multiservice functions of trees such as reduced soil erosion, increased nutrient cycling and biological activity in the topsoil, improved micro-environment conditions, and greater tolerance to drought. Trees also yield an extraordinary array of products including fuelwood, building material, food, fodder, and medicines that are essential to nutrition, health, and trade. Such systems have provided, and can continue to provide, the ecological and socioeconomic framework for the self-sufficiency of rural households.

Development strategies will require an evolution of existing agricultural systems rather than radical change, although the latter may be possible in the few high-potential areas. The approach adopted should:

- increase African research capabilities through human and institutional development;

- strengthen linkages among policy-makers, researchers, extension agents, and farmers; and

- be more responsive to farmer problems, needs, and priorities.

Farming practices must adapt to local needs and ecological conditions, while controlling deforestation and regenerating vegetative cover. It appears likely that advances in Africa's smallholder agriculture will only be realized within a development framework that combines traditional wisdom with scientific knowledge, guided by past achievements and failures. Success will depend on an unprecedented degree of cooperation among African countries, as well as the donor and international research and development community.

The workshop agenda has a variety of topics and themes to be addressed in different sessions. The key-note address in session II must play a fundamental role in establishing some common ground among such a diverse group of participants. Time spent at the outset on developing clear definitions and concepts, while identifying successful technologies and research deficiencies, will have great payoffs in the later discussion and planning sessions. The case studies in session III will, of course, support this effort by describing firsthand experiences, and providing opportunities for exchanging and sharing information.

The role of networks in session IV is an area of critical importance and concern. Properly structured, communications and linkages among national programs, donor projects, and international activities can greatly reduce duplication, minimize unnecessary waste of funds and time, and maximize effectiveness and impact at both the program and farmer levels. Mechanisms to improve the function of research networks requires particular emphasis. Also of special concern is the role and operating mode of International Agricultural Research Centres (IARCs). These centres are important sources of agricultural research and training, and have potential for strengthening national research institutions. Although the Consultative Group of International Agricultural Research (CGIAR) recognizes this, it spends only 1.6% of its operations budget on such support, and only 12% on training. As a representative of a national program in SADCC region, I feel that most IARCs efforts are motivated more by their own interests than by national problems, needs, and priorities. The latter should clearly form the basis for collaboration with national institutions. In so doing, the overall effectiveness, impact, and continuity of IARCs would be improved. I hope that these issues will attract the attention they deserve during the course of this workshop, and I am pleased to note that the workshop's first theme is devoted to this task.

Session V identifies six target issues to be addressed during the workshop, with session VI serving this goal through small group discussions. These two sessions are perhaps the most important to the overall success of the workshop. Good planning and preparation by the workshop organizers is paramount to any small group discussion. Equally important is the need for open, thoughtful, and constructive contributions from all participants.

The first theme on the role of networks has already been discussed. The second theme concerns community participation in natural resource management. Approaches used in this regard vary greatly by country, and even by project, some being top-down, others bottom-up. But one fact stands out: successful efforts usually involve active participation by the targeted group. At issue is how to encourage community initiatives in resource management under conditions where these resources have traditionally been free, or communally used. Mechanisms are needed that create an awareness of the real and intrinsic value of natural resources, and generate a responsibility for their management through clubs and other appropriate associations. Ideas and opportunities of this nature need to be fully explored.

The third theme involves training, a vital component in building institutional capabilities for integrated research, and creating effectiveness at the farm level. Curricular development is needed for long- and short-term training opportunities that involve junior as well as senior staff in both research and extension. This natural cycle of integrated research, which in this case closely follows agroforestry concepts, will be particularly demanding because of its interdisciplinary requirements. Although curricula development is important, it will have limited impact without basic research facilities, linkages with other local and international scientists and groups, and incentive mechanisms. These and other issues require special attention.

Integrated research on trees, crops, and animals is, by nature, long-term, and hence will have policy implications which are the subject of the fourth theme. Long-term research, particularly in an interdisciplinary mode, commonly conflicts with budgetary allocations in most national programs. Coordination among local institutions as well as IARCs and donor agencies will be essential to address effectively goals and needs that transcend conventional disciplinary boundaries. Various methods for generating political, financial, and institutional support need to be explored in depth. Discussions should include international funding opportunities, coordination strategies, effective methods for communicating research programs and results, and high-profile farmer impacts in both the short- and long-term.

The fifth theme concerns the role of non-governmental organizations. Government institutions and major donor agencies have not always been effective in meeting their goals and objectives. Private and voluntary groups from abroad, as well as local organizations and the rural non-farm private sector have become increasingly active in bridging many gaps. These groups can be instrumental in transferring information on local needs to governments, and donor agencies, and the private sector, while simultaneously representing the farmer.

Land and water management is the topic of the sixth and last theme. In its broadest sense, this includes all plant, soil, and water resources encompassed by a specific area for any given form of land use. However, I will restrict myself to comments on soil and water conservation. Many promising technologies exist for increasing vegetative cover, maintaining or improving soil fertility and organic matter content, reducing erosion and run-off, and improving water-use efficiencies. The role or contribution of trees needs to be assessed in relation to technologies such as recession farming, water harvesting, micro-catchments, terracing, tied ridges, contour bands and hedgerows, minimum tillage, mulching, manuring, and composting.

In this brief address, I have attempted to emphasize the urgency of developing appropriate research aimed at restoring the long-term productive capacity of land upon which most SADCC economies depend. Commitment to this endeavor will require a high level of effort, funds, and cooperation among African governments and international groups, along with a willingness to discover and address the needs of the rural people. This workshop should serve as a departure point for consolidating our thoughts, ideas, and knowledge in planning for tomorrow's needs.

Lastly, I wish you all successful deliberations and exchange of information and experiences. I hope too, that our visitors will acquaint themselves with what we in Malawi are doing, and trying to accomplish under the foresighted leadership of His Excellency, the Life President, Ngwazi, Dr Kamuzu Banda. We look forward to your suggestions and advice, and wish all of you a safe return home at the close of the workshop.

Mr Chairman, ladies, and gentlemen, I have the pleasure to declare this workshop officially open. Thank you very much.

THE NEED FOR INTEGRATING CROP, LIVESTOCK, AND FORESTRY RESEARCH IN THE SADCC REGION WITH A NATURAL RESOURCE MANAGEMENT PERSPECTIVE

Bede N. Okigbo

Introduction

Many Southern African Development Coordinating Conference (SADCC) countries continue to experience food crises with decreasing per capita production and increasing reliance on food imports. The situation is further exacerbated by frequent droughts, economic debt burdens, decreasing commodity export prices, and high rates of population growth and urbanization. Civil strife and political instability continue to constrain development in some countries.

In seeking solutions to these problems, increasing attention is being given to sustainable agricultural development in which strategies are based on indigenous farm resource use and reliance on biological processes, such as nitrogen fixation and nutrient recycling. Sustainable agriculture is an integral component of a larger and more rational natural resource management strategy.

Concepts of Sustainable Agriculture

Sustainable agriculture may be defined as the successful management of resources to satisfy changing human needs while maintaining or enhancing the natural resource base and avoiding environmental degradation. However, the definition must also include the ability of an agricultural system to maintain production over time in the face of social and economic pressures.

The evaluation criteria for sustainability should include the family nutrition and farm income, as well as the more conventional focus on crop and livestock productivity.

Importance of sustainable agriculture in SADCC region

The agricultural and environmental crises in the SADCC region arise from low agricultural productivity, which does not satisfy the demand for food created by the rapidly increasing populations and high rates of urbanization (Table I). The situation is compounded by economic and political problems. Soil degradation, caused by deforestation, overgrazing, intense cultivation, and mining activities, adversely affects agricultural productivity. Frequent droughts exacerbate food shortages, and the presence of many political refugees requires emergency food imports.

Table 1. Some vital statistics of SADCC countries

Country	Area (million) Ha	Population (million)	% in Agriculture	GNP 1986* US $ per capita	Agriculture* % of GNP 1986	Population Growth rate % per year 1970-84	Growth rate Agriculture % per year 1980-84	Food & Prod. Growth rate per capset 1980-84	Growth rate Gross Agric. Prod. per capset 1970-84	External Debt Million US $
Angola	124.6	7.7	71	617	46	3.3	0.38	0.38	-5.8	NA
Botswana	59.5	0.9	66	622	4	3.8	0.97	0.97	-3.7	358
Lesotho	3.0	1.3	82	176	21	2.3	-0.27	-0.27	-2.4	186
Malawi	9.4	6.0	79	150	37	2.8	2.49	2.49	0.4	1114
Mozambique	78.4	12.1	83	145	59	4.0	-1.30	-1.30	-4.3	-
Swaziland	1.7	0.5	69	548	NA	2.7	3.3	3.3	1.7	232
Tanzania	88.6	18.9	83	220	59	3.4	-0.33	-0.33	0.3	3955
Zambia	74.1	5.6	70	433	11	3.0	1.40	1.4	-1.0	5300
Zimbabwe	38.6	7.4	70	569	11	3.3	-6.98	-6.98	-1.6	2480

SOURCE: ECA/ADB (1987).

SOURCE: FAO (1986a)

*World Resources 1988-89

Natural resource management

The United Nations Advisory Committee on the applying of science and technology to development defined a natural resource as anything found by man in his natural environment that may be used in some beneficial way. This definition can be subdivided into products, such as mineral ores, fossil fuels, ground water, plant and animal life, etc., and amenities, such as waterfalls, harbours, scenic mountains, beaches, etc. Soil is regarded as a renewable resource, which is capable of being regenerated by natural processes.

Conservation refers to the management of resources to minimize waste. In the context of agricultural development, conservation implies the monitoring and control of resource use through appropriate policies. Such policies regulate deforestation and rangeland burning, fuelwood collection, grazing of communal lands, mining, and urbanization.

Integrated land use management

Sustainable agriculture cannot be achieved unless production systems are well suited to land use capability. For example, in mountainous areas, integrated watershed management should involve contour planting on steep slopes and the selection of specific crops and crop/livestock combinations for different types of topography. Such a land use pattern would often incorporate relay cropping sequences and cropping mixtures to maintain a soil cover. This diversity of production also reduces the risk of crop failure and provides for both subsistence and cash crop needs.

Integrating crops and livestock takes advantage of mutual relationships. Crop residues provide feed for ruminant livestock, while animal manures serve to enrich the soil and increase crop yield. This type of integration also enhances family labour productivity throughout the year. Agricultural sustainability requires a combining of mechanical, cultural, biological, and chemical pest and disease management systems that minimize environmental degradation.

For centuries traditional farming systems relied on indigenous farm resources, including the land, labour, capital, and management skills of the farmer. Renewable resource management was based on biological processes, such as nitrogen fixing and nutrient recycling. More modern farming practices emphasize exogenous farm: increased productivity depends on escalating inputs of energy and expenditures of farm capital, which can not be sustained.

It is, therefore, imperative that selected elements of traditional and modern agriculture be integrated into farming systems that are more compatible with farm resources and ecological considerations. This integration will require the collaboration of research scientists from several academic disciplines to address production constraints in the crop, livestock, and forestry subsystems simultaneously. Such a holistic or systems approach provides a means of monitoring subsystem interactions and measuring the impact of each technical intervention on the entire production system.

Inter-institutional collaboration

SADCC countries vary in ecological conditions (Table 2), population densities, institutional capacities, and level of economic development. It is, therefore, difficult for any single country to develop the human resource capacity necessary to support agricultural research of sufficient scope and depth to address issues of sustainability and natural resource management. This reality suggests a need for research collaboration by universities and government institutions within and across national boundaries.

Table 2. Percentage of land in SADCC countries in different climatic zones and the countries with areas in each climatic zone

Climatic zone	Length of growing period (days)	Percentage of SADCC land area	Countries affected
Desert	0	6.9	Angola
Arid	1-74	14.9	Botswana, Mozambique, Tanzania, Zimbabwe, Lesotho, and Angola.
Semi-arid	75-119	15.9	Botswana, Mozambique, Tanzania, Zimbabwe, Lesotho, Angola, Swaziland and Zambia.
Dry Subhumid	120-179	19.0	Mozambique, Zambia, Tanzania, Zimbabwe, Lesotho, and Angola, Malawi, Swaziland.
Moist Subhumid	180-269	40.3	Angola, Zambia, Tanzania, Malawi, Mozambique, Lesotho and Swaziland.
Humid	270	3.0	Mozambique, Tanzania, Angola and Malawi

Note: Underlined countries have only a small proportion of land area under the climatic zone indicated.

Technical support and manpower training is also provided to national agricultural research systems by the International Agricultural Research Centres, such as ICRISAT, ILCA, CIAT, CIMMYT, IITA, ICIPE, AND ICRAF. In addition, the Southern Africa Centre for Cooperation in Agricultural Research (SACCAR) links national research institutions with regional and international development assistance agencies, such as the Food and Agricultural Organization (FAO), the United Nations Environmental Program (UNEP), and bilateral donors.

Priorities for sustainable agriculture

While most attention is given to the problems that arise in the generating and adapting of new production technologies designed to sustain agricultural productivity, several post-harvest activities related to food processing, storage, and marketing are frequently overlooked. Similarly, agricultural research institutions often allocate limited resources to improve agricultural production in environments conducive to optimal levels of return, concentrating on the more marginal and ecologically fragile production environments.

Sustainable agriculture calls for more comprehensive approaches to integrate policy formulation, agricultural research planning, and natural resource conservation. Attention must be given to the need to provide productive employment in rural areas and to national food security. Both applied and adaptive agricultural research must be sensitive to the potential impact of new technologies on the farm environment. There is also a need for greater understanding of natural use under different production systems and socioeconomic pressures. This calls for a more effective linkage of research, training, extension, and farm participation in the research process.

Research focus for sustainable agriculture

Research on natural resource management in agricultural production begins with environmental characterization at macro and micro levels; then, shifts towards specific physical, biological, energy, cultural, and socioeconomic factors. Emphasis is given to the interactions between the crop, livestock, and forestry subsystems and production factors, such as soil fertility, water retention, nitrogen fixation, soil erosion, and evapotranspiration rates among others. Given the importance of women in food production in SADCC region, especially in countries where men have migrated to urban areas to work in mines, special attention must be given to technologies that will relieve labour constraints in fuelwood collection, post-harvest food processing, cooking, and crop husbandry practices.

Designing improved farming systems

Alternative approaches to resource management are generally based on modifications of existing production systems. These often seek to mimic natural ecosystems by integrating crops, livestock, and forestry operations harmoniously. Mixed cropping, crop rotations, and management schemes combining crop and livestock enterprises are used to diversify production and adapt food production to specific environments. By careful attention to cropping sequence and crop rotations, weeds, insects, and plant diseases can be controlled.

The conscious and rational combination of crop, livestock, and forestry subsystems is called integrative farm structuring (Francis, 1986). This structuring is based on biological interactions that result both in a sustainable food and income supply, and the regeneration of soil productivity. Such a system efficiently uses all available indigenous farm resources and minimizes reliance on expensive and potentially hazardous exogeneous inputs.

Research on the design of improved farming systems will depend on a greater balance between research station and on-farm research, a closer linkage between research and extension services, and more farmer feedback. Many SADCC countries have already established the foundation for this type of research through the creation of multidisciplinary farming systems research teams to study household resource dynamics and screen technological innovations that are more economically sound, culturally acceptable, and relevant to farmer needs. These teams also document indigenous knowledge and the role of off-farm activities in the allocation of family labour.

Participatory approaches to development

Technology design, testing, and adoption are most effectively accomplished where there is active farmer involvement. Various methods have been used to encourage farmer participation. These include:

- the development of integrated cattle, tree, annual cropping systems in West Africa (Sumberg and Okali, 1988);
- client oriented approaches to research in Zambia (Kean, 1988); and
- working with farmer groups in Botswana (Norman, 1988).

Agricultural research and extension services must be structured flexibly to support and encourage participatory methods and the intervention of NGOs. To be effective managers of natural resources, farmers must understand the technical basis of alternative management schemes. Likewise, researchers must incorporate farmer experience and knowledge of the local environment into the technology generation process.

Training for sustainable agriculture

African agricultural research is often accused of lacking the capability to generate the technologies required to significantly contribute to economic development. Research problems range from understaffing to poor management. There is also a lack of continuity in funding, particularly for projects supported by foreign loans. Without adequate long-term funding, research objectives have a short-term time frame.

Most agricultural training facilities are isolated from agricultural research institutes, and the academic preparation of research staff is often below international standards. Many countries are too small to develop the critical mass of scientists required for interdisciplinary research. The lack of salary incentives and promotional opportunities results in a high rate of staff turnover.

Communications between university and government research institutions or between government research and extension institutions is often poor, further limiting interdisciplinary interaction. Agriculture, forestry, fisheries, and livestock are often housed in different ministries and supported by different funding agencies, making coordination difficult.

Many research scientists are not in touch with global scientific information networks, and must work with inadequate and poorly maintained equipment. Training is generally commodity focused with little attention given to systems analysis. Very often little importance is given to training in the social sciences, or women or to the preparation of support staff for highly trained professionals (Table 3). Few people are trained in agribusiness. Agricultural courses often have a low prestige on university campuses, and continuing education courses are frequently not related to market opportunities.

Table 3. Current situation, 2000 and annual estimated output requirements for trained personnel in agriculture (including general livestock) FAO (1984b)

Country	Trained personnel agric. and general livestock		Agric. family units (AFU) in year 2000	Irrigated areas as % total arable land	Projected agric. inputs index for year 2000 (1975=100)	Minimum estimated requirements for trained agric. manpower for year 2000		AFUs per extension field worker in year 2000	Annual output requirements to reach minimum targets	
	Prof. level	Tech. level				Prof. level	Tech. level		Prof. level	Tech. level
Angola	-	-	1645	0.0	382	909	4546	724	-	-
Botswana	180	1067	175	2.0	300	93	466	751	-	**
Lesotho	157	553	333	2.0*	400*	190	952	700	11	63
Malawi	443	3557	1752	2.3	448	1039	5194	754	43	328
Mozambique	129	703	1538	1.7	471	920	4602	668	77	382
Swaziland	533	1024	112	2.0*	350*	62	308	727	**	**
Tanzania	1305	6661	5221	2.0*	511	3218	16092	649	184	916
Zambia	411	2213	1289	1.6	517	795	3974	649	55	267
Zimbabwe	467	2954	1278	4.0	273	677	3384	755	42	186

- no data available

* estimates

** current 1983 availabilities already exceed minimum requirements for year 2000 and replacement needs.

SOURCE: FAO (1984a)

Nevertheless, human resource development is essential to national economic growth. Education plays a key role in the preparation of technicians and scientists with skills needed for the generation of improved technologies and the dissemination of new management practices to farmers. However, this education should balance theory and practical content for the African environment. Formal coursework should be supplemented by technical in-service training to continuously upgrade staff capabilities.

Conclusions

High priority should be given to the development of comprehensive land use policies based on research that emphasizes agroecological and socioeconomic mapping in SADCC countries. Development strategies could then be devised for agriculture, forestry, tourism, and industrial planning. Integrated watershed management, integrating crops, livestock, forestry and fisheries, should be incorporated according to land capability classifications.

A holistic systems approach in agricultural research will make basic, applied, and adaptive research more effective in providing relevant production technologies. Multidisciplinary farming systems research methodologies, which involve participatory research techniques, should be encouraged. Indigenous knowledge should be considered in the design of improved production systems, and farmers should be involved in planning and testing innovations. Research on sustainability will require long-term monitoring of environmental parameters, such as soil and water quality.

Finances must also be allocated to improve the training of middle level technical support staff. Educational curricula should be reviewed to overcome disciplinary weaknesses, especially in natural resource management and environmental sciences.

Interdisciplinary collaboration is essential in national agricultural research programs. The international agricultural research centres will play a key role in manpower development and technical support through various research networks. More emphasis should also be given to linking universities in developed countries with those in SADCC region.

SACCAR provides an excellent mechanism for promoting collaboration in regional research. However, special initiatives may be necessary to integrate research on agricultural productivity with research on natural resource management.

References

Chambers, R., Ghildyrl, B.P. 1985. Agricultural research for resource poor farmers: The farmer first and last model. Agric. Adm. 20, pp. 1-30.

Davis, T.J., Schirmer, I.A. 1987. Sustainability issues in agricultural development. Proc. of 7th Agriculture Sector Symposium. The World Bank. Washington, D.C., USA.

Farrington, J. 1988. Participatory Research. Exp. Agric. 24 (3); pp. 269-297.

Fisher, J.L. 1964. Natural Resources Planning and Economic Development. UNESCO/UN-ECA. Paris, France pp. 203-204.

Francis, C.A. 1986. The potential for regenerative agriculture in the developing world. Am. J. Alternative Agric. 1(2); pp. 65-74.

INSAR/SPAAR. 1987. Guidelines for strengthening national agricultural research systems in sub-Saharan Africa. The World Bank. Washington, D.C., USA.

Kean, S.A. 1988. Developing a partnership between farmers and scientists: The example of Zambia's adaptive research planning teams. Exp. Agric. 24; pp. 289-99.

Norman, D.W. 1988. Technology development and farmer groups: Experiences from Botswana. Exp. Agric. 24; pp. 321-331.

Okigbo, B.N. 1988. Sustainable agricultural systems in tropical Africa. A paper presented at the International Conference on Sustainable Agriculture. Columbus, OH, USA. Sept. 20-24.

Okigbo, B.N. 1989. The Development of Sustainable Agricultural Production Systems in Africa: Roles of International Agricultural Research Institutes and National Research Systems. Special lecture series No. 1, IITA. May 26.

OTA/BA/AID. 1987. Plan for supporting natural resources management in sub-Saharan Africa. Office of Technical Resources, Agency for International Development. Washington, D.C., USA.

Sumberg, G.J., Okali, C. 1988. Farmers on-farm research and development of new technology. Exp. Agric. 24(3); pp. 333-342.

Worthington, E.B. 1964. A Definition of natural resources. UNESCO/UN/ECA. Paris, France. pp. 9-20.

INTEGRATED AGRICULTURAL RESEARCH AND DEVELOPMENT IN SADCC MEMBER STATES

L.P. Singogo and J.A. Kategile

Introduction

Concern has been raised on land degradation in sub-Saharan Africa which is indicated by declining soil fertility and texture and changes in soil acidity. Soil erosion on account of water and wind erosion is prevalent in this region and monocropping, deforestation, overstocking, and lack of soil and water conservation measures have been identified as the causative factors. The problem is urgent but complex as there are no simple solutions to it. A solution would call for multi-disciplinary research and development approach but this cannot be organized easily by the existing institutional structures as they are compartmentalized to provide solutions to individual commodities. Realizing this a study was undertaken in Southern African Development Coordination Conference (SADCC) member states to discuss the concept of integrated approach and seek the views of leaders and scientists in this region. This was done in preparation for a workshop on the topic where specific objectives were to:-

- discuss the merits of the workshop;
- seek the views of the leaders and scientists on integrated approach;
- discuss and agree on the participation in the workshop; and
- make an inventory of ongoing research and development on related fields of integrated approach and sustainability.

Methodology

This study sought information and views of leaders and scientists in crop, livestock, and forestry research in SADCC countries. Seven countries out of nine were visited and are included in the report. Information from the leaders of research and individual scientists was sought through interviews. To guide the interviews a set of questions formed a general guideline but there was no formal questionnaire. Discussions were held with individuals and groups and notes were taken during the discussions. This paper condenses and analyses Singogo's report.

Human population

The increase in human population in the SADCC countries ranges from 2.1 to 3.4% per annum and this raises the demand for food and other amenities (housing, clothing, fuel/wood, and health etc.,). Population movement due to urbanization and civil commotion cannot be ignored in this region. The human population movements create localized demand situations and availability of labour. In all SADCC member states urbanization is on the increase at 6 to 8% annually, being highest in Botswana.

According to the information obtained during the interviews, the rural areas are facing the problem of labour shortages due to looking after cattle in the cattle posts. The situation has forced a number of cattle owners to move their livestock into villages resulting in overstocking and overgrazing in these villages. Urbanization has also increased the demand for firewood resulting in wide scale deforestation in the areas surrounding the urban centres. The availability of transport for ferrying firewood and charcoal has further accelerated the rate and extent of forest depletion. The impact of urban centres on deforestation is recognised as a factor in the region.

Zambia is the most urbanized country in sub-Saharan Africa and this high concentration of people in urban centres has implications on the demand for fuelwood and therefore deforestation. In Mozambique, the civil disturbances have forced wide scale movements of the human population into safe areas near the cities and towns, placing a heavy demand on available resources.

Further, the movement of people in Mozambique has been accompanied by their livestock into the Southern part of the country resulting in overstocking and overgrazing. Unfortunately, this part of the country has marginal climatic conditions with an annual rainfall of about 400 mm and therefore it is ecologically fragile area.

Changing but collapsing agricultural systems and concerns

Agricultural production systems in Africa have been changing with time. During the period of colonization shifting agricultural systems had been developed to sustainable levels. In the systems, portions of land were allowed to rest for a number of years in order to build up soil organic matter and nutrients. The introduction of large scale farming reduced the land available for the traditional systems of production.

The increase in human population densities also reduced the land available for shifting cultivation for household needs, putting a constraint on the system. Moreover, the colonial governments policies were clearly against shifting cultivation. These factors contributed to the collapse of shifting cultivation. Parallel to this were the introduction of cash crops into the traditional systems e.g., cotton, tobacco, and coffee and the encouragement of food crop production technologies, especially for cereal crops of maize and sorghums. These technologies were introduced as monocrops virtually on a continuous basis.

The negative effects of monocropping on soil condition and fertility are well known. Declines in maize yields with time were reported in Zambia and Tanzania. In Zambia concern was raised on commercial farmers who have failed to maintain soil fertility of the cultivated land. The introduction of the flue cured tobacco in Tanzania did not take into consideration the impact of the crop on deforestation. It is estimated that the curing of tobacco from one acre of tobacco requires the extraction of wood from six acres of woodland. There is, therefore a lot of concern on deforestation caused by tobacco production.

The single technological packages for crop production are monolithic without any considerations on long term soil and water management and possibilities of integrating the crop with livestock and trees. Due to these weaknesses, soils which are continuously monocropped have nutrient imbalances, are of poor soil structure, and have increasing acidity. Further, soil erosion is common in cultivated areas. The declines in yield of cereals inspite of the application of inorganic fertilizers at the recommended rates is a symptom of land degradation.

As human population densities increase more land is cleared for arable cropping. The expansion encroaches on forested areas, grazing land, and marginal fragile areas. In Zimbabwe, the majority of the communal areas are in ecozones IV and V which are fragile and easily degradable, but the population pressure forces farmers to open up more land. This trend can also be seen in other SADCC countries. Livestock numbers in the region are increasing at about 1 to 2% per annum but this is significant as grazing areas are being encroached by arable farming and the carrying capacity is in general declining when stocking rates are increasing.

Capital livestock numbers tend to be high in the marginal semi-arid areas which are fragile. This is mainly due to tsetse infestation in the forest areas and also due to allocating good arable land to crop production. Lesotho is a good example which has set aside the foothills and mountain zones for grazing. These areas are prone to soil erosion.

Overgrazing, deforestation, and lack of soil conservation practices have resulted in severe soil erosion and degradation. A similar situation exists in the highveld of Swaziland. Botswana is in the semi-arid to arid ecozone and livestock is the most important subsector of the agricultural industry. Although intermittent droughts kill scores of head of cattle, the long term trend of livestock numbers is on the increase. This is of concern to policy makers as high numbers are associated with overstocking and overgrazing.

The problem of overstocking is also facing other SADCC member states. Conventional range management technologies have not fitted in the small scale and communal areas due to land tenure problems and socioeconomic factors. For example, fencing of some of the Swazi Nation Land (SNL) by farmers has not improved the fenced rangeland but have instead deteriorated the land even further. It is suggested that overstocking has been the cause of the failures. In Lesotho, scientists and officials who were interviewed expressed the need to involve communities in issues of utilization of communal resources such as rangelands and forestry products. It is apparent that technical solutions have to fit into existing socioeconomic environments.

Table 1, shows a summary of the concerns which were raised by the respondents to the discussions. Across the countries there was a general agreement on the following areas:-

- fuel and wood are in short supply;
- arable cropping is encroaching forested areas;
- rangelands are overstocked;
- serious shortages of feed in dry season; and
- soil erosion is a serious problem.

The shortages of poles for building was common but not universally indicated and availability of other materials such as bricks reduced the demand for poles. The majority of those interviewed did not respond to the issue of watershed. It is felt that this was a reflection of the internal weakness of the unstructured interviews.

Table 1: Identified concerns on sustainable Agriculture in some SADCC member states and priorities for integrated research

Concerns priorities	Botswana	Lesotho	Swaziland	Mozambique	Tanzania	Zimbabwe	Zambia
Fuelwood	Urban	Rural and Urban	Rural and Urban	Urban	Rural and Urban	Rural	Rural and Urban
Building materials	Settlements	-	Rural	-	-	Rural	Rural
Arable cropping encroaching forests	-	-	Expanding	Expanding	Expanding	Expanding	Expanding
Stocking rates	Overstocked	Overstocked	Overstocked	Localized overstocked	Overstocked	Overstocked	Localized
Dry season feed	Very scarce	Very scarce	Very scarce	Scarce	Very scarce	Very scarce	Scarce
Soil erosion	Very serious	Very serious	Very serious	Serious	Very serious	Very serious	Serious
Water harvesting	Needed	Watershed	-	-	-	-	-
Integrated approach priorities	Soil conservation and dry season feed	Integrated community approach	Integrated institutional approach	Training in integrated research	Integrated research approach	Integrated institutional linkages	Soil improvement
Agroforestry technology	For feed and conservation	For fuelwood, conservation and feed	Department of research program	Fuelwood and poles	Fuelwood and feed	Incorporation of MPTs in crop/ livestock systems	Soil improvement

Ongoing National Agricultural Research System (NARS) research activities in alleviating concerns on sustainable agriculture

Institutional

The research and training institutions in the SADCC countries are based on compartments of disciplines. The ongoing research programs are developed along institutional structures. However, these institutions are generally capable of responding to policy demands for solutions to single commodities. Research programs on sorghum is a typical example of policy led research activities. Food shortages in the semi-arid areas led the governments to emphasize the growing of drought tolerant sorghums in the semi-arid areas and researchers were asked to develop appropriate technologies.

The same institutions (research and training) have been less successful in organizing sustainable multidisciplinary farming systems research teams. The institutions are vertically integrated on the basis of disciplines and institutions. Although at great odds some of the African governments have attempted to institutionalize multidisciplinary approach.

In Zimbabwe, a subcommittee on Agroforestry comprises of Department of Research and Specialist Services (DRSS), Department of Agriculture and Technical Services (AGRITEX), Natural Resources, Water Resources Management, University of Zimbabwe, and Forestry Commission. The subcommittee on Agroforestry also includes soil and water conservation and is under the Research Council. The committee forms the basic frame work from which most of the activities on integrated research are coordinated.

In 1983, the government of Tanzania in collaboration with Rodell Institute, initiated a national research program on resource efficiency farming systems at Mlingano in Tanga. The program is concerned with integrated research in crops, trees, and livestock. Alley cropping, intercropping trees with food crops, mulching, composting, and fodder production are among the activities undertaken at the research station.

ICRAF has a regional collaborative research program linking Malawi, Tanzania, Zimbabwe, and Zambia. The in-country program and activities are based in NARS' research stations. It is, however, still an open question as to whether the programs have been internalized or otherwise and their continuation after ICRAF's involvement.

Research activities

The nonexistence of mandated institutions to carry out multidisciplinary research on sustainable integrated agriculture has not killed initiatives by individual scientists and institutions on carrying out research in the related fields. The authors view the following aspects as most relevant:-

- afforestation (fuelwood, soil and water conservation);
- soil conservation (soil and water conservation);
- land management (soil and water conservation and fertility);
- controlled grazing (soil and water conservation and livestock feeds); and
- agroforestry (fuelwood, soil and water conservation, food production, and livestock feed).

The following is a list of research and development institutions and activities which were identified during the visits. It is appreciated that the list is not exhaustive.

Land and water management

▪ LESOTHO	Soil and Water Conservation and Agroforestry Program (SWACAP) - financed by IFAD Agricultural Planning Conservation Unit of the Ministry of Agriculture. Lesotho Work Camp Integrated program - FAO supported
▪ BOTSWANA	National Tillage (Research and Extension)
▪ TANZANIA	Hifadhi Ardhi Dodoma (HADO) - SIDA funded
▪ MOZAMBIQUE	Edward Mondlane University National Institute of Agricultural Research (INIA) in Manica Province
▪ ZIMBABWE	GTZ financed program on Coordinated Agriculture in Rural Development Program in Masvingo
▪ SWAZILAND	Research Division of Ministry of Agriculture and Cooperatives Faculty of Agriculture

Controlled grazing

▪ BOTSWANA	Animal Production Research Unit (APRU) - Range Management APRU Browse utilization Communal Areas Management Associations
▪ LESOTHO	Matelile Rural Development Program Agricultural Planning Conservation Unit
▪ SWAZILAND	N.G.Os Local authorities Department of Agricultural Extension/FAO
▪ MOZAMBIQUE	Institute of Animal Production (IPA)
▪ TANZANIA	Commission of Research and Training at Mpwapwa, West Kilimanjaro, and Kongwa Hifadhi Ardhi Dodoma (HADO)
▪ ZIMBABWE	Department of Research and Specialist Services at Matopos and Makoholi

Afforestation

■ BOTSWANA	Forest Association of Botswana
■ LESOTHO	Division of Forestry
■ SWAZILAND	Forestry Section of Land Use Planning Division
■ MOZAMBIQUE	Forest Department
■ TANZANIA	Tanzania Forestry Research Institute National Tree Planting Day
■ ZIMBABWE	Forestry Commission
■ ZAMBIA	Forest Department - FAO supported project in Ndola

Agroforestry

■ ZAMBIA	Lusume Services (NGO) in Southern Province Soil Productivity Research Agric Extension/ICRAF in Eastern and Lusaka Provinces
■ ZIMBABWE	Department of Research and Specialist Services University of Zimbabwe - Crop Science Department of Zambezi Valley
■ TANZANIA	Faculty of Forestry - Sokoine University of Agriculture (SUA) Morogoro Commission of Research and Training (CRT) at Mpwapwa CRT/ICRAF at Tumbi, Tabora Farming Systems Research Committees (Zonal)
■ MOZAMBIQUE	Animal Production Institute (IPA)
■ SWAZILAND	Veld and Pasture Management Section of Agricultural Research Division.

Integrated research on crops, trees, and livestock

Commission of Research and Training at Mlingano, Tanga, in Tanzania is the only research program integrating alley cropping (intercropping trees with food crops), multipurpose trees of Leuceana and Sesbania providing organic matter for the soil and fodder for livestock and composting and use of compost manure for crop production.

Issues to be discussed at the workshop

The intention of this aspect was to obtain information on NARS aspirations on the concept of integrated agricultural research approach. The question was open ended and therefore the responses varied from conceived priority elements within the whole integrated approach to conceived problems in planning and implementating integrated projects (Table 1). However, an integration of the ideas summarises the strategy for planning and implementing research and development in integrated agriculture.

It is logical to place training on the topic as a prerequisite to planning and implementation as the majority of the scientists are trained in accordance to discipline and commodities. Training is needed to instil additional perspectives and also to equip the scientists with the necessary research methodologies for multidisciplinary work. There are also institutional problems which have been discussed earlier.

There are essentially two examples within the region viz, integrated research program based in one institution, and components of the integrated research being investigated by different institutions which are linked by a lead institution. It is not fair at this stage to point out their attributes and weaknesses.

Some countries indicated clearly that soil erosion is the most important element in integrated research approach. One could interpret this to imply that if this element is included in the ongoing research program this will go a long way in solving the existing problems of unsustainable agriculture. The shortages of animal feeds in the dry season is faced by all countries and is closely linked with overstocking. It is apparent that NARS scientists have accepted that destocking cannot be implemented but the alternative solution is to increase feed supplies for dry seasons feeding.

Another priority was the need to involve the communities in research and development. This agrees with the philosophy of farming systems approach of involving the target groups but additionally, it is realized that grazing and forestry resources are communally utilized resources and hence the need for involving the communities.

An expert on population would be disappointed to see that the increase in human population was not pin-pointed as a priority area as it is the underlying factor. This aspect was not included as it is a speciality on its own merit.

Conclusion

In all the countries visited, researchers, extension staff, and NGO personnel expressed their concern on the ongoing unabated processes resulting in the degradation of the land resource base. All pointed out that the present usages of land i.e., cropping, grazing, and fuel extraction contribute to leaving the land bare and thus prone to soil erosion. The movements of human populations into urban and other types of settlement centres have created markets for fuelwood resulting in deforestation around these areas and beyond.

A number of research activities are being carried out by the SADDC countries on some elements of integrated agriculture but these are on a small scale with relatively little impact. Site located development activities on soil and water conservation are carried out by NGOs mainly but the coverage is patchy. Suggested solutions to these problems include:-

- institutional structure aspects;
- training in integrated agriculture;
- community approach to research and development;
- soil and water conservation;
- afforestation;
- animal feed production; and
- integrated approach in research and development.

AGROFORESTRY RESEARCH NETWORKS FOR AFRICA (AFRENA) PROGRAM IN THE SADCC REGION

D.N. Ngugi

Introduction

Most countries in Africa have problems of food and fodder shortages, degradation of nonrenewable resources, and decreasing access to fuelwood supplies. In the Southern Africa Development Coordination Conference (SADCC) region, imports of cereal staples have increased considerably in the last decade or so. Shortage of food and fodder is partly because of declining agricultural production associated with declining soil fertility caused by soil erosion and degradation, little or nonuse of manures or fertilizers, and the ravages of erratic rainfall. High population growth rates (2.5 - 3.3% per year) in most of the countries in the region have put enormous pressure on the land thereby exacerbating the problem of food shortage. Thus, soil restorative fallows used to sustain soil productivity under traditional shifting agriculture, have become shorter and therefore ineffective, or disappeared from the farming systems altogether. Sometimes low crop production is a direct result of poor crop husbandry practices, e.g., late planting due to late land preparation - often a direct result of draft animals being too weak to plough at the beginning of the rains due to poor nutrition during the dry season.

The rapidly increasing population has also led to deforestation for fuelwood, charcoal, building poles, and timber or to make room for agriculture. In Zambia, for instance, it is estimated that deforestation is proceeding at the rate of about 200 000 ha/year. Deforestation and overgrazing have contributed to severe soil degradation by water or wind erosion, which is evident on hillslopes and in semi-arid lands in the region, for example Shinyanga in Tanzania.

The role of agroforestry

Agroforestry "the deliberate growing of woody perennials on the same unit of land as agricultural crops or animal, either in some form of spatial mixture or in sequence, where there must be a significant ecological or economic interaction between the woody and non-wood components of the system" (Lundgren, 1982), has the potential to solve or ameliorate some of the land use constraints (Table 1) in Africa and SADCC region in particular.

Constraints to development of agroforestry

Agroforestry as a practice of integrating trees into existing farming systems has been practised in the world and SADCC region from time immemorial, the Chitemene system in Northern Zambia and the Chagga system in Kilimanjaro region of Tanzania are good examples. However, scientific and institutional constraints have prevented full development of agroforestry for its wide application (leave alone improving it) to address land use problems in the world at large and the region in particular. These constraints are:

- lack of multidisciplinarity, exacerbated by research organized by discipline;
- few education curricula incorporating agroforestry;
- lack of a body of knowledge and research methods; and
- lack of institutional "niche" where concerted development can take place. Instead research is scattered in various government and non-government institutions without proper linkage or coordination. Within SADCC, research may be based in one or more ministries, universities, councils or parastatal institutes. Without proper linkages and coordination there would be duplication of effort or significant gaps.

Table 1. Land use Problems and Agroforestry Potential in Africa

Problem	Agroforestry alternative
Degradation of hilly lands	Multipurpose trees on terraces Hedgerows along contours
Weak draft animals	Living fences Fodder trees and shrubs
Shifting cultivation	Improved fallows Hedgerow intercropping Multistrata system
Degradation of semi-arid lands	Windbreaks and shelter belts Multipurpose trees on crop lands

Lack of scientific manpower trained in agroforestry research methods

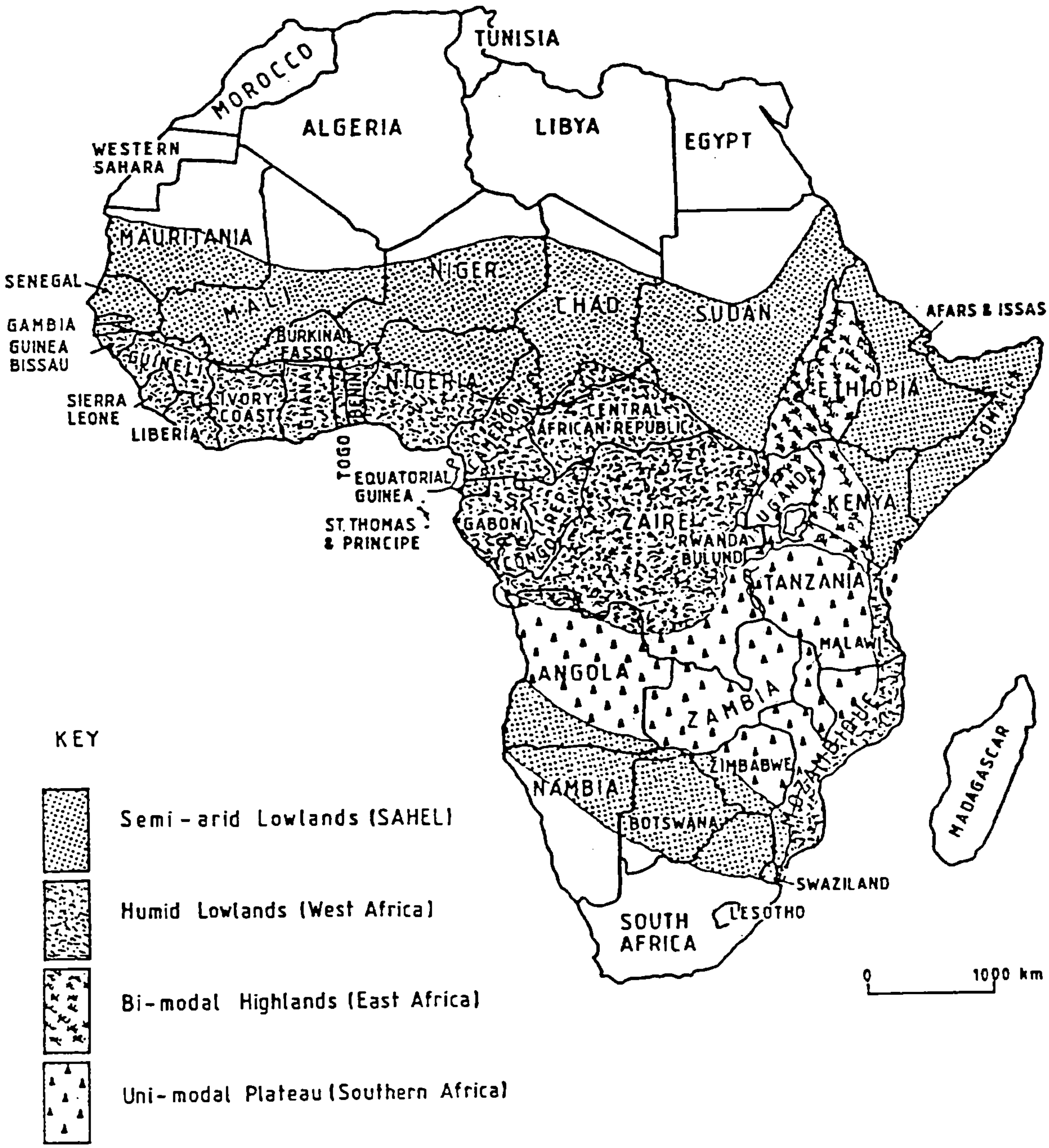
It is in this context that collaborative agroforestry research programs have been developed by the International Council for Research in Agroforestry (ICRAF) and various countries in sub-Saharan Africa under the Agroforestry Research Network for Africa (AFRENA) program. These are intended to generate agroforestry technologies by addressing problems unique to agroforestry research.

Agroforestry Research Networks for Africa

Four ecozone-based networks are planned by ICRAF for sub-Saharan Africa under the AFRENA program (Fig.1):

- the Unimodal (rainfall) upland plateau in Southern Africa (Malawi, Tanzania, Zambia, and Zimbabwe);
- the Bimodal rainfall highlands of Eastern and Central Africa (Kenya, Uganda, Burundi, Rwanda, and Ethiopia);
- the Humid lowlands of Central and West Africa (Cameroun, Ghana, and Cote d'Ivoire); and
- the semi-arid lowlands in the sahelo Sudanian zone of West Africa extending to parts of Eastern and Southern Africa (initially Burkina Faso, Mali, and Senegal).

FIG. 1: ICRAF: AFRENA ECOLOGICAL ZONES



These networks have reached different stages. However, this paper reviews the Southern Africa AFRENA program.

The Southern Africa (SADCC) AFRENA Program

The main objectives of AFRENA program are:

- to strengthen national capability and capacity in planning and implementing agroforestry research;
- to generate agroforestry technologies to address identified constraints to production and sustainability; and
- to institutionalize (over the long term) agroforestry in terms of integration, technology generation, and dissemination.

In order to achieve these objectives, an ecozone approach was adopted in all AFRENAs as a focus for collaboration in research among and within the participating countries and ICRAF. Collaboration among and within the countries ensures a more efficient use of scarce research resources in addition to facilitating exploitation in intercountry complementarities and advantages. Also, by focusing research on an ecozone, it is possible to concentrate on a limited number of agroforestry technologies addressing major priority problems. The case for using networking on an ecozone basis to promote agroforestry research was described by Torres (1986).

The Unimodal Upland Plateau

The ecozone was chosen as target for the Southern Africa AFRENA program on the following basis:

- it supports high human and livestock population;
- it is a priority area for government development policies;
- it has acute land use problems (soil fertility, soil erosion, shortage of fodder, lack of fuelwood and timber); and
- agriculture is dominated by small holders who produce most of the food from low-input farming systems. The low-resource small holders are likely to benefit more from agroforestry than the high input commercial farmers.

The ecozone covers about 1.4×10^6 km^2 embracing parts of Malawi, Tanzania, Zambia, Zimbabwe, Mozambique, Zaire, and Angola. Initially, however, only the first four countries are involved in the network. Botswana, Lesotho, and Swaziland fall outside the ecozone but they would benefit from technologies generated in other AFRENA with comparable agroclimatic conditions. Similarly Angola and Mozambique would benefit from technologies developed in the Southern Africa AFRENA being in the same ecozone.

The main biophysical characteristics of the plateau are:

- altitude: 900-1500 m above sea level;
- rainfall: unimodal, annual average 600-1500 mm falling from November to April;
- vegetation: miombo/savanna, dominated by genera ***Brachystegia, Julbernardia, Isoberlina***; and
- soils: predominantly sandveldts, moderately to heavily leached.

The AFRENA model

The phased implementation of the Southern Africa AFRENA program is illustrated in Fig. 2. The following phases are in the implementing process:

- research planning;
- research formulating and design; and
- research implementing.

Research Planning Phase

During the research planning phase land use systems in the delineated ecozone in each country were described, identifying constraints and agroforestry potentials using the diagnosis and design (D and D) method. This inventory was done by a special multidisciplinary national task force in cooperation with ICRAF scientists. Priority land use and agroforestry interventions were determined in consultation with policy makers (members of national steering committee for agroforestry).

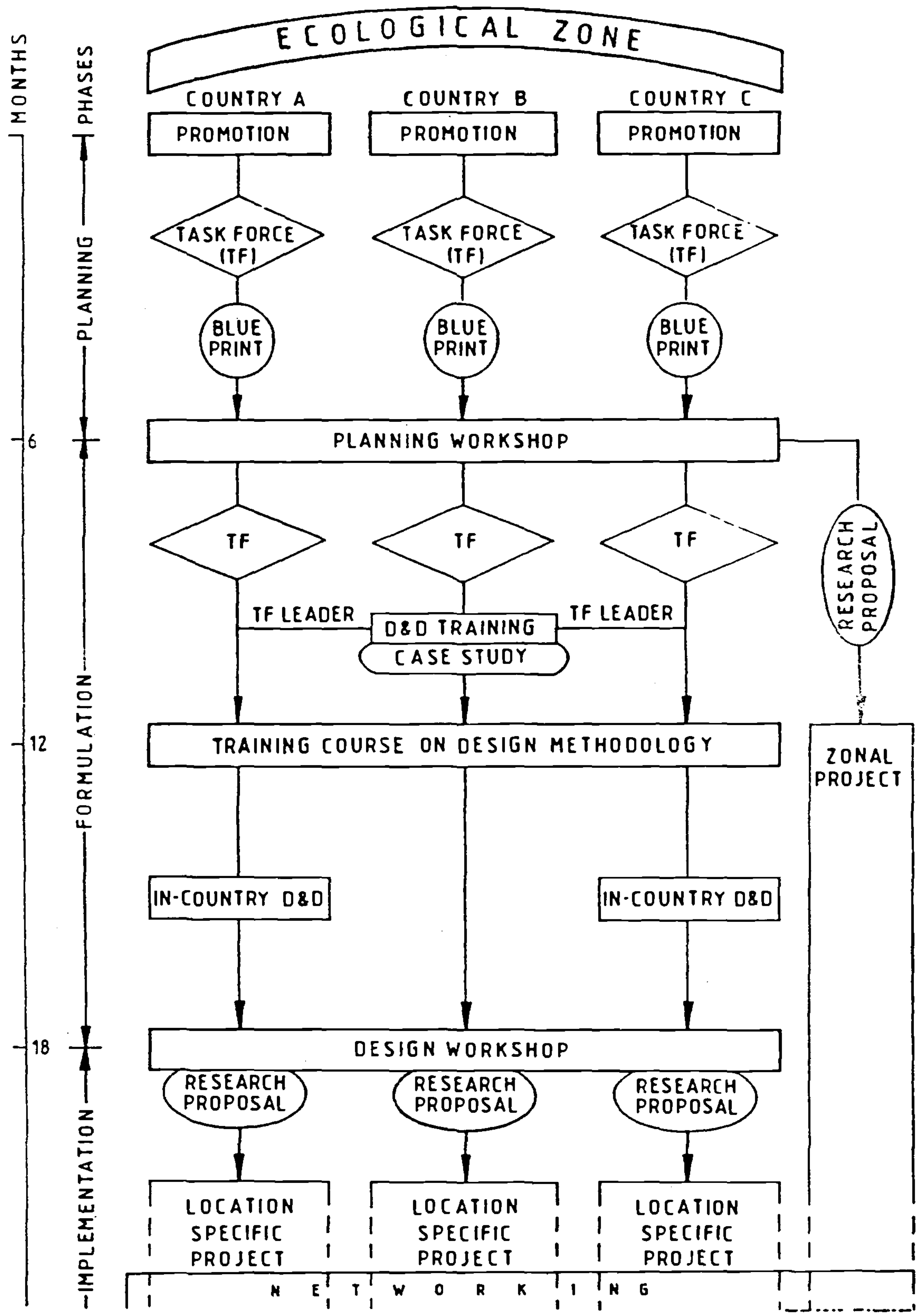
Research Formulating and Design

The research formulating and design phase involved micro D and D in the priority land use system during which more details on the system components, operation, and constraints were gathered and analysed. The information gathered provided design specifications for the proposed research plans and technologies. The specifications related among other things to the type of tree, location of planting in the landscape planted, spatial arrangement and management, consideration of the implications on the crops, livestock, and the environment.

Research Implementing

The research implementating has involved multipurpose tree (MPT) screening and management trials of some promising MPTs in agroforestry technologies. Structuring of the process ensures maximum collaboration between ICRAF and national scientists (including policy makers) from conceptual stage through implementation.

FIG 2. INTEGRATED RESEARCH AND TRAINING IN AGROFORESTRY NETWORKING



Progress:

Development of zonal and country research projects

Following the D and D field surveys by the Task Forces, a total of 14 land use systems were described for the ecozone, in what are termed "blueprints" on agroforestry (Kamau and Odra 1988; Kwesiga and Sabas 1988; Kwesiga and Kamau 1989; Minae 1989). The proposals in the "blueprints" were discussed at a regional workshop held in Harare in September 1988. The areas identified for zonal research were:

- selection of MPT species to fit technology specification;
- maintenance/improvement of soil fertility by trees in suggested spatial/temporal arrangements;
- fodder production for the long dry seasons; and
- on-farm research, adapting prototype technologies to farmers' circumstances.

In order to facilitate the implementing of the zonal project, participating countries cooperated with SACCAR and ICRAF along the following lines:

- countries provide research facilities for zonal activities at their stations in Makoka (Malawi), Tumbi (Tanzania), Mount Makulu (Zambia), and Harare (Zimbabwe);
- national forestry and agricultural institutions from Malawi, Tanzania, and Zambia second one professional each to work full-time in the zonal project;
- the zonal project recruit four senior scientists (one for each of the identified research areas) and supplement operational costs;
- each of the expatriate scientists attend the designated stations fulfilling both managerial and scientific responsibilities on site, and a scientific responsibility in the zone (according to their expertise); and
- a project coordinator be recruited to be responsible for training, facilitating project logistics, and promoting active interaction among participating institutions.

The five year zonal research program entered the research implementing phase in November 1989. The field experiments were launched in 1987/88 (initially on-station) at the zonal research sites in Tanzania and Zambia and in the 1988/89 season in Malawi. Similarly experiments for the location specific country program have already been initiated in Zambia and Malawi. The main technologies being developed are shown in Table 2 (Avila and Ngugi 1988).

Table 2. High priority Agroforestry technologies under development in the Southern Africa AFRENA Program

* ZONAL PROGRAM COUNTRY PROJECT/ LAND USE SYSTEM	AGROFORESTRY TECHNOLOGIES											
	Hedgerow intercropping	Improved fallow	Mixed intercropping	Boundary planting	Fodder banks	Trees on pasture	Trees on contours	Living fence	Tree plot	Homesteads/Gardens	Tree-wet areas	Wind/shelter belts
ZONAL PROGRAM	X	X	X	X	X							
MALAWI: LILONGWE (Crop-livestock)	X		X	X	X				X	X	X	
TANZANIA: SHINYANGA (Agro-pastoral)	X			X	X			X		X		X
ZAMBIA: CHIPATA (Crop-livestock)	X	X	X				X	X				
ZIMBABWE (Crop-livestock)	X		X	X	X	X	X	X		X	X	

Training

Training is another major feature of the AFRENA program aimed at building national capacity and capability in agroforestry research planning and implementing. The training component provides for postgraduate training, short research internships, in-zone courses, research workshops, and monitoring tours. To date, four scientists have embarked on agroforestry-biased MSc programs overseas. It is planned to train a multidisciplinary team of three scientists per country by the end of the five year program. Five research workshops and two short courses have been mounted since the planning activities of the program begun.

Discussion and conclusion

Research

The Southern Africa AFRENA program set out to strengthen national capability in planning, designing, and implementing agroforestry research project using the land use system assessment approach. The program has made progress in that multidisciplinary teams of nationals (small as they may be) have been trained and are fully involved in agroforestry research. The importance and advantages of integrated planning in agroforestry research has been demonstrated through close interdepartmental cooperation during the research implementing phase. Involving policy makers in the planning process through the steering committees has ensured maximum administrative support. However, the launching of AFRENA has raised various issues as follows:

- **Training**

  The AFRENA experience has confirmed the severe shortage of research scientists trained in agroforestry enquiry. There is need, therefore, to develop local and regional capacity and capability to train in agroforestry. Technician training is equally important especially in such a field as agroforestry where research methods are still evolving. Along with these, there is need to develop teaching materials in support of both formal and vocational training in agroforestry in all levels.

- **Research approach and methods**

  As the research implementing work continues, it is clear that the researchers need to discuss and agree on research methods/techniques to use in various studies and under different conditions, e.g., what data to record, when and how often, and for what period. In major areas of research such as on-farm research, there is need to develop suitable methods to take account of the perennial nature of most MPTs, land tenure issues, etc. A general agreement on guidelines on minimum data set to take in various studies would be of immense help and will facilitate comparisons of the research results.

- **Information dissemination**

A lot of agroforestry research was in place well before the entry of AFRENA in the Region. Several non-governmental organizations (NGOs), development project agents, and universities were already conducting agroforestry research. However, information on these, activities is scattered and often unpublished. There is need, therefore, to document the findings from these activities and to provide effective mechanisms for sharing the information. ICRAF has launched the "AFRENA Report Series" to facilitate information exchange among the AFRENA and others working in agroforestry. An efficient information network would strengthen research besides facilitating multilocational trials among collaborating scientists.

- **Pests and diseases**

It has become clear that one of the problems that agroforestry systems will have to contend with are pest and disease complexes probably hitherto unknown under traditional cropping systems. It is, therefore, timely to start studying and documenting pests/diseases simultaneously with other research work for obvious reasons. Early warning systems on outbreak of serious pests such as ***Leucaena*** Psyllid would promote early counter measures. This is an obvious area where collaboration among the relevant departments or international centres would be highly profitable. ICIPE has already indicated willingness to collaborate in this area.

- **Seed production and supply**

By the time we want to test prototype technologies on-farm, we will need seeds of proven MPTs. It is, therefore, important to start addressing the whole issue of seed collecting, multiplying, handling, storing, and distributing. Expertise to be found in departments of forestry would come in handy. Of even greater importance and urgency is the conserving of indigenous tree germplasm whose potential for agroforestry and other uses is yet to be assessed and used.

- **Institutionalizing agroforestry**

Successfully established national steering committees in the collaborating countries through the AFRENA have a role to play in future development of agroforestry. This will be done by facilitating interdepartmental institutional collaboration both within and between countries. This is an important function of the committee until agroforestry research is institutionalized in each country. The high degree of national commitment to institutional and inter-institutional collaboration in planning and implementing of agroforestry research in the AFRENA program augers well for future development of agroforestry research in the region.

References

Avila, M., Ngugi, D.N. 1988. ICRAF's research and collaborative strategy with national institutions. Paper presented at the Crop-Livestock Interaction workshops, Harare, Zimbabwe, 21 June - 1 July 1988.

Kamau, I., Odra, J. ed. 1988. A Blueprint for agroforestry research in the unimodal upland plateau of Tanzania. AFRENA report No. 6 ICRAF, Nairobi, Kenya.

Kwesiga, F., Kamau, I.M. 1989. Agroforestry potential in the unimodal plateau of Zambia. AFRENA Report No. 7 ICRAF, Nairobi, Kenya.

Kwesiga, F., Sabas, E. 1988. Agroforestry research project for the Sukuma agro-pastoral system in the unimodal upland plateau (Mwanza/Shinyanga Region), Tanzania. AFRENA Report No. 9 ICRAF, Nairobi, Kenya.

Lundgren, B. 1982. Introduction. Agroforestry systems, 1, pp. 3-6.

Minae, S. 1989. Agroforestry potentials for the land-use systems in the unimodal plateau of Southern Africa - Malawi, AFRENA Report No. 5 ICRAF, Nairobi, Kenya.

Ngugi, D.N., Saka, A. 1988. Agroforestry research project proposals for the Lilongwe land-use system. AFRENA report No. 8 ICRAF, Nairobi, Kenya.

Torres, F. 1986. Agroforestry research networks in tropical Africa, paper presented to the first International conference of agricultural research systems, IFARD, Brasilia, Brazil, 6-11 September 1986.

THE KENYAN DUAL PURPOSE GOAT PROGRAM

AN OVERVIEW

J.F. Moses Onim, P.P. Semenye, N.A. Mbabu, and H.A. Fitzhugh

Introduction

The Kenya Government and the United States Agency for International Development (USAID) started the Kenyan Dual Purpose Goat (DPG) program in 1980. USAID funds were a grant provided from Title 12 of U.S. Congress of 1975. The Kenyan DPG program is part of a larger organization encompassing research on small ruminants operating in five countries, including Morocco, Peru, Brazil, Indonesia, and Kenya. The Small Ruminant Collaborative Research Support Program (SR-CRSP) in these five countries is a collaboration between scientists of the host countries and those from U.S. universities and other institutions. In Kenya, SR-CRSP is conducting multidisciplinary farming systems research in which the following institutions and disciplines are involved:

- Kenya Agricultural Research Institute in the Ministry of Science and Technology
- Texas A&M University - Animal breeding and systems analysis
- Washington State University - Animal health
- University of Missouri - Sociology
- Winrock International - Economics, and

  - Production systems:

- Goat nutrition and management
- Feed resources
- University of California, Davis - Management entity (ME)

Kenya has a policy of self sufficiency in crop and livestock production in the small scale farming sector. Average human population in Kenya grows at the rate of 4% per year. This has subdivided farming land where an average household of six people in western Kenya now owns about one hectare. Competition between pasture and crop land has forced farmers to reduce their livestock herds and grow more food crops (Sidahmed et al. 1984). As cattle decreased, milk for household use was reduced to the extent that protein deficiencies among children and expectant mothers became apparent. In view of this, Kenya approved SR-CRSP research proposal to introduce into the heavily populated rural areas of western Kenya DPGs that would produce meat and milk as protein sources. It was argued that the DPG would not suffer from tick borne diseases as crossbred dairy cattle would, and one goat would require a fifth of what one adult cow would need for feeds. These arguments convinced the Kenya government to make available several agricultural/livestock research stations for the program, and USAID to give a grant to fund this research activity.

Baseline Surveys

Once the areas for the on-farm crop/livestock research was identified in western Kenya, a rapid survey was done to characterize them and identify goat production constraints (Sands et al. 1982).

This and other late surveys studied several parameters including land holding per household, types and numbers of different livestock, livestock grazing management, e.g., communal grazing, tethering, zero-grazing, etc., major livestock diseases, types of crops grown and their combinations, cash vs food crops, size of household, labour availability throughout the year, division of this labour between crops and livestock, and cash flow within, out of, and into the farm. A list of important constraints was detailed and became priority areas for research before and during the introduction of the DPGs on-farm.

Constraints to overcome before introducing DPGs to farmers

There were several constraints that various research disciplines of the Kenyan SR-CRSP had to overcome before introducing the DPGs to small scale farmers in western Kenya. The major constraints were:

- **Social factors.** Especially the consuming of goat meat and milk in certain sections of the community. Labour profiles and economics of the DPG had to be worked out.

- **Diseases.** The most important ones were pneumonias, brucellosis, and orf.

- **Pest and parasites.** Important pests were external ones (ecto) especially fleas, mites that cause mange, and ticks. Intestinal parasites especially nematode worms - ***Haemonchus contortus***, and liver flukes (fasciolasis) appeared in lowlands.

- **Adaptation of the breed** under small scale intensive management.

- **Nutrition and management of the DPGs.**

- **Development of feeds** for the DPGs and agronomic packages that are suitable for small scale farmers.

To tackle these research problems, a multidisciplinary team consisting of an animal scientist, an animal breeder, veterinarian, agronomist, agricultural economist, and a sociologist was hired by the program. To work with each of these scientists was at least one government scientist. Most of the participating government scientists soon had an opportunity to pursue further training (MSc or PhD) overseas.

On-farm research implementation

Different programs have taken various approaches to conduct on-farm research. The SR-CRSP in western Kenya adopted a five step approach.

- Baseline surveys for identifying constraints.
- On-station component research on the DPGs and developing suitable feeds and feeding experiments. A large scale crossbreeding project was started between two locally adapted breeds (females) and two exotic well known dairy breeds (males). Characterizing socioeconomic factors continued and monitoring of a limited number of DPGs placed on the farms (Brown et al. 1983a).
- Continuing on-station research; scientist managed on-farm trials; on-farm production of DPGs; and an expanded on-farm performance monitoring program (Brown and Ndrito, 1983b; Ruvuna et al. 1983; Brown et al. 1984).
- Extensive on-farm evaluation of DPG systems based on technology packages developed in the first two steps. Researchers monitor adaptation and changes that farmers suggest to make technical packages work better for them.
- Revised technical packages are given to extension personnel for wider use within the country and beyond.

Selection of farmers for on-farm crop/livestock research

SR-CRSP in western Kenya used the random selection to identify farmers to participate in on-farm for research for better representation of the general population.

Before the arrival of SR-CRSP in western Kenya, several villages had been selected by the Ministry of Economic Planning to study the import of various economic changes. The SR-CRSP team selected three of these villages on the basis of their demographic and edaphic characteristics, ecological zones, and farming practices. In each village (referred to as a cluster), a land register was used to select farmers randomly to participate in the SR-CRSP baseline survey.

Respondent farmers were given one or two pregnant does or a doe and a kid. For up to five farmers with does, one improved breeding buck was provided to serve the does. The doe belonged to the program. The farmer, however, could use the milk, the kids born on the farm, and manure in return for his labour and participation.

For crop experiments, the land for scientist managed on-farm experiment, was rented from the farmer. However, the farmer was expected to observe differences in various treatments and protect the experiment from livestock damage and crop thieves. After sampling, forages and produce were given to the farmer. Farmers from each cluster were invited to hold a field day at one of these experiments periodically where they participated in discussing results. Those farmers convinced that scientist managed trials are good, are then encouraged to take the next step to farmer managed trials.

Farmer managed experiments should be simplified to deal with one or two variables. For example, the farmer may be asked to compare milk yield between local does and DPGs to see which one produces more milk for the same inputs. Similarly, the farmer can easily compare the effect of green manure on maize yields in a "with and without" unreplicated trial. Several farmers doing the same trial within one cluster can be used as replicates. This data can then be statistically analyzed and reported.

Research Highlights for solving the identified constraints: Development of the Kenya DPG breed

The animal breeding project set out a breeding scheme in which two adapted local Kenyan breeds (females) would be crossed to three exotic dairy breeds (males). The local breeds were the Small East African Goat (SEAG) and Gala *(G)*. The exotic breeds were Toggenberg *(T)*, Anglo-Nubian *(AN)* and Alpine *(A)*. However, three alpine breed was later dropped. The Kenyan DPG *(F1)* progeny would then be crossed with each other to produce a synthetic population (a four-way progeny). Each four-way cross kid would then have genes from two local and two exotic parents, and their gene pool would be intercrossed to stabilize the population.

Kenyan DPG so far tested on-farm have faster growing kids which mature at 10 kg more than the SEAG. Their milk yield is approximately 1.0 kg and dry matter manure output is 0.5 kg/day respectively. The project has also developed, and is still fine tuning, a simulated goat model in their Systems Analysis subproject.

Social studies

The DPG has been readily accepted by farmers in six villages in three districts in western Kenya. The program currently has 150 respondent farmers, but the number could easily reach thousands if more DPGs were available. The rate of generating DPGs cannot match the farmers demand for DPGs.

Goat milk has also been readily accepted by farmers in all the six villages. When the program started in 1980, it was feared that religious and customary taboos in the communities, might deter some members of the villages from consuming goat products (Nolan, 1982). However, currently the demand for goat milk by the respondent households and neighbours is greater than the present level of production.

A study was conducted to establish whether people distinguish goat milk (fresh or sour) and cheese from similar products from cow milk (Boor et al. 1983). When ranked for taste and quality, the heat treated cow milk was last, while fresh cow and goat milk ranked equal as "good". Farmers have many positive things to say about goat milk including that, fewer people react adversely to it compared to cow milk, and that it is more readily digestible.

Both sociological and economic projects have studied availability and household labour profiles throughout the year to assess how the introduction of DPGs would fit into or interfere with these profiles. Data show that a DPG's enterprise is economical and socially acceptable to small scale farmers. According to Conelly et al. (1987), overall, based on 9496 random observations over the year in Hamisi cluster, the direct labour costs of maintaining livestock in Hamisi required 2% of all daylight time, or about 15 min/person per day. This compares to an average of 1.5h/day (11.6%) devoted to crop production, 40min/day (5.4%) to off-farm labour, 2.5h (20.8%) to household tasks, 30 min/day (4.0%) to social and religious activities, 4.2 h/day (34%) inactive, 2.5 h/day (20.1%) attending school and 2.1% unknown. When comparing an intensive (cut-and-carry) livestock management system in Hamisi cluster to that of semi-intensive one in Masumbi cluster where there is more herding, Conelly and Nolan (1986) observed that 18.7 and 6.0% of working day time is spent on livestock by the household in Masumbi and Hamisi respectively. The farmer, therefore, saves 12.7% of farming time when s/he opts for intensive livestock management.

DPGs health

Diseases of the DPGs in western Kenya of economic importance have been ranked by Siamba and Semenye (1989) as pneumonias, helminthiasis, ectoparasites (mange and ticks), diarrhoeas and scours, abscesses, trauma and wounds, malnutrition, and abortions.

The most common cause of pneumonia with high death rates is a Mycoplasma strain F38. The Health project has developed an easy to store and administer field vaccine for Contiguous Caprine Pleuro-Pneumonia (CCPP) (Rurangirwa et al. 1986). This vaccine is effective and will benefit many countries in Africa and the near East where CCPP is rampant.

For helminths, especially ***Haemonchus contortus,*** suitable drenching schedules have been developed. However, this is expensive for small scale farmers, and, therefore, cheaper management methods are being sought to reduce drenching frequencies. The nutrition and Management project is conducting an experiment on the effect of wilting forages before feeding it to the goats. Preliminary results indicate that wilting forages reduce the number of ***H. contortus*** larvae in the feeds, parasite intake. The health project also observe breed resistance/tolerance differences to this parasite. Local SEAG showed the least infestation in a study where several goat breeds were artificially inoculated with ***H. contortus*** larvae (Shavulimo et al. 1986).

Ectoparasites are controlled with strategic dipping and management, e.g., tick picking and pricking. Diarrhoeas and scours, abscesses, traumas, and wounds are attended to by the veterinary field staff, assisted by SR-CRSP field staff. The farmers pay cost price for the treatments.

Malnutrition is occasionally observed where farmers tether their animals without changing them often, or where the cut-and-carry system is practised without adequate feeding. This is simply a management problem.

Nutrition and management (NM)

Major nutritional constraints to the DPGs in western Kenya are: low availability and quality of feeds; high moisture content of feeds; low mineral contents in feeds; toxicities, and high levels of antinutritional factors in feeds, especially in tropical legumes.

Some of the constraints will be addressed by the Feed Resources project. NM project has conducted experiments which demonstrated that sweet potato vines can replace milk for goat kids. This can lead to an earlier weaning of up to 60 days, thereby relieving up to 60 kg of milk for household use (Semenye et al. 1987). Sweet potato vines have high crude protein content (20%), high palatability, digestibility (70%), and water content (80%).

To overcome low mineral contents in feeds, NM is developing a mineral feed block which contains the deficient minerals in feeds and added ingredients high in protein and energy. The feed block will replace the conventional mineral block.

Several experiments have been conducted to determine the suitable levels of feeding forages from tropical legumes that are known to contain toxic substances and other antinutritional factors (Semenye et al. 1987). Examples are leucaena ***(Leucaena leucocephala)*** and sesbania ***(Sesbania sesban*** var. ***nubica)***. The former contains mimosine while the latter contains sapponin, which is perhaps the toxic principle. When fed at the right quantities, these legume forages have shown good values as sources of protein for low quality crop residue diets (Anon. 1986, Semenye et al. 1987).

Experiments are underway to study the effect of reducing moisture content in feeds, by wilting on intake and growth rates of goats. Preliminary results indicate that animals on wilted feeds gain more live body weight by approximately 22.8% (Semenye - personal communication).

In goat management, the routine livestock management procedures were followed. Sole tethering and tethering with some herding were studied with respect to uptake of intestinal worms and its impact on access to grazing and feeding. Milk hygiene and management are emphasized to farmers because of milk-borne diseases, especially brucellosis.

Feed resources (FR)

The feed resources project is to develop interventions for generating adequate feeds for the DPGs on small scale farms in western Kenya. One of the major constraints has been low soil fertility with low pH (e.g., 4.4). Low soil fertility has resulted in high deficiencies of phosphorus (*P*) and high levels of iron (*Fe*) and Alluminium (*Al*), making the soil toxic to plants and leading to low crop and forage yields. To overcome these constraints, experiments have shown that use of green manures from legumes (leucaena and sesbania) can increase maize grain and biomass yields by 70.5 and 79.3% respectively (Onim et al. 1989). Similarly, goat manure increased maize grain yields by 57.8%. Forage yield responses to manure and fertilizer application is often higher than that of grain yields.

High population density (up to 900 people km^2) means that there are, therefore, few pastures and fallow lands. Intercropping food and feed crops and developing crop cultivars that have high yields of food and feeds e.g., maize, sweetpotato, finger millet, pigeon pea, etc., and especially the double cobber maize cultivar (Onim et al. 1986) has been attempted and is popular with the farmer. The double cobber maize cultivar has a potential for alley cropping since it produces double cobs at a frequency of 50%.

Simplified hay baling (Onim et al. 1985b) and silage making (Otieno et al. 1986) have been good feed conservation technologies for small scale farmers. To overcome low quality crop residue, diet supplementation with legume forages has shown excellent potential. A large gene bank of sesbanias (14 species and 200 accessions) is being screened at Maseno Research Station to meet this challenge.

Discussion

The assessment of on-farm crop/livestock trials should be done with two groups in mind. The first and most important are farmers. Farmers should be partners in on-farm research, since they will have to apply the results of these trials to increase crop and livestock production. Assessing of such trials should use simple and practical methods and units, e.g., crop yields should not only be weighed, but also measured (e.g., in tin-fulls) to show yield differences from various treatments. For livestock experiments, milk yields should be measured in millilitres but also simply in full bottles. Kid, lamb, and calf growth rates should not only be determined by weighing, but also by such crude methods like visual estimates and handlifting. Farmers' abilities to estimate weights and sizes by such methods should not be underestimated. They are capable of detecting small differences. Results obtained from farmers' estimates should then be compared to the conventional methods and be correlated. This approach gives farmers confidence in the results obtained and it makes adoption of the improved methods easier and faster.

The treatments proposed for such on-farm experiments should, therefore, be those that show conspicuous differences with the traditional method. On-station experiments therefore, should precede on-farm experiments to screen out trials which may not show obvious differences between treatments in on-farm trials. It is difficult for a scientist to explain a failure to a group of farmers in on-farm trials. Should there be a failure, its causes must be clearly explained to farmers in terms that they can understand.

The second level of assessment should be done through suitable statistical analyses and interpretation. Because of variable conditions in the farms, researchers should expect larger coefficients of variation than most of their laboratory and station colleagues are used to. Most refereed journals do not readily accept such data for publication. This has frustrated many researchers who have conducted excellent on-farm trials and obtained good practical and applied results. There are however, several journals now that accept to publish results from on-farm experiments.

On-farm trials should be assessed using biological parameters but must also be subjected to a thorough economic analysis. Although on-station experiments often show large yield differences compared to farmers, when inputs are costed, usually the on-station results may not be any better.

Similarly, on-farm trials should be subjected to sociological evaluation. Once a trial on on-station is showing good biological and economic potentials, it should next be tested for its social acceptability. A high yielding crop variety may be rejected by the farmers at a later stage because it has poor cooking and eating qualities. A lot of time and money could have been saved if farmers' views were sought. Similar examples will also be found in livestock on-farm trials. And that the good farmer response for the DPGs in western Kenya provides a good case to support the on-farm research approach where farmers are fully participating in developing and testing of the DPG technologies.

References

Anon. 1989. International Livestock Centre for Africa (ILCA) Annual report 1985/86. Addis Ababa, Ethiopia. 50 p.

Boor, K.J., Fitzhugh, H.A., Ochieng, E. 1983. Consumer Acceptability of Goat Milk Products. Proceedings of second Kenya SR-CRSP Workshop, 22 February 1983. Naivasha, Kenya pp. 35-39.

Brown, D.L., Chavulimu, E., Salim, M.K., Fitzhugh, H.A. 1983a. Effects of Sweet Potato Vines Additions and Stover Maturity on Maize Silage Quality. Proceedings of the second Kenya SR-CRSP Workshop, 22 February 1983. Naivasha, Kenya.

Brown, D.L., Nderitu, M. 1983a. Performance and milk requirements of E.A x Toggenburg kids weaned at two months of age or 10 kg body weight. Proceedings of the second Kenya SR-CRSP Workshop, 22 February 1983. Naivasha, Kenya. pp. 17-19.

Brown, D.L, Chavulimu, E., Fitzhugh, H.A., Sidahmed, A.E. 1984. Effect of ensiling or drying on five local forage species in western Kenya. Proceedings of the third Kenya SR-CRSP Workshop, 5 - 6 March 1984. Kabete, Nairobi, Kenya. pp. 29-36.

Conelly, W.T., Nolan, M. 1986. Time allocation and the organization of household labour in smallholder farming systems in western Kenya. Proceedings of the fifth Kenya SR-CRSP Workshop, 4-6 November 1986. ILRAD, Kabete, Nairobi, Kenya. pp. 213-224.

Conelly, W.T., Mukhebi, A.W., Oyugi, L., Knipscheer, H.C. 1987. Household labour allocation in an intensive crop/livestock system in western Kenya. Proceedings of the sixth Kenya SR-CRSP Workshop, 4 - 6 November 1987. ILRAD, Kabete, Kenya. pp. 135-152.

Nolan, MF. 1982. Dual purpose goats in western Kenya; A summary of sociological constraints. Proceedings of the first Kenya SR-CRSP Workshop. pp. 133-114.

Onim, J.F.M., Semenye, P.P., Fitzhugh, H.A., Mathuva, M. 1985a. Research on feed resources for small ruminants of smallholder farms in western Kenya. Proceedings of a Workshop on Animal feed resources for small-scale livestock producers. 11-15 November 1985. IDRC-MR 165e. pp. 149-158.

Onim, J.F.M., Mathuva, M., Otieno, K., Fitzhugh H.A. 1985b. Simplified hay making for small scale farmers in western Kenya. Proceedings of the fourth Kenya SR-CRSP Workshop, 11-12 March 1985. Kakamega, Kenya. pp. 25-28.

Onim, J.F.M., Mathuva, M., Otieno, K., Fitzhugh, H.A. 1986. Comparing some maize populations to standard varieties for feed Kenya SR-CRSP Workshop, 4-6 November 1986. ILRAD, Kabete, Nairobi, Kenya. pp. 9-20.

Onim, J.F.M., Mathuva, M., Otieno, K., Fitzhugh, H.A. 1989. Soil fertility changes and response of maize and food beans to green manures of laucaena, sesbania, and pigeon pea. Agroforestry Systems journal, Holland, (in press).

Otieno, K., Onim, J.F.M., Semenye, P.P., Mathuva, M.N. 1986. Evaluation of small-scale silage preparation using molasses as an additive. Proceedings of the fifth Kenya SR-CRSP Workshop 4-6 November 1986. ILRAD, Kabete, Nairobi, Kenya. pp. 32-39.

Rurangirwa, F.R., McGuire, T.C., Chema, S. 1986. Towards development of a vaccine against Contagious caprine Pleuropneumonia caused by F-38. Proceedings of the sixth Kenya SR-CRSP Workshop, 4-6 November, 1986. ILRAD, Kabete, Nairobi, Kenya. pp. 76-81.

Ruvuna, F., Cartwright, T.C., Smith, G.M., Bradford, E.G., Berger, N.M., Ahuya, C., Muia, J. 1983. Preliminary results of performance of different breeds of goats at 01 Magogo. Proceedings of Kenya SR-CRSP Workshop, 22 February 1983, Naivasha, Kenya. pp. 83-98.

Sands, W.M., Fitzhugh, H.A., McDowell, R.E., Chema, S. 1982. Mixed crop-animal systems on small farms in western Kenya. Small-Ruminant CRSP Technical Report No. 17.

Semenye, P.P., Musalia, L., Otieno, K, Onim, J.F.M., Fitzhugh, H.A. 1987. Interaction of dual purpose goat with subsistence crops and weeds. Proceedings of the sixth Kenya SR-CRSP Workshop, 4-6 November 1987. ILRAD, Kabete, Nairobi, Kenya. pp. 65-71.

Semenye, P.P., Musalia, L., Onim, J.F.M., Fitzhugh, H.A. 1987. Toxicity of ***Leucaena leucocephala*** and ***Sesbania sesban*** sun dried leaf hay. Proceedings of the Sixth Kenya SR-CRSP Workshop, 4-6 November 1987. ILRAD, Kabete, Nairobi, Kenya. pp. 93-101.

Shavulimo, R.S., Rurangirwa, F.R., Ruvuna, F., James, A.D., Ellis, P.R., McGuire, T.C. 1986. An evaluation for resistance against ***Haemonchus contortus*** in three goat breeds: East African, Galla, and East African x Toggenburg. Proceedings of the sixth Kenya SR-CRSP Workshop, 4-6 November 1986. ILRAD, Kabete, Nairobi, Kenya. pp. 113-121.

Siamba, D.N., Semenye, P.P. 1989. Preliminary results of factors affecting mortality of dual purpose goat kids in western Kenya. Proceedings of the seventh Kenya SR-CRSP Workshop, 22-23 February 1989. ILRAD, Kabete, Nairobi, Kenya. (in press).

Sidahmed, A.E., Reed, J., Butterworth, M., Otieno, K., Fitzhugh, H.A., 1984. Chemical composition and digestibility values for some important for age resources consumed by Dual purpose goats in western Kenya. Proceedings of the Third Kenya SR-CRSP Workshop, Kabete, Kenya. 5-6 March 1984. pp. 53-57.

INVOLVING FARMERS IN INTEGRATED CROP-LIVESTOCK RESEARCH: LESSONS FROM ALLEY FARMING RESEARCH

L. Reynolds

Introduction

The farming systems approach to research relies on an understanding of the whole farm environment, an appreciation of the off-farm factors that influence that environment, the objectives of farmers, and the contribution of individual members of the farm family towards those objectives. For a livestock project this approach is particularly important where livestock are a minor element within the farming system, such as occurs in the humid zone of West Africa. Small ruminants are kept as scavengers, with minimal input of time or resources from the farmer. Any suggestion that farmers allocate more resources to livestock would be at the expense of other farm activities, and there is little to indicate that such an approach would be viewed with favour.

International Livestock Centre for Africa (ILCA) decided that any improvement must work with, and build on the existing farming system. When research is focused on minor aspects of the farm enterprise, the proposed technology must be multidisciplinary and involve farmers in research processes critical (Sumberg and Okali, 1988). Farmer involvement is important at the beginning because subsequent research activities will be based on constraints identified, and recognize factors limiting farmers' freedom of action to adopt suggested alternatives or improvements. Unless the foundations are correctly aligned, the final structure may be incapable of meeting its designed goals.

Constraint diagnosis

The diagnosis stage involves the identifying of target groups. These may be based on national policy criteria, within geographic or hierarchical boundaries. In ILCA humid zone case, full time smallholder farmers either owning small ruminants or intending to keep animals in the future, cropping around 2 ha of land in the forest or derived Savannah zone were the target groups.

An area where both forest and Savannah zones occur, where the soils and cropping patterns were representative and which was accessible year round to the research team, was identified with assistance from the local state extension service.

Having selected a target group, researchable topics were identified and prioritized in a diagnostic stage. In many instances too little emphasis is placed on on-farm diagnostic activities for an applied research program (Brerlee and Tripp, 1988). Ex-ante studies at farm level must include a social scientist to conduct informal surveys, to talk with farmers so that they understand what is happening, to discuss the farming methods used, the resources employed, and the basis for their decisions over resource allocation. However, ex-ante studies are merely tools to identify issues for subsequent phases of research.

Multidisciplinary teams are usually recommended for on-farm research, including representatives of the commodity research program for the major enterprises in the target system, social scientists, and representatives of other relevant disciplines (Byerlee and Tripp, 1988). The operational and fixed costs of such a group will be high, perhaps too high for a poorly endowed national research organization to adopt even with the necessary personnel. Chambers and Jiggins (1987) propose that dependence on large multidisciplinary teams, and the necessity for large surveys, and massive multidimensional data analysis could be avoided if scientists encouraged resource poor farmers to discuss and articulate their problems at the start of a research program. The Design and Diagnosis (D and D) technique developed by International Council for Research in Agroforestry (Raintree, [ICRAF] 1986), and the Rapid Rural Appraisal method attempt to overcome this problem (Khon Kaen University, 1987).

There is, however, considerable debate about the mode of operation for these studies. Chambers and Jiggins (1987) propose that resource poor farmers should identify priority research issues, design, manage, and evaluate the trial themselves. Such a view, limiting the role of the researcher to that of a consultant, makes unrealistic assumptions about the breadth of knowledge farmers have of the available options and techniques (Farrington and Martin, 1988). There are different opinions on whether the target farmers should be resource poor, or the more progressive farmers. Barlow et al. (1986) argue that progressive farmers are more likely to adopt, and act as role models for the rest of the community. ILCA's experience working with individual progressive farmers failed to indicate that the rest of the community were likely to follow the example set by the few and adopt the complex alley farming technology.

The researcher should be capable of analysing and interpreting interactions observed and discussed with farmers, and find possible solutions to the priority constraints. Proposed solutions should be explained to farmers in detail, and farmers' comments and suggestions sought to avoid incorporating activities that would be incompatible with the rest of the farm activities.

ILCA together with national researchers and extension staff identified disease and nutrition as the major constraints to animal production. However, the farmers were more concerned about the constraints to crop production, poor soil fertility, high cost and limited supply of fertilizer, and labour requirements for land clearance after fallow. Demographic surveys of the target area gave information on household size and composition, available labour, and off-farm activities.

Identifying of solutions

ILCA had established that farmers had little interest in planting pasture, or indeed setting aside any land specifically for forage crops. However, a single intervention that could deal with crop production and at the same time providing forage might be more acceptable. In the target area of southwest Nigeria, farmers leave stumps of trees and shrubs in their fields during cropping periods, because they regenerate soil fertility during fallow periods. Certain tree species improved soil fertility through the decomposition of leaf litter, and provided forage, fruit, or stakes. By linking the principles of alley farming - the use of tree foliage to improve soil fertility and to provide forage during the cropping season - to accepted principles of fallowing, the technology seemed easier for the farmers to understand and accept. In alley farming, food crops are grown between rows of trees. The trees are pruned regularly to prevent shading of the companion food crop, providing mulch for the crop and forage for livestock if required. Alley farming is essentially a modified version of traditional bush fallow, with foliage from rows of leguminous trees during the cropping cycle replacing the leaf litter obtained from natural regrowth of trees and shrubs during the fallow (Kang et al. 1984). ***Leucaena leucocephala,*** is a source of high quality animal feed, and ILCA believed that farmers would be prepared to use a portion of tree foliage for livestock, rather than using all as mulch. ***Gliricidia sepium,*** a leguminous tree originally introduced to Africa as a shade tree for cocoa, has also been used for mulch and fodder.

In West Africa during the diagnostic survey, the biological parameters of alley farming for certain crops, particularly maize, had been established in on-station trials. Studies on soil fertility, tree productivity, and crop production gave satisfactory results (Kang et al. 1984). Livestock trials showed that tree foliage was palatable and, when used as a supplement, increases animal performance (ILCA, 1986a; 1987).

Concurrent with the on-farm trials, on-station studies investigated the effect of including fallow, the effect of removing different proportions of tree foliage for fodder on crop yields and sustainability, and on ways of managing the trees during fallow periods to maximize dry season fodder (Kang and Reynolds, 1989; Kang et al. 1989). Using all the tree foliage as mulch increases maize yields by 40-50%, but the largest response comes from prunings applied when planting maize. This increases crop yield by around 30%. Second and third prunings, applied at 6-8 week intervals have less effect, raising yields by 15 and 5% respectively. If a proportion of all prunings is removed for forage the effect on crop yields is directly proportional to the quantity of mulch applied. Thus the economic return from the use of prunings as animal feed should be equal to, or better than that obtained from using the same quantity of tree prunings as mulch (Sumberg et al. 1987). Maize yields of 3-4 t/ha from two crops per year have been maintained for 7 years to date on continuously cropped alley plots on-station. Soil nutrient levels, especially soil organic matter content, are enhanced during alley farming so that the cation exchange capacity of the soil (to take one example) improves. If alley farms are left to go into fallow, fodder production can be maximized by allowing the trees to grow uncut from January to October (through the later part of the dry season, and for all rains), pruning and sun drying the leaves, and taking a second cut during January in the middle of dry season.

The major benefit to small ruminants from using leucaena and gliricidia as supplementary feed is on survival rate of offsprings. In smallholder systems mortality rates of 30-40% in first 6 months after birth are common. In on-station trials, inclusion of browse in a basal Panicum maximum diet raised survival from 45 to 97% indicating a link between nutrition and resistance to disease. Growth rates also improved, and parturition intervals decreased so that the overall productivity index, measured as the kg offspring weaned/dam per year, for West African dwarf sheep increased by 1.68 kg for ever 100 g browse dry matter (DM) included in the diet (Reynolds and Adediran, 1988).

· Forage plots consisting of trees and grass, or of just trees were also explored, although farmers were not ready at that time to accept them on-farm. Tree-only plots could yield over 30 t edible DM/ha, but in the absence of returned nutrients, the yield declines over time to around half that level. Tree/grass plots can produce 20 t DM forage/ha, but, again, nutrients must be returned, as manure or inorganic fertilizer, to maintain yields (Reynolds and Atta-Krah, 1989). ***Leucaena/ Pennisetum purpureum*** plots are used in the Kenyan coastal area to provide forage for stall fed dairy cattle (W. Thorpe-personal communication), indicating the potential of this system.

On-farm studies

It was unlikely that farmers in the target area had any prior knowledge of the technology. As their options from which to select improvements were limited by their previous experience, additional experience of researchers was essential in selecting alley farming. ILCA had introduced alley farming to a few individual farmers in 1982, but there was no indication that neighbouring farmers saw the technology as relevant to them. Attention paid by ILCA to these individual innovative farmers during establishing and managing phases led other farmers to view the demonstration farms as being less appropriate to the average farmer.

In 1984 a pilot project was established in the target area described above, and alley farming was introduced to a community, rather than to individuals. Discussions were held with the Chief and village elders, and then with the whole farming community through a farmers meeting. Farmers restated their problems and alley farming was introduced as a possible solution. Interested farmers were shown demonstration farms and learned from the owners their perceptions of the benefits and problems of the technology. At a later date demonstrations of tree planting were held on farmers' fields and packages of seed distributed to those present for use on their own farms. ILCA posted a technician in the village who then worked with the extension officer advising and encouraging farmers. Further planting demonstrations were held on individual farms, at the same time that farmers intended to plant tree seeds, but planting was the responsibility of the farmers themselves. At this stage elders from an adjacent village approached ILCA asking to be allowed to join the project, to which ILCA agreed. On a few farms, established on infertile land, where tree growth was initially slow, and the leaves were chlorotic, 20 kg/ha of P(single superphospate) was applied along tree rows. Later in the year demonstrations of thinning, pruning, and mulching were held.

The project at this stage determined how suitable and acceptable the system was to the community (Atta-Krah and Francis, 1987). No attempt was made to collect quantitative biological data from the farms, but qualitative data, based on weekly visits and subjective scores were recorded. Farms were scored for tree condition and growth, weediness, type and condition of the companion food crop, and general appearance. The most suitable companion food crop was maize or newly-planted cassava. Trees under mature cassava were subject to too much shade, and crops such as melon or yam tended to smother the slower growing tree seedlings. However, despite a slow start most trees under unsuitable crops survived (Sumberg and Okali, 1988). All farmers used mixed cropping, with maize and cassava as most common combination.

Several farmers had allocated land that was at the end of its normal cropping cycle, ready to go into fallow. Trees growth and productivity on these infertility levels was low. However, farmers were initially unsure of the technology and by using poor fields they limited the risk.

An important factor for successful establishment was careful weeding. Farmers with better management and hence higher food crop yields also had better trees. First prunings were made when planting a second season food crop for those farms where trees had been planted at the start of the rains. If tree planting had been delayed until later in the season, first pruning waited until the next rainy seasons started. In the first year after planting, tree foliage yield was low, and most farmers used minimal amounts for forage. A few farmers were more enthusiastic about livestock feeding and, in one case, branches were removed long before they reached recommended lengths of 1.5 m and some dieback of trees and tree mortalities were observed.

In the third and subsequent years more emphasis was placed on collecting biological data to assess the economic impact of alley farming. Standardized trial plots were established on farmers' fields, to determine tree productivity, use of foliage, and crop livestock response. Labour data was also collected, including time taken to clear for cropping alley farms that had been in fallow.

The degree of involving farmers in decision making over trial management has an effect on the results. Ashby (1987), showed that when farmer participation involves autonomous decision making over trial management, crop yields under identical experiment conditions were lower than when farmers and researchers consulted together. The conclusions about technology will, therefore, depend upon the degree of farmer involvement in the test. The tests should be performed under farmer control in conditions that will prevail after researchers have withdrawn, in order to have a more accurate picture of the eventual impact of the technology on productivity.

Results from farmer managed trials are encouraging. As expected, variation between farms is often greater than treatment effects. Within-farm comparisons, however, show the effects of mulch treatments (Table 1). When all tree prunings were removed from an alley farm, 2.1 t of maize grain/ha (total from two cropping seasons) was obtained. Where all prunings were used as mulch on another section of the same alley farm maize yields were 3.1 t/ha. A similar increase in crop yield was obtained when tree prunings were used to mulch portion of a conventional no-tree farm. Tree productivity was around 5 t of leaf and soft stem DM/ha, with a range of 1.5-8.5 t/ha. Alley farms were established in both the forest and Savannah zones. Although soil fertility was better in forest, the productivity of the alley trees was over twice as high in Savannah, probably because of shading effects in forest zones.

Most trees prunings were used for mulch, with 12% offered to animals. Cut and carry supplement from Leucaena and Gliricidia was likely on 9 days/month, with wide variations between individual farmers. However, those farmers who were more liberal with supply of forage, soon realised that their alley farms would be insufficient to allow regular feeding at high levels in addition to providing mulch to their crops. The original research design envisaged that 25% of the prunings from a 0.2 ha plot would be used for forage, sufficient to provide a quarter of the daily needs of a typical herd of four animals. In practice the mean size of an alley farm was only 0.1 ha. In 1989 eight farmers planted tree only feed gardens of approximately 12 m x 12 m. This marked a radical change in attitude because nobody showed interest in forage plots at the start of the program.

Table 1. Effect of mulch application in alley farms on maize grain yield (1st season 1989), in the fifth year of cropping, under farmer management

		Maize grain t/ha		
Farm No.	Mulch yield t/ha	a	b	c
1	5.78	1.75	3.15	3.19
63	2.80	2.71	2.54	2.59
70	5.50	1.53	2.22	2.97
72	7.28	2.57	3.49	3.47
Mean	5.34	2.14	2.85	3.06

a - No mulch
b - 50% mulch
c - 100% mulch

Surveys revealed that farmers' major complaint about alley farming was labour requirements. However, it was established that, excluding weeding times, less than 10% extra labour time was needed (Table 2). Farmers reported that their alley farms were less prone to weed growth (an effect of the mulch), which would suggest that less weeding labour would be needed. Results from an earlier on-station trial indicate that maize production on traditional no-tree plots requires 175 man-h/ha (Ngambeki, 1985). Thus, there would be little, if any, extra labour needed for alley farming, but the distribution would change. Less time is needed for preparing land, and presumably weeding, but extra labour is needed for pruning at two or three occasions during the crop. The first pruning is required before ridging so that prunings can be incorporated in the soil for maximum effect. If the farmer follows recommended agronomic practice and weeds the maize crop 3 - 4 weeks after planting, and weeds a second time 4 - 6 weeks later, the second pruning occurs in between the two dates. If, however, one weeding is performed 6 - 8 weeks after planting (as often happens), it will coincide with the need to prune the trees to prevent excessive shading of the food crop. The conscientious farmer will not have a problem, but others may face competition for labour between weeding and pruning.

Early in the project the question of rights to land and the implications of systems of tenure on adoption was raised. Planting trees has long term implications for land use, and those whose rights may be temporary could be less enthusiastic about, or even prevented by the landlord from planting permanent crops. The prospective alley farmer requires access to the land on which the trees are to be planted, with sufficiently secure land rights to justify the effort of planting. The right to harvest and use the foliage must allow an adequate return on the investment, and allow arable crops planted with the trees to benefit from the systems ability to maintain or improve soil fertility (Francis, 1987a; b). In the project area those who rented land had to ask permission from landlords before planting trees but Francis found no case where permission had been refused.

Table 2. Labour requirements (man-h/ha) for maize cultivation in farmer managed trials in southwest Nigeria

	Alley farm	Conventional farm
Land clearing and ridging	191.7	234.9
Pruning and mulching	67.5	—
Planting	25.4	25.1
TOTAL	284.6	260.0

Values shown are means for 4 cropping seasons on 5 farms.

Barriers to women participating in a new technology occur at three levels. First, women may not be represented in on farm research and extension teams. Secondly, since men frequently dominate at the community level and regulate relationships with outsiders, they often benefit first from innovations. And, the division of labour within the household may make it difficult or unattractive for women to adopt a technology (Francis and Atta-Krah, 1988). During the first year of the project few women planted alley farms, although the majority of rural women are actively involved in agriculture. To counter this reluctance, ILCA posted a female researcher/extension worker to the village, and in the second year the proportion of new plantings by women reflected the proportion of women in the farming community. This indicated the suitability of alley farming for both men and women. Women farming on their husbands' land usually sought their permission before starting alley farms. Participation of women in alley farming in southwest Nigeria seems less determined by land tenure factors than by competing demands on their time, and by the presence or absence of a female extension worker. With just male extension staff the adoption rates by women were low (ILCA, 1986b).

Recently ILCA conducted an adoption survey around the villages where alley farming has been adopted (C.di Domenico-unpublished data). In the five years since the start of the pilot project, alley farming has spread to farmers in other villages within a radius of 20 km from the pilot research villages involving around 200 farmers. 73% of the alley farmers used fertilizer on their nonalley farms, compared to 9% who still use it on alley farms. It is significant that farmers are confirming the value of the "fertilizer bushes", as leucaena and gliricidia were named by Cashman (1987), when she worked with women in the villages. About 18% of the farmers said that they had already planted additional alley farms, and a further 50% intended to increase the size of their alley farm in the near future. 19% of the farmers were satisfied with the size of the existing alley farm, and 9% were constrained by non-availability of land for expansion. Farmers who had ceased alley farming, did so, mainly because of failure of the trees to establish (50%) and loss of interest for undefined reasons (33%). Most successful alley farms were within easy walking distance from the compound (77%), and closer to home than the nonalley farms. The success rate with alley farms established long distances from the compound (over 6 km) was low.

The survey showed that 11% of the alley farmers were women, suggesting that after the female researcher/extension worker was withdrawn from the villages the proportion of new plantings by women decreased. Indeed, at one village meeting in 1989, 3 women were present in a group of 33 participants. Female extension staff should, therefore, encourage the involvement of women.

Conclusion

The use of leguminous trees for maintaining and improving soil fertility has proven to be biologically viable and socially acceptable to smallholder farmers in southwest Nigeria. Involving farmers at early stages in developing this technology has been particularly important in ensuring that inappropriate input requirements were avoided. On-farm trials, with farmer management, establishes the social acceptability and appropriateness of technology. Alley farming maintains soil fertility without the purchase of expensive external inputs. Alley farmers have minimized applying inorganic fertilizer on alley farms, allowing this expensive input to be concentrated on nonalley farms.

Livestock production is a minor farm enterprise, and farmers were initially unwilling to allocate resources for forage production. However, some farmers who have used a portion of tree foliage from their alley farms to feed livestock, have realized the benefits and have now planted tree-only forage plots to supplement fodder available from alley farms. Thus attitudes have changed and farmer behaviour has modified to incorporate benefits to both the crop and livestock subsectors of the farming system. Women extension staff play a critical role in encouraging female farmers to adopt the new technology.

References

Ashby, J.A. 1987. The effects of different types of farmer participation on the management of on-farm trials. Agricultural administration and extension, 25, pp. 235-252.

AttaKrah, A.N., Francis, P.A. 1987. The role of on-farm trials in the evaluation of composite technologies. Agricultural Systems, 23, pp. 133-152.

Barlow, C., Jayasuriya, S.K., Price, E., Maranam, C., Roxas, N. 1986. Improving the economic impact of farming systems research. Agricultural systems, 22, pp. 109-125.

Byerlee, D., Tripp, R. 1988. Strengthening linkages in agricultural research through a farming systems perspective: the role of social scientists. Experimental Agriculture, 24, pp. 137-151.

Cashman, K. 1987. Seeing the forest for the trees. In: How systems work. Farming systems research symposium 1987: Abstracts. university of Arkansas/Winrock International. Fayetteville, AK, USA.

Chambers, R., Jigging, J. 1987. Agricultural research for resource poor farmers Part II: a parsimonious paradigm. Agricultural administration and extension, 27, pp. 109-128.

Farrington, J., Martin, A.M. 1988. Farmer participatory research: a review of concepts and recent fieldwork. Agricultural administration and extension, 29, pp. 247-264.

Francis, P.A. 1987a. Land tenure and agricultural innovation. Land Policy Use, pp. 305-319.

Francis, P.A. 1987b. Land tenure and the adoption of alley farming in southern Nigeria. In: Land, trees, and tenure. pp. 175-180. eds. Raintree, J.B., ICRAF/Land Tenure Centre, University of Wisconsin, Madison, USA.

Francis, P.A., Atta-Krah, A.N. 1988. Incorporating gender concerns into on-farm research: the household and alley farming in southwest Nigeria. In: Methodologies handbook on intra household dynamics and farming systems research and extension. eds. Fieldstein, H., Jiggins, J. Farming Systems Support Project/University of Florida, FL, USA. (in press).

ILCA (International Livestock Centre for Africa), 1986a. ILCA Annual Report 1985/86, ILCA, Addis Ababa, Ethiopia. 88 p.

ILCA, 1986b. Women's activities and the potential for alley farming southwest Nigeria. Report to the Ford Foundation. ILCA humid Zone Programme, Ibadan, Nigeria. 58 p.

ILCA, 1987. ILCA Annual Report 1986/87. ILCA, Addis Ababa, Ethiopia. 82 p.

Kang, B.T., Wilson, G.F., Lawson, T.E. 1984. Alley cropping: a stable alternative to shifting cultivation. IITA, Ibadan, Nigeria. 22 p.

Kang, B.T., Reynolds, L. eds. Alley farming for the humid and sub-humid tropics. IDRC, Ottawa, Ont, Canada 1989.

Kang, B.R., Reynolds, L., Atta-Krah, A.N. 1989. Alley farming. Advances in Agronomy, 43, (in press).

Khon Kaen University, 1987. Proceedings of the 1985 conference on Rapid Rural Appraisal. Rural systems research and Farming systems research project. Khon Kaen, Thailand.

Ngambeki, D.S. 1985. Economic evaluation of alley cropping laucaena with maizemaize and maizecrowpea in southern Nigeria. Agricultural Systems, 17, pp. 243-258.

Raintree, J.B. ed, 1986. An introduction to Agroforestry diagnosis and design. ICRAF, Nairobi, Kenya.

Reynolds, L., Adediran, S.O. 1988. The effects of browse supplementation on the productivity of West African dwarf sheep over two reproductive cycles. In: Goat production in the humid tropics. pp. 83-91. eds. Smith, O.B., Bosman, H.G., PUDOC, Wageningen, The Netherlands.

Reynolds, L., Atta-Krah, A.N. 1989. Forage production for cattle sheep and goats in the humid zone of West Africa. Paper presented at the West African Feed Resources Workshop, Bethania, Togo. November 1989, 25 p.

Sumberg, J.E., McIntire, J., Okali, C., Atta-Krah, A.N. 1987. Economic analysis of alley farming with small ruminants. ILCA Bulletin, 28; pp. 2-6.

Sumberg, J.E., Okali, C. 1988. Farmers, on-farm research and the development of new technology: experimental agriculture 24, pp. 333-342.

SADCC/ICRISAT

SORGHUM AND MILLETS IMPROVEMENT PROGRAM

S.C. Gupta

Introduction

The establishment of the Sorghum and Millets Improvement Program (SMIP) is almost complete. Input into sorghum and millets is expanding. The sixth annual workshop for example, was extended from 3 to 5 days to include food technology, economics, livestock feed, and station development and operations. We are evaluating our relations with national programs to keep it relevant and to establish a monitoring capability. Our objectives remain the strengthening of the role of national research in improving sorghum and millets. Our activities continue to be research, education and training, station development, and management.

Current staff position

SMIP staff consists of an Executive Director, Administrative Officer, a Sorghum Breeder, Forage/Millet Breeder, Cereals Pathologist, Cereals Entomologist, Cereals Agronomist, an Economist, a Food Technologist, Station Development and Operations Officer, Regional Station Development and Operations Officer, and a Regional Training Officer.

One Soil Scientist is seconded to SMIP by International Fertilizer Development Centre (IFDC). There is also a student in the second year of his post doctoral fellowship focusing on pearl millet breeding. The program is also supported by a number of consultants as and when necessary.

Collaboration with national programs

SMIP collaborates with national programs to ensure relevance in crop improvement efforts. National programs are represented in the annual regional workshop, which is a reporting and planning meeting. This meeting covers food technology, market economics, feed uses, station development, and management. The meeting is a forum for reporting and particularly planning. National programs are increasingly contributing materials to regional activities. The annual work plans are developed and finalized at this workshop.

SMIP holds one or two monitoring tours each year to several of the SADCC countries. In 1989 the sorghum monitoring tour began in Zimbabwe but focused on Tanzania. The tour, from 6 to 19 May, included 17 national scientists from 7 SADCC countries. A sorghum breeder from the ICRISAT East African program and five scientists from the SADCC/ICRISAT program participated.

A forage travelling workshop took place from 23 January to 7 February 1989. The group visited forage research in Zimbabwe, Botswana, Lesotho, Mozambique, and Swaziland.

Monitoring tour(s) are decided at the annual workshop. These tours provide an opportunity for sorghum and millet scientists in the region to visit each other's stations and see their work.

Scientists of the regional program spend about 30% of their time visiting national programs. These visits provide good opportunity for exchanging ideas, observing problems on the spot, and when relevant, developing research strategy.

The Director of SACCAR is Chairman of the SMIP technical advisory panel, an annual meeting held while the crop is in the field. Several days are spent discussing in depth activities of the regional program and its relationship with national programs. The next meeting was to be held in Malawi in March 1990. The Project Manager of the regional program reports annually to the SACCAR Board.

While developing Phase II program, it was projected that the regional program would offer post doctoral and research associate opportunities and provide a short term orientation of the regional program to returning students. These plans did not, materialize, however, although there is in-country demand for returning students. We want to develop joint research projects ideally approved at national working meetings. These projects outline objectives, participating scientists, strategy, and support. We feel that these projects will document the contribution of both national and regional programs.

Staff of the regional program are developing a method to quantify input by the program, joint research, and input by national programs. This is being done for each country. Once a suitable format has evolved, we would like our colleagues in national programs to make their assessment. Eventually, we expect the input from the regional program to decline. By quantifying these inputs it will be possible for SACCAR, donors, and ICRISAT to see what the relative contribution of the regional program is. This will be relevant to establish the useful duration of the direct ICRISAT contribution to the regional program. Several meetings have been organized by the regional program focusing on different areas.

In February 1988, there was an international meeting on crop use, followed by a regional meeting which focused on results of the international meeting to regional interests. In late November 1989, a small meeting focussing on grain standards particularly as related to the milling and brewing industries was held. In March 1988, the regional program participated with ICRISAT Centre and International Sorghum and Millet Collaboration Research Support Program (INTSORMIL) to organize an international symposium and diseases of sorghum and pearl millet. A meeting of directors and chief agricultural research officers, with outside consultants, to focus on the concept and organizations of the experiment station is planned for January 1990.

National - Regional research collaboration

National and regional research have a common interest in improving crops through the generating and exploiting of variability. Generating of variability includes acquiring and generating germplasm, crossing and early generating evaluation, screening for resistance and quality traits. Exploiting of variability leads, via a logical sequence of nursery selection and yield trial evaluation, to new varieties and hybrids for various uses. The generating of variability is primarily a function of SMIP and the exploiting of variability is primarily a function of national programs. There should, therefore, be a flow of useful breeding stocks from SMIP to national programs. This flow is working well, but requires close communication between interested parties. SADCC country programs differ in their capabilities ranging from generating of variability through the sequence of selecting and testing of new varieties and hybrids to a substantial input by the regional program in evaluation.

Regional countries differ in their requirements and problems. Long season types are required in Tanzania, since several leaf diseases are severe in some parts of that region, *Striga hermontheca* is important around Lake Victoria in Tanzania while *S. forbesii* is found around Ilonga in Tanzania and Kwekwe in Zimbabwe. As a consequence of these differences, the regional program interacts with each SADCC country based on its strength and needs. It is for this reason that some view the program as an array of bilateral interactions rather than a network.

SMIP scientists assist the scientists returning from study leave to establish their research programs. They provide appropriate breeding materials and our off-season facilities to generate the crosses/genetic variability. Joint projects with national programs have been developed in Tanzania and Zimbabwe. In Tanzania a project on the photosensitive varieties in pearl millet has been developed; in Zimbabwe, discussions have been initiated to cross the best local accessions from Zimbabwe with selected introduced material. The resulting variable populations can be exploited by both programs. Assistance has been committed to the Zimbabwe national program for two years to conduct communal trials. Some entries are from the regional program.

The regional program has responded to a number of activities that are felt to be regionally relevant. It was recommended at the first workshop that the regional program identify a limited number of national stations representing different environmental situations. These locations would be used to evaluate introductions and early generation breeding stocks. It was recognized that entry numbers are frequently high and discard rates are also high. For regional program to do this at a defined number of stations is cost effective and reduces the burden on national programs.

These locations have also been useful to screen for yield-limiting traits. In the case of pathology, the priority of diseases and identification of useful "hot spots" for screening were a bigger problems than originally anticipated. Screening for stemborer resistance is undertaken at Matopos using artificially reared insects. Studies on the vulnerability of different varieties of sorghum seeds to insect grain feeding is conducted in a laboratory with controlled climate. Evaluating for response to moisture stress can be done at Sebele, Botswana; Lusitu, Zambia; and Matopos, Zimbabwe. Developing and adapting procedures for evaluating of quality traits and their use for both grain and feed can be done at Matopos. In late 1989, the regional pathologist evaluated the position in the region. Swaziland was reported to have a problem with sorghum downy mildew and the local varieties were found to be susceptible. The country was found to be vulnerable to downy mildew but the levels of infection were not adequate for screening. Screening is good at Matopos, Henderson, or Golden Valley. Screening of promising entries in Swaziland for response to downy mildew in Matopos and Henderson will reduce the chance of distributing a highly susceptible line in Swaziland that could encourage the disease.

Regional program is beginning to identify problems and ecological situations in the region that are unique. It could be cost efficient to develop crop improvement activities for SADCC countries capitalizing on these unique opportunities.

Education and training

The original strategy for education was developed by two consultants. In 1985, the strategy was subsequently modified and approved by the CTC. The objective, over a ten year period, was to have in position a relevant team of sorghum and millet scientists in each SADCC country. The educational program was subcontracted to INTSORMIL. Forty scientists participated in the degree training program in the first five year phase of the program. Although this level of training is encouraging, it is less than the initial estimate. At the March, 1989, SACCAR Board Meeting it was suggested that the base be expanded to include more disciplines. Tim Schilling (INTSORMIL) and Lovegot Tendengu (SADCC/ICRISAT) have now visited most SADCC countries to activate educational program for Phase II.

We budgeted for sixty students, however, sixty-two nominations have been approved and there are fifteen additional students awaiting approval.

So far, the regional program has conducted six training programs (Table I).

Table 1: Conducted Regional Training Programs

Year	No. of Trainees	Course
1986	9	Breeding nursery management
1987	7	Breeding nursery management
1987	16	Station management
1988	14	Station management
1989	15	Station management
1989	22	Pest identification and scoring
Total	83	

Training programs of 1986, 87, and 88 were conducted by staff from ICRISAT Centre. They also teamed up with regional staff to conduct 1989 Station Management course. Additional nursery/trial management courses could not be held because staff had to be at their homes during the cropping season. We want to strengthen this training by holding it during the off season (winter) at Mzarabani.

In the first five years of the regional program twenty-two individuals were supported for training at the ICRISAT Centre. Recently, a scientist from Mozambique went to the Coastal Plains Research Station at Tifton, Georgia, to learn forage quality evaluating techniques. Two scientists from Lesotho attended a two week training program at Matopos on quality testing procedures, including grain quality testing, product formulation, and sensory evaluation methods. One BSc technology student from the Bulawayo Polytechnic is spending eight months in an in-service type training program in food technology. The sorghum breeder and entomologist, Department of Research and Specialist Services, Zimbabwe, and the sorghum breeder and entomologist from Botswana are undertaking PhD thesis research with regional scientists at Matopos.

For the past two years we have had ten and twelve third year University of Zimbabwe students spend the December-February holidays working with us. We feel that this internship program has been mutually beneficial. We look forward to repeating this program in December.

Two scientists from the region have participated every year in sorghum millet field days at ICRISAT Centre, India. These field days facilitate exchange of ideas among scientists in the world. In 1990, the Centre will also start courses on sensory evaluation methods and pollination techniques.

Station development

Facilities for regional program experiment station development have been established at Matopos, Mzarabani, and at several national stations. These include land shaping for more uniform soil surface, irrigation, and drainage. Assistance has also included computers, transport, farm machinery, and laboratory equipment to evaluate forage quality. An effort is being made to respond to equipment needs as well as to improve the roles of station management and the relationship between station operations personnel and the user scientists. This task is formidable in both manpower and financial resources terms. It is, therefore, difficult to collaborate equally with all stations at the same time.

Seed production

Seed shortage, particularly of hybrids for advanced testing, farmers' field trials, and extension became apparent at our recent workshop. It was, therefore, agreed that seed producing activity be introduced in our stations operations unit to meet the identified needs.

As our forage program expands we have had an increasing number of Zimbabwe farmers asking for starter stocks of pearl millet and napier grass cuttings. We provided small amounts of these from material growing at the Matopos station.

We are interested in the study made by Denargro on seed producing in SADCC countries and would be willing to train and provide consultancy services.

Research highlights

Sorghum Breeding

Significant progress has been made in the region in identifying best performing selections from introduced sorghum accessions (SDS and IC numbers) and in developing and selecting new crossbred lines (SDSL numbers) with superior grain yield, grain quality, and better resistance to downy mildew virus and important leaf diseases in the region.

- **Varieties released/prereleased:** Two selections - SDS 1513 (Red) and SDS 1954-1 (Red) have been released in Swaziland. Mozambique is releasing two varieties which they named MACIA (selected from SDS 3220) and MOMONHE (selected from IS 8571). Malawi has identified two cultivars: ICSV 1 and ICSV 112 for pre-release.

- **Promising varieties:** Eight white and seven red/brown selections from SDS introductions, including SDS 3472, SDS 2338=7, SDS 170, SDS 1770-6, SDS 2656, MP 531, SDS 2293-1, SDS 2293-6, (all whites), LARSVYT 19, SDS 1503, SDS 1599, SDS 3487, SDS 1948-3, SDS 1710-1, and ZAM 1518 (all reds/browns); and 11 new crossbred (SDSL) varieties including SDSL 87013, 87015, 87018, 87021, 87029, 87032, 87035, 87040, 87046, 88048, were made. These are promising for yield and drought resistance across several locations in the region and were selected and promoted to three collaborative variety trials with national programs in fifteen locations for each trial in the region.

  Three SADCC/ICRISAT crossbred lines SDSL 8703, 87019, and 87020 have been found to be the best for food quality in preliminary screening.

- **Promising hybrids:** Fifty-three white and four red advanced hybrids have also been selected and promoted to five collaborative hybrid trials with national programs in ten to twelve locations each in the region.

- **Breeding material:** In assisting national programs to improve their breeding program capabilities in sorghum, we have generated several hundred breeding lines (F2, F3, and F4) and developed four new breeding (random mating) populations for the region. These breeding stocks have been made available to national scientists in six of the nine SADCC countries that can use them for selecting improved genotypes and lines.

- **Pearl Millet Breeding**

  Varieties released/prereleased: ICTP 8203 has been released in Namibia as Okashana 1. Two varieties: WCC75, and ICMV 82132 (Kaufela) have been released in Zambia.

- **Varieties in national testing:** Five varieties: SDMV 89004, SDMV 89005, SDMV 89007, ICMV 8701, and ICMV 82132 in Botswana; six varieties in Zimbabwe: SDMV 89003, SDMV 89004, SDMV 89005, SDMV 87002, and ICMV 8701 one variety, SDMV 89003 in Malawi is in national testing.

- **Promising varieties/hybrids in collaborative trials:** Twenty-seven varieties of different maturity types are in advanced collaborative trials in five SADCC countries where pearl millet is an important crop: Zimbabwe, Tanzania, Zambia, Malawi, and Botswana. Two hybrids, SDMH 88002 and 88003 have produced 50% more yields in the last two years in Zimbabwe compared to the released variety PMV 1. Eighteen promising hybrids have been sown in collaborative trials.

- **Population breeding:** Eight breeding populations have been generated to meet the requirement of different agro-ecological zones. These are being improved for wider adaptation by the regional program and for specific adaptation by national programs.

- **Finger Millet Breeding**

  Varieties released: A finger millet accession from ICRISAT Centre IE 2929 is released as Lima in Zambia.

- **Varieties in National Testing:** A variety SDEM 113 is in agronomy trials in Zimbabwe. Thirty early maturing varieties have been selected by Tanzanian scientists over the last two years for evaluation in their national trials. Several selections are under test in Zambia from introductions of over 1000 accessions from SADCC/ICRISAT program.

- **Promising varieties:** Twenty-four promising varieties tested over the last two years have been identified for large scale testing in collaborative trials. The most promising varieties are SDEM 113, 723, 937, 1079, 1059, and 1072 (early maturing), and SDEM 217, 396, 224, and 227 (late maturing).

  Germplasm accessions: There are 2596 accessions representing all the finger millet growing areas of the World. Accessions from Zimbabwe, Zambia, and Malawi have been evaluated in their respective countries. The accessions from Zimbabwe mature early in comparison to accessions from Zambia and Malawi.

- **Hybrid:** Over 500 crosses have been sown to identify hybrid plants. Selected plants will be advanced by pedigree method to produce new varieties. Early generation material will be provided to interested scientists to make their own selections.

Forage Breeding

- **Varieties in national testing:** Six forage pearl millet varieties (SDMV 89104, 89106, and 86-10242) in Swaziland and eleven pearl millet varieties (SDMV 89101 - 89105, PS 198, PS 212, ICMS 7704, 435 x 51, and 435 x 51 - 3 in Mozambique are under advanced testing. Forty-one forage varieties are in preliminary trials in Botswana.

- **Promising varieties:** Twenty-two varieties of sorghum and twelve of pearl millet have been selected for evaluating in collaborative trials in SADCC countries.

- **Dual purpose types:** Crosses are made between high yielding grain varieties with brown mid-rib lines to improve the dry matter digestibility of crop residue while maintaining the grain yield production. New sources of brown mid-rib genes have been identified in local germplasm of sorghum and pearl millet and are being evaluated to determine if there is an improvement in dry matter digestibility. An experiment is planned to estimate genetic variability of crop residue quality traits in high yielding grain varieties of sorghum and pearl millet.

- **Interspecific hybrids:** Twenty interspecific hybrids between pearl millet and napier grass generated in 1988 are under test with and without irrigation. 103 new interspecific hybrids have been generated. At present a crop is established from cuttings. It is for communal farmers to establish a crop from seed, and, therefore, ICRISAT is looking for ways to produce seeds commercially.

- **Sorghum and millets for forage:** Several crosses have been generated to improve forage sorghum and pearl millet for forage yield and quality.

Cereals Agronomy

The agronomy unit recognised major problems of drought, the need for appropriate technology and producing practices. Research objectives are: to identify and alleviate producing constraints, to develop information on suitable crop management in order to improve production and water use efficiency (WUE), and to provide information for improving quality of research results. The following activities are undertaken to fulfil the above objectives.

- **Production constraints:** An evaluation of agronomic constraints to increased sorghum and millet production has been undertaken. More information is available about improving stand establishment and crop growth uniformity in sandy soils by using nematocides. Sandveld, Matopos, Makoholi, and Mlezu stations in Zimbabwe and Sebele research station in Botswana confirmed our previous findings that presence of nematodes in sandy soils poor seedling establishment and crop growth variability. Treatments receiving nematocides Nemacur or Furadan were uniform in crop growth and plant stand. Grain yield increased by 62% and 77% over the control (1 806 kg ha^{-1})) for the cultivar SV1, and 30% and 23% for the cultivar Red Swazi (1 685 kg ha^{-1}). Correlation analysis indicate that grain yield was significantly associated with seedling vigour ($R=0.44$, $P=0.01$), plant height ($R=0.41$, $P=0.101$), and crop growth uniformity ($R=0.88$, $P=0.05$). Further experiments are being conducted to determine ways to overcome the problem. Preliminary results indicate that the dosage of nematocide (Furadan and Nemacur) can be reduced and the results of seed dressing are encouraging.

  ICRISAT has also evaluated the performance of four cereal species viz sorghum, pearl millet, finger millet, and maize with and without Furadan treatment in an exploratory experiment conducted at Sandveld, Makoholi, and Mlezu research stations. The results indicate that sorghum is more sensitive to nematodes than the other cereals.

  Differences among sorghum cultivars for emergence from 5 to 10 cm sowing depth have been identified. It seems that newly released cultivars are sensitive to sowing depth, particularly if sown in dry soil. This finding suggests that selection pressure should be applied on this trait.

- **Crop management:** Investigation has been undertaken to determine cultural practices best suited to potential and newly released hybrids/varieties of sorghum and millets over a wide range of environments. Effects of till, nitrogen side dressing, and hand weeding on WUE and performance of a sorghum hybrid DC-75 and a variety SV1 were studied at Matopos during the 1988/89 crop season. WUE improved to 11.4 kg ha^{-1}/mm of rain with the yield 4 891 kg ha^{-1} in a treatment which received stubble mulch, 50 kg ha^{-1} nitrogen (N) 3 hand weedings, while it remained at 2.4 where there was no stubble mulch, no N and no weeding. Yield was increased by 40% to 2 150 by application of N alone and 129% to 3 506 by weeding alone and 182% to 4 314 by a combination of both N application and weeding.

Hybrid sorghums performed better or at par with varieties across all treatments and produced on average 36% more grain yield than variety (3 319 kg ha^{-1} vs 2 431 kg ha^{-1}). There was no significant interaction indicating yield increase was achieved across the low, moderate, and high production levels.

Sorghum cultivars SV1, DC-75, and Red Swazi were evaluated for their response to date of planting (DOP). There was significant genotype x DOP interaction, indicating that farmers could be provided with the option of selecting cultivars depending on the start of the season.

- **Studies of drought:** A drought screening method by inducing/relieving waterstress was developed. Comparisons were made between plots on tied ridges with those that were well drained. Supplementary irrigation was given to the nonstressed plot. Drought intensity and drought susceptibility indices were developed. Using these indices, promising hybrids MMSH 375, and MMSH 378 were ranked 1, 2, and 3 respectively (1 being most promising).

Cereals pathology

Identifying diseases: In 1989, disease samples were sent to CAB International Mycological Institute, UK, for confirming and identifying pathogens on sorghum and millets in Angola, Botswana, Lesotho, Malawi, Swaziland, Tanzania, Zambia, and Zimbabwe. Five of the most important diseases for pearl millet in the region were: Ergot (Malawi, Tanzania, Zambia, and Zimbabwe); leaf spots (Botswana, Malawi, Tanzania, Zambia, Zimbabwe); pearl millet, downy mildew (Malawi, Tanzania, Zambia, and Zimbabwe); rust (Tanzania, Zambia, and Zimbabwe); and smut (Malawi, Tanzania, Zambia, and Zimbabwe). The major diseases of finger millet were blast and blight. Seven most important diseases for sorghum in the region were: Ergot, (Botswana, Malawi, Tanzania, Zambia, and Zimbabwe); anthracnose (Botswana, Tanzania, Zambia, and Zimbabwe); leaf blight (Tanzania, Zambia, Zimbabwe, and Botswana); covered kernel smut (Botswana and Tanzania); downy mildew (Botswana, Tanzania, Zambia and Zimbabwe); sooty stripe (Zambia and Zimbabwe).

Identified locations for testing (hot spot locations) against:

- **Pearl millet diseases**

Pearl millet downy mildew	- Mongu, Zambia;
Ergot	- Ngabu, Malawi; Panmure, Zimbabwe
False mildew	- Panmure, Zimbabwe
Other leaf spot diseases	- Mongu, Zambia

- **Sorghum diseases**

Anthracnose	- Mansa, Zambia
Ergot	- Masumba, Zambia; Panmure, Harare, Gwebi, Zimbabwe
Grain molds	- Ifakara, Tanzania;
Sorghum downy mildew	- Golden Valley, Zambia; Matopos, Panmure, Zimbabwe;
Leaf blight	- Golden Valley, Zambia, Henderson, Zimbabwe;
Striga asiatica	- Hombolo, Tanzania; and
Striga hermonthica	- Ukiriguru, Tanzania.

- **Screening techniques:** Screening techniques have been developed or adapted for ergot and smut of pearl millet and downy mildew and leaf blight of sorghum at locations where the diseases are endemic. Research is attempting to develop a capability to screen for sorghum sooty strips.

- **Identifying sources of resistance:** All pearl millets of the regional program and foreign introductions were screened for resistance to locally important diseases. ICMPES 28 had multiple disease resistance to ergot, false mildew, and rust.

  Some 3000 sorghums were tested in all SADCC countries but Angola and Mozambique. For the first time ICRISAT has confirmed resistance in a single entry to as many as three diseases; i.e., against downy mildew, leaf blight, and anthracnose. Promising entries with multiple resistance were SC 326-6, IS 8283, and IS 18688. In addition, sources of resistance were found for downy mildew, leaf blight, and anthracnose. Forage varieties were identified with a low incidence of downy mildew and low leaf blight severities. Forage millet varieties with resistance to false mildew and ergot were identified.

- **Pathotypes:** It appears that regional pathotypes are present for pearl millet downy mildew and rust, sorghum downy mildew, and anthracnose.

Cereals Entomology

- **Screening:** Screening trials were evaluated. The SADCC sorghum shoot pest nursery (4 000 entries) and the International Sorghum Stem Borer and the International Sorghum Shootfly Nursery were evaluated at Matopos, Panmure, and Mzarabani (Zimbabwe), Golden Valley (Zambia), Kasinthula (Malawi), and Hombolo (Tanzania). Useful results were obtained from Matopos, Panmure, Mzarabani, and Golden Valley only because of drought.

- **Stemborer yield loss trial:** This trial is part of the PhD thesis research of Mr Sithole, entomologist with the Department of Research and Specialist Services, Zimbabwe. The trial was artificially inoculated at Matopos and compared with natural infestation at Panmure. Significant yield loss was found with early infestation. Late infestation showed marginal yield loss (infestation 20 days after emergence vs 45).

  A trial was also conducted to determine the impact of leaf feeding by stemborers. Plant height was reduced more when infestation occurred 22-24 days after emergence compared to 30 days.

Food Technology Crop Use

- **Grain quality:** Several procedures have been standardized and are being used: pearling index, milling yield, endosperm hardness score, floating test, gelatinizing temperature, and size grading fractioning. These tests have been used to grade sixteen traditional varieties of sorghum to provide a reference base for quality evaluation of improved sorghums from the breeding program. Traditional varieties have been acquired from Lesotho and Botswana to expand the regional data base on acceptable food quality.

Malting and Diastatic Power

A laboratory micro-malting (20 grams) procedure has been standardized. The laboratory procedure is capable of malting 50 x 20 gram samples in one operation. The technique has been used to micromalt 554 samples in support of the thesis research of J.N. Mushonga (Head Crop Breed Institute and Sorghum Breeder, Department of Research and Specialist Services, Zimbabwe). It will be useful in the future to evaluate breeding samples. The procedure for diastatic power has been modified and standardized in our laboratory for evaluating these malts. The micro malts from the research material of J.N. Mushonga have been evaluated for diastatic power.

- **Sweet sorghum quality evaluation trial:** Sweet stemmed sorghum are being evaluated as a possible source of alcohol for blending with petrol. Seventy-four sweet stemmed sorghums were sown at Aisleby (irrigated) and at Matopos (dryland). Sequential harvests were made at pre-flowering, flowering, early dough, and late dough stages of crop development. Brix and dry matter determinations were also made at these stages of maturity. At the hard dough stages Brix readings at Aisleby and Matopos ranged 11.1-19.1 and 14.2.20.5 respectively. A trend of higher mean Brix and dry matter values was observed over all stages of maturity for entries grown in the rainfed as compared to the irrigated location.

- **Collaboration with Carlsberg Research Centre:** Two screening methods for evaluating sorghum malt modification were tested during a study visit to the Carlsberg laboratory. These rapid techniques made use of fluorescent dyes and malt friability measurements. The objective is to substitute simple rapid test (8 min/sample) for the laborious diastatic power measurement.

- **Sorghum/Millet cellulose:** Leaf and stem material of five varieties of sorghum and one variety of pearl millet were sent to the Carlsberg laboratory where experiments are underway to make a compressed chipboard and paper. These experiments are preliminary, but chipboard made using sorghum and millet is equally as strong as that made from wood.

Economics

- **Lesotho:** A coarse grains market reconnaissance survey was conducted in Lesotho with the assistance of two representatives from the Department of Agricultural Research. This led to the planning and implementing of more formal farm household and marketing agent surveys. These will assess the potential viability of sorghum dehullers and evaluate sorghum marketing problems.

  At the suggestion of the Principal Economist, a master's degree candidate funded by SADCC/ICRISAT returned to Lesotho to conduct her thesis research. Four months of data collecting ended in November 1989 and she returned to Purdue University to write a thesis on a grain market performance.

- **Tanzania:** A very brief reconnaissance of major production and marketing issues was conducted early in 1989. This led to the planning of a more formal market system reconnaissance scheduled for November 1989. This will examine factors influencing market flows of small grains and constraints to industrial use. It will be implemented by an economist and food technologist from Sokoine University of Agriculture. This will lead, if funding becomes available, to a longer term assessment of marketing constraints and opportunities in the Tanzanian small grains economy.

- **Zambia:** A study of sorghum and millet substitution for maize and wheat in the milling, baking, brewing, and stock feed industries of Zambia was conducted by a team comprised of the SADCC/ICRISAT economist and food technologist and several Zambian professionals. The team's report has recently been submitted to the Government of Zambia for consideration. This offers a basis for the establishing of a new sorghum and millet (and cassava) production and market policy for Zambia based on industrial user demand.

  A conference paper on the industrial use of sorghum and millet was jointly prepared with a Zambian scientist from the University of Zambia. This was presented at the Fifth Annual Conference on Food Security Research in Southern Africa in October.

- **Zimbabwe:** A joint assessment of the dynamic comparative advantage of sorghum and millet in Zimbabwe was initiated in collaboration with a Fulbright scholar and a representative of the Zimbabwe Ministry of Agriculture. This study considers the evolving competitive position of sorghum and millet in the agroeconomy over the next ten years.

A visiting research scholar with the SADCC/ICRISAT Economics Program is completing one year of farm surveys. The scholar is investigating factors influencing farmer decisions to grow and consume alternative coarse grains (sorghum, millet, and maize).

Two Zimbabwean research associates are examining marketing constraints facing small farmers with diverse resource facilities and varying access to market infrastructure. In general, the preliminary emphasis of the economics unit has been on shorter term studies which identify sorghum and millet marketing constraints and assess the competitive position of these crops in the national agro-economies. These studies offer relatively quick results of immediate relevance to regional policy makers. Each set of national results will help determine the likely contribution of sorghum and millet as industrial inputs and as food security crops within SADCC countries over the next 10 - 20 years.

Future Outlook

The contribution of SMIP to different national programs will vary from country to country and from one research activity to another depending on their strength and needs. ICRISAT will assist research programs which are strong by supplying early generating breeding materials, and will continue to produce the finished products for the others until their programs are strengthened. In the next five years, ICRISAT hopes that there will be adequate scientific manpower in sorghum and pearl millet improvement in most of the countries and will develop joint projects with them to improve these crops. This collaboration will strengthen the research capabilities of national programs. SMIP will however continue to produce finished products of finger millet and forage breeding for most of the countries which are not likely to be able to do this by themselves during this period.

As national programs become strong, SMIP may reduce emphasis on developing finished products and contribute more on coordinating research activities and collaborative trials in which most of the varieties/hybrids will be contributed by national programs. The program on crop use including the use of sorghum and millets as grain feed will expand. At present we are collaborating with Matopos research station, Zimbabwe, on comparative nutrition of small grains in beef fattening diets.

We suggest establishing a modest seed production unit in our program to produce seeds for advanced trials, farmers field trials, and some extension activities. Our effects will continue to improve the research stations in the region. There is need to establish something like a SADCC Academy of Sciences where the scientists from the Region can publish their results.

THE STRUCTURE AND FUNCTION OF CIMMYT'S MAIZE PROGRAM IN THE SADCC REGION

Bantayehu Gelaw

Structure

On the recommendations of the Consultative Group for International Agricultural Research (CGIAR), the International Maize and Wheat Improvement Centre (CIMMYT) with headquarters at El Batan, Mexico has been involved in a research program designed to increase maize production in Africa. A memorandum of understanding (MOU) between the Government of Zimbabwe and CIMMYT was signed on 6 March 1985 establishing a CIMMYT regional base in Zimbabwe to better serve the Southern African Development Coordinating Conference (SADCC) region. Three resident regional staff, a maize breeder, a maize agronomist, and an agricultural economist, were posted to the base. The University of Zimbabwe provided office space and logistical support for these scientists.

In addition to the general MOU signed between the Government of Zimbabwe and CIMMYT, a separate tripartite agreement was signed between the University of Zimbabwe, CIMMYT, and International Institute for Tropical Agriculture (IITA) on 2 March, 1985. This agreement allows CIMMYT and IITA to jointly establish a Mid-Altitude Maize Research Station (MAMRS) at the University farm. The station was initially established with the posting of a CIMMYT maize breeder and an IITA entomologist. In 1987 CIMMYT and IITA agreed to concentrate their efforts in areas where they have a comparative advantage. This led to IITA withdrawing its entomologist from Zimbabwe. A tripartite agreement between the University of Zimbabwe, CIMMYT, and IITA was also amended and a revised agreement between the University of Zimbabwe and CIMMYT was signed on 6 April 1988.

CIMMYT posted three maize scientists, an entomologist, and two breeders to MAMRS in order to accelerate the maize germplasm development process. One of the two maize breeders was assigned by CIMMYT to develop materials adapted to the lowland tropical environments while the other breeder continued to concentrate on developing germplasm for the mid-altitude ecologies. Again, the MOU between the University of Zimbabwe and CIMMYT was amended to enable CIMMYT to develop maize germplasms for both mid-altitude and tropical ecologies. CIMMYT also posted an agricultural economist to Malawi to support the maize research program there.

By mutual agreement between the donors and CIMMYT, Tanzania, a SADCC member, falls under CIMMYT's East African Regional Program located in Nairobi, Kenya. However, Tanzania can still collaborate with CIMMYT's Southern African Regional Program. In fact, this arrangement allows CIMMYT Tanzania to have the best of the two worlds.

Aim

The concept of regional research networks is to facilitate the exchange of germplasm, information, ideas, and skills, so that accumulated experience and useful materials can be shared. The paucity of skilled manpower in the region makes it imperative that countries collaborate and learn from each other's strengths and weaknesses.

CIMMYT's activities in the region are geared toward strengthening research capabilities of national programs without duplicating existing activities. It was possible to achieve this goal by encouraging collaboration on maize trials and nurseries, project preparation, information exchange, and various types of training. Fellowships, workshops, conferences, seminars, field tours, newsletters, and scientific literature were shared. Essential items of equipment and supplies to conduct useful research were provided, facilitating discussion on policy issues related to increased production. Linkages between research and extension and as between research institutions and universities were improved.

The following examples illustrate CIMMYT's regional research network activities:

Germplasm

CIMMYT has been collaborating with national programs in distributing and conducting maize progeny, variety, and elite variety trials. It has also provided segregating lines and populations to National Agricultural Research Systems (NARS). This has enabled the release of a number of maize varieties based on CIMMYT germplasm in Malawi, Zambia, Tanzania, Mozambique, Lesotho, and Swaziland.

Project Preparation

CIMMYT has continuously provided information to NARS through maize abstracts, scientific literature, a newsletter, workshop proceedings, annual reports, workshops, seminars, conferences, and field tours.

Workshops

CIMMYT has organized and financed a number of workshops in the region. These include:

- The East, Central, and Southern African Regional Maize Workshops which drew participants from the nine SADCC member countries, plus others. Three such workshops have been held since 1985. 5 000 and 2 500 copies of proceedings of the first and second workshops have been distributed to participants and collaborators.
- Eastern and Southern African Regional On-Farm Research (OFR) training workshops jointly conducted with the University of Zimbabwe every year.
- Research and Extension Administrators' Workshops.
- Research and Extension Linkage Workshops.

- Workshops on Research Methods for Cereal/Legume Intercropping jointly organized with CIAT.

- OFR Trial Data Analysis, Interpretation and Reporting Workshops.

- Extension Diagnostic Training Workshops.

- Workshop on the Economic Analysis of Trial Results.

- Introduction of OFR Concepts and Methods Workshops.

- Networkshop on Crop/Livestock Interactions in OFR.

- National Maize Research Workshops.

Newsletter

A Farming Systems Newsletter (now referred to as Bulletin) is published by CIMMYT four times a year and is distributed to over 500 readers and institutions.

Scientific Literature

CIMMYT has, for the last several years, distributed maize abstracts, annual reports, bibliographies, and abstracts of selected articles to cooperators in the region.

Equipment and Supplies

From time to time CIMMYT has provided supplies and minor equipment such as pollinating bags, moisture testing meters, sprayers, motor-bikes, etc., to NARS to help their research activities.

Training

CIMMYT has provided various types of training to NARS over the last twenty years. These include: in-service training in Mexico, in-country training, regional training, and visiting scientists. CIMMYT is now involved in undergraduate training in cooperation with certain donors.

Interactions with other IARCs and Organizations

A number of CIMMYT's regional workshops and training activities are jointly conducted with other IARCs or organizations. CIMMYT has collaborated with CIAT, ILCA, ICRISAT, IITA, ICIPE, WINROCK, ISNAR, and IBPGR whenever it was feasible. CIMMYT cooperates closely with SACCAR and has kept it fully informed of all its regional activities.

Harare Maize Research Station

Originally, this station was established to develop maize materials for the mid-altitude ecologies. Realizing the importance of maize in the lowland tropics, the agreement between the University of Zimbabwe and CIMMYT was amended to include the development of maize germplasm for lowland tropical environments. Its activities include incorporating resistance to streak virus, breeding for resistance to the major diseases such as *H. turcicum, H. maydis, P. polysora, P. sorghi, Diplodia,* and *Fusarium* ssp. Breeding efforts are also directed towards improving agronomic characteristics, grain yield and stability, earliness, and harder grain types.

All products at this station are freely available to all NARS. The station is also being used as a training site for national program researchers and visiting scientists.

Future Plans

- CIMMYT plans to establish a global drought and insect network with one possible site within the SADCC region.

- CIMMYT has developed a pre-proposal for a maize seed production and training project for Eastern and Southern Africa. The best option would be to attach it to the Harare Maize Research Station. As the concept is regional in nature, CIMMYT plans to take it up with SACCAR.

- CIMMYT participated in the SADCC Maize and Wheat Network Feasibility Study and assigned its Regional Maize Breeder to lead the consultancy group. It is waiting for the response of the Board of SACCAR for a possible follow-up action.

- CIMMYT is in the process of devolution of its Crop Management Research Training (CMRT) from Mexico to selected regions. SACCAR seems to offer an excellent opportunity for the devolution of CMRT to SADCC region.

PARTICIPATORY RESEARCH FOR RURAL COMMUNITIES IN ZIMBABWE

A SYNOPSIS OF THE ENDA-ZIMBABWE COMMUNITY MANAGEMENT OF INDIGENOUS WOODLANDS DEMONSTRATION PROJECT: CHIVI AND ZVISHAVANE OF ZIMBABWE

Davison J. Gumbo

Overview

The Chivi and Zvishavane Community Management of Indigenous Woodlands Demonstration Project has now been running for close to thirty months. The project is to facilitate local communities at the Village Development Committee (VIDCO) level to draw up woodland resource plans based on their local conditions, experience, and knowledge. The process of drawing up such plans is done with the assistance of an ENDA employee called a Community Worker (CW). CWs under ENDA are farmers acting as resource persons in the consultative process towards producing resource plans.

Resource plans drawn are based on a community's accumulated knowledge and experience of the woodland resource. This knowledge and experience is combined with insight derived from the quantitative studies to provide the cornerstones of the project. Communities involved in this project are encouraged to continue and improve existing traditional woodland management strategies such as controlled cutting. These management strategies are backed by planting interventions where farmers plant trees in their homes, fields, garden, and in the grazing areas. The management prescriptions are decisions of the communities.

The project established one nursery in the first year and three others in the second year. Over 23 000 trees were distributed from these nurseries and planted by farmers in homes, fields, and grazing areas. In grazing areas forty-three plots were put up as part of the enrichment planting exercise. Twenty-five VIDCOs have been involved and this number will increase by forty-eight villages per year since each CW is now working with two wards per year.

Background to the Project

The project area is semi-arid with a varied environment. The project focuses on a participatory, adaptive and fine-tuned approach, rather than the orthodox and particular technical packages.

The project evolved out of a research process between 1985 and 1987 in the Mazvihwa Communal Area. A variety of techniques is used to give local people an opportunity to articulate their concerns, needs, and objectives. Research is linked to village level planning for tree resources conducted at the VIDCO level. This process enables the people of each area to make their own response to perceived woodland problems, using a variety of approaches; these include planting in community woodlots, and managing communal woodland regeneration through protecting or the enhancing systems of rule-making.

Trees in this semi-arid area are considered central to the production system. Trees meet a variety of needs, requiring a variety of tree species. Certain indigenous trees, for example raise soil fertility and enhance soil moisture, and are often left in fields against government agricultural extension advice. Others are for shade and fruits, often exotics, in homesteads. Communal woodlands demand trees that are good browse for stock, provide firewood and building timber, and have fewer competitive interactions with grass. Ecological variation and historical factors, mean that the precise resources and needs of each area are different.

Community rule-making about use of tree resources is an important institution in local society, even if not entirely effective. For example, a number of valuable species can not be cut anyhow. Certain areas are also protected from cutting. In the wider woodland, cutting is supposed to be scattered to prevent over-exploitation of particular patches. With the shift from chiefly authority to elected committees since independence, and with increasing woodland pressure, these rules have had to change and adapt. The project facilitates this change where appropriate. Many communities feel that more effective management of existing woodland is likely to be more productive than mass planting of seedlings.

The project approach fosters a dialogue between CWs and the communities through a series of interviews and meetings at village level. The research process allows VIDCO to assess and analyse the local situation and come up with a one week appraisal and a village meeting facilitated by CW. It is a reversal of the top-down message or package-oriented extension approach of conventional forestry and natural resource conservation projects. CWs establish what numbers of which species, indigenous and exotic are required in each VIDCO area using interviews and group discussions. The community and schools provide seeds and the seedlings are grown in a village management plan during the rainy season. The trees are fenced to protect them from browsing animals. Communal woodland planting is generally a combination of replanting bare patches and enrichment planting of highly valued species. Individual farmers also collect seedlings for planting in their homes and fields, but most obtain trees by selecting and protecting naturally regenerating indigenous trees. Rural institutions, such as schools and clinics are also supported in tree planting activities.

Since late 1987 the project has operated in four areas: Runde, Mazvihwa, Chivi north, and Chivi south. Each area has a CW facilitating community planning in two wards during the year. During the initial project phases ENDA supported nurseries and planting activities, as well as CWs. In the coming phases of the project certain activities will be taken up and run by the community.

ENDA learns from the project experience. There are two parallel research activities assessing the project's impacts and suggesting future directions. One is attempting to establish a comparative idea of woody biomass availability and use in the four project areas. Studies are being carried out on the woody biomass resources in each area, the woodland dynamics of different vegetation associations, firewood consumption, brick burning, and construction uses. Germination and survival rates of nursery produced seedlings are also being investigated.

The other study is investigating the socio-political-religious factors that determine the ability of VIDCOs and rural communities to plan effectively and manage natural resources. The effectiveness of the project's participatory approach is continuously evaluated through staff workshops.

Central to these research activities is a team of village based researchers (VBRs). These are local people with some secondary education who live in the project area. There are sixteen VBRs representing all wards in the project area. VBRs assist in collecting information for research projects in their home areas, feed back research results to the community, carry out community evaluating of the project activities, and support CWs in village level planning for woodland resources.

Project Objectives

The overall goal is to improve the quality of life of the communal area dwellers through assisting and encouraging participatory planning. The specific objectives of this project are:

- participation-oriented planning of woodland management for both individually "owned" areas and communal lands. Such plans shall include rule-making and planting interventions;
- establishing necessary infrastructure and superstructure including nurseries required for successful execution of plans identified and developed in the first objective;
- monitoring tree establishments, use, and the quality of communal woodland being managed;
- continuous assessment of progress in the community management process;
- training government and other resource personnel in new approaches to community forestry in Zimbabwe; and
- developing non-formal educational materials for use by communal groups and the non-governmental organization (NGO) network in promoting the development of indigenous woodlands.

Project Implementation: The Community Planning Process

Community participation is the key to success in this project. A number of methods characterize the ENDA project approach and these are:

- people defining and articulating their own needs;
- change evolving under its own momentum;
- the raising of awareness through self-consciousness and self-diagnosis;
- innovations and decisions being made by the community; and
- taking advantage of existing institutions by strengthening them.

These principles have been turned into a community planning process where the main aims are to:

- identify, with local communities, their specific needs and aspirations under different local ecological conditions, and
- define and implement with the communities appropriate woodland management and planting strategies to promote sustainable development.

For the listed objectives to be realized the community must participate throughout all stages of the project. The planning process, which takes about seven days, is started with a ward meeting where the project idea is introduced by CW. For the CW the week starts with interviews and discussions with at least 30% of the village population. The interview sample must provide a good cross section of the community. The VIDCO lists have provided a "who is who" in the village. The interview sample is picked from these lists using a simple random sampling method.

During the interviews, the CW include; some farmer-guided rapid appraisal of the woodland resources. The discussions attempt to gain insights into attitudes to tree planting, existence of management rules, local priorities, etc., through a series of semi-structured interviews. Interviews should also seek information on the following:

- trees needed in communal grazing areas for firewood, browse, timber, etc.;
- trees in the fields for fruits, soil, and crop management;
- trees in the home for shade, windbreaks, fruit, etc.;
- management practices people employ in their grazing areas (cutting practices, replanting, selecting, and protecting of certain species) and the rules that the local community may want to reinforce; and
- how an indigenous woodland project might be organized.

The interviewers often included key informants. Key informants included among others, elders, traditional lineage leaders, spirit mediums, and technocrats. Key informants provide an understanding of institutions and their influences on the planning process. At the end of the seven days the CW has gained a good impression of the local situation.

A general VIDCO meeting devises a VIDCO woodland resource plan which will include planting interventions and revamping of old management rules. This forms the basis on which CW decides on planting requirements for the nursery and also for follow up and monitoring.

Maximum contact is maintained throughout the process with all extension agents particularly from the Agriculture Technical and Extension Services (AGTRITEX), the Forestry Commission, the Department of Natural Resources, and Ministry of Community Development who can advise on the design of the project.

Emerging Themes

Woodland resources plans come out of attitudes and perceptions of the communities involved as clearly summed up by Mukova of Chivi North, "... a community cannot live without trees and therefore trees must be grown ..." Attitudes like this show the important niche trees occupy in the day-to-day lives of rural people in the project area. In 1988 at least 15% of the farmers interviewed had planted trees either in their homes or in the fields. An equal number had also selected and protected tree seedlings that had regenerated on their own. Of the former lot at least 30% had planted indigenous fruit trees. This fact coupled with the existence of traditional management of sacred wood groves (*rambotemwa*) clearly paved the way for the strengthening of old woodland management rules.

CWs' returns from the four areas demonstrated the local peoples profound consciousness and understanding of the important niche trees occupy in their lives. Information gathered across the four project areas was in most cases uniform.

Deforestation

Local perceptions about environmental degradation varied because of the nature of land tenure policies and their implementation by the colonial government. For instance the Land Apportionment Act of 1934-5 designated Mashaba areas (Mushandike ranches) as commercial farming lands; thus, moving farmers and increasing pressure on communal lands. The establishment of commercial farms also occurred in the Shabani (Mazvihwa and Runde communal lands), where people were also moved to make way for the settler farmers. The present state of deforestation in the Madamombe area of Chivi can be attributed to such movements which led to overpopulation and general resource degradation.

The Land Husbandry Act of 1959 had an impact on the project areas between 1960 and 1971. In some areas it was immediate, while in others it was delayed due to inaccessibility by the law enforcers. Most of the people were put in "lines" *maraini*, and grazing/arable land were demarcated. This, Act then, exerted yet more pressure on trees in some areas while in others whole forests were cleared to make way for arable farming, marking the beginning of the start of a general decline in the woodland resource.

It is assumed that deforestation was triggered by a variety of factors, including policy, settlement patterns, mines, use (tillage and grazing), and perceptions and attitudes. However, the people reiterate that they were never given a chance to express views on the role and importance of indigenous trees, nor were they allowed to manage woodland resources.

Trees in the Home

"Home" in the context of the project refers to the homestead and the homefield area. Of farmers interviewed in 1988, 60% indicated that they had exotic fruit trees at home; including mangoes, oranges, lemons, Mexican apples, peaches, and pawpaws. A small percentage stated that they had indigenous fruit trees such as *Berchemia discolor, Parinari curatellifolia, and Scelerocarya caffa*. Most of the trees kept in the home were for fruit, shade, and (less frequently) windbreaks.

The diagnosis further showed that people were interested in planting trees in their homes. Trees found in homes appeared to be the most desired trees for planting. Exotic fruit trees were potential revenue earners but, in general, fruit trees were an important source of nutrition for both children and adults.

Trees on Arable Lands

Retention and maintenance of trees on arable land was stressed by people interviewed against the normal agricultural practice. The extension message clearly stipulates that for farmers to maximise crop production, they must do away with trees in their fields.

However, it would appear that farmers left some species of trees on the fields which did not have any adverse impact on crops. Trees still found on fields throughout the area include *Azanza garkeana, S.caffra, P. curatellifolia, Diospyros mesipiliformis,* and a variety of *Ficus* sp which the farmers have, over the years, allowed to grow to assist crop growth by supplying nutrients through their leaves. The idea of trees being giant nutrient pumps appeared to be well accepted. Farmers also asserted, however, that not all trees were beneficial to crops. Trees like *C. mopane* were clearly not wanted on arable lands.

Even with the benefits to be derived from planting trees in arable lands, some farmers seemed a little hesitant to plant trees in their lands. However, 25% of the 1988 interviewees stated quite clearly that they would like to try it out mainly with *P. curatellifolia* and *S. caffra*. These trees are a well known food source and do not have negative impact on crops under them. The latter is also a source of an indigenous wine known as *mukumbi* which is often a good substitute for the more conventional beer.

Caution has been the by-word as far as tree planting on arable land in concerned. It is important for the project not to appear to be in conflict with extension and the easiest way to avoid apparent conflict is to turn the decision making process to the farmer.

Tree in Grazing Areas

Grazing areas are the source of firewood, construction poles, browse, and bushwood fences. Decisions about necessary amounts of each are made on a communal basis. Once this information was available it was taken to nurseries and tree seedlings raised, which were distributed to individuals, VIDCOs, and institutions such as schools and clinics.

The Research Program

In parallel to project implementation, two research programs have been initiated. These were biophysical and ecological monitoring and social research. These projects monitor progress and provide useful insights for policy recommendations and for guiding the future direction of the project. These two research themes interact with the ongoing project implementation as field staff, through CWs an VBRs contribute to the research process. CWs and VBRs provide accurate and detailed local information and are key actors in generating a process of community debate and discussion of research issues.

Social Research

Social research recognizes the potential role communities can play in managing their local natural resources. The research investigates the nature of local technical knowledge of woodland resources and the potential contribution this knowledge can make to local management strategies. The role of local institutions is the focus of this section of study.

Research Objectives

The research objectives are as follows:

- to investigate the potential role of local knowledge of woodland resources in community management;

- to understand the way rural community institutions work in relation to woodland management;

- to provide better information for project implementation and assistance with community level planning, and

- to investigate the effectiveness of the participatory method in the diagnosis and design process of natural resource management projects.

The expected outputs will complement the project experience and also provide the following:

- an assessment of local knowledge in relation to ecological research results;

- improved understanding of institutional issues for project implementation;

- encouragement of local debate and discussion of issues; and

- a review of participatory approaches to community woodland management.

The other research element is the ecological and household monitoring research. The broad objective of the study is to substantiate and augment indigenous technical knowledge by quantifying issues raised during the initial interviews. Specific objectives are:

- to produce comparative maps showing the changes in woodland resources over the years;

- to determine the standing wood biomass and species composition of the woodlands, emphasizing the most abundant, desirable, and useful trees;

- to determine wood biomass use, species preference, and consumption patterns with quantitative data on fuelwood, biomass used in construction, and in wood carving;

- to estimate rates of change in woodland and woodland resources and to predict the future status and trend of woodland resource populations on the basis of their present use and species composition;

- to determine woodland dynamics with particular reference to natural regeneration and tree planting interventions in fenced and unfenced areas;

- to determine implications of the reafforestation project on woodland dynamics; and

- to research the performance of indigenous trees under nursery conditions and recommend appropriate management techniques.

Project implementation consists of five major areas of study each with its own sub-studies. The areas are:

- **Woody biomass determination, use, and use patterns**

  The fuelwood study consists of a number of studies to provide use rates at various points in a household's day-to-day use of wood. Monitoring is carried out by VBRs on certain stipulated days and times. Generated data show that the more stressed an area is the more fuelwood used and the larger the wood stockpiles (bakwas) because the remaining tree species have little to offer when burnt. The sub-studies focus on areas of incoming fuelwood (household), kitchen (fireplace), and bakwa.

- **Fuelwood use for rural industry**

  Rural industry consumes considerable woody biomass. Industries include beer brewing, brick-making, and wood carving. Most of these activities are seasonal and are carried out irregularly throughout the year. Measurements are carried out by VBRs. To date no significant results have been obtained.

- **Woodland Dynamics study**

  The first study looks at the impact of fencing interventions on planted seedling survival and natural regeneration in communal grazing areas. The second is to establish natural dynamics of different woodland types. Data from ten plots have been collected. Eighteen permanent plots in the non-fenced areas using six different vegetation types have been established where there are varying degrees of deforestation. The study monitors fixed vegetation transects in non-fenced areas, and fixed quadrants in fenced areas.

- **Biomass determination**

  This study is to determine the standing woody biomass within selected areas. Such information will be related to woody biomass studies within the project. Data are gathered from various belt transects in different tree densities. The density classes will be determined using aerial photographs.

- **Seedling Performance**

  This study intends to determine the following:

- indigenous seeds and seedling physiology;
- germination behaviour; and
- seedling growth analysis.

General Concluding Remarks

The project has succeeded to date in mobilizing people in the project area. The general feedback sessions organized by CWs and VBRs have been well attended and have become a focus of debate and drama for local people. The research has encountered a few problems in the random selection of interviewees. Some, especially new immigrants to the area do not want to be interviewed while others do not understand why they have been excluded.

Participation at all work parties is being carefully monitored to establish the community division of labour and influences on it. To date it would appear that men do the heavy work while women and children plant.

The project team has agreed that:

- there is need to focus the research proposal on realizable targets, so that detailed and reliable data are gained which can be analysed and reported within existing time constraints;
- the conflict between critical, analytical research, and involvement in project implementation be considered;
- methodological innovations for participatory research and community feedback be documented to provide information for other NGOs active in this area; and
- the results of the research will be reported and distributed as the research progresses.

Although the project is participatory in design, there needs to be some control of the research areas. It has been difficult to combat the disruption caused by people's visits to the research areas.

POLICY ENVIRONMENT CONDUCIVE TO LONG-TERM RESEARCH

D. Medford

Introduction

The first part of this paper describes new developments in the implementation of the Zambian National Conservation Strategy (NCS), whereby the Zambia National Conservation Committee (NCC) is about to become a statutory National Environmental Council (NEC). Past interactions between NCC and agricultural programs before the act establishing NEC comprise the latter part of the paper.

Thirdly, an optimistic prognosis will be made of the future of these interactions. Finally, the paper looks at the internal economic efficiency of our Research and Development (R and D) programs.

Management of Natural Resources in Zambia

In 1980 the United Nations commissioned the International Union for the Conservation of Nature and Natural Resources (IUCN) to prepare the World Conservation Strategy in response to escalating global environmental problems. His Excellency the President Dr K.K. Kaunda of Zambia, took up this initiative with IUCN, and, after a feasibility study in 1982 and 1983 the Ministry of Water, Lands, and Natural Resources (MWLNR) launched in 1984 the preparing of NCS with technical assistance from IUCN.

The NCS was completed early in 1985 and approved by the Party and its Government in July. At the same time NCC, comprising members with multisectorial and interministerial interests plus non-governmental organization (NGO) members, prepared the ground for NEC and carried out its NCS work before an Environmental Council Bill could be enacted.

An Environmental Council Bill, prepared in four years is now being considered by the Cabinet and has been approved to be introduced to Parliament. The President will appoint the Chairman of NEC. A Vice-Chairman will also be appointed and the Council with members from government ministries, parastatals, and NGOs will oversee activities for coordinating and serving conservation of renewable natural resources in all development sectors.

The Council will meet quarterly and action arising from its deliberations will be carried out, or delegated through the Secretariat of NEC. This Secretariat will be led by an Executive Director, a Deputy Director, and a Secretary. There will also be a Technical Advisory Committee, appointed by the Council, to advise on scientific matters ranging from acceptable levels of allowable pollutants to the best use of natural resources in the interests of Zambians.

The NEC Secretariat will be a strengthened version of its precursor, the NCC Secretariat supported by IUCN except that the NEC secretariat, under the Council, will have statutory powers. Moreover, the Technical Advisory Committee will carry out functions previously carried out by various technical subcommittees of NCC, e.g., the subcommittees on pesticides, herbicides, and fungicides; environmental impact assessments; Zambia environmental education program (ZEEP); and soil conservation land agroforestry.

Zambia is determined that NEC succeed. His Excellency the President will appoint the Chairman and that the Executive Director is appointed when the Right Honourable Prime Minister and the Council agree.

Past successful NCC activities which were approved by the Government Republic of Zambia (GRZ), will be included in NEC's program. These are:

- decentralizing of the NCS to the provinces;
- establishing an environmental economics capacity within the National Commission for Development Planning (NCDP);
- implementing ZEEP with the World Wide Fund for Nature (WWF);
- establishing the Zambian Natural Resources Data Centre (NRDC) within the University of Zambia;
- supervising environmental impact assessments (EIAs) required by NCDP and other agencies; and
- developing human resource; in the field of conservation for development.

Other major activities to implement the NCS will arise when the NEC is inaugurated. They will include those concerned with directing the seven environmental inspectorates envisaged in the legislation which will report to the Council.

Currently, MWLNR's Department of Natural Resources (DNR) also manages and oversees conservation for development in Zambia. But six key personnel of the Department have virtually full-time duties within the present NCC secretariat. It is anticipated, however, that more of its members will be absorbed into the new NEC secretariat. In addition, a Provincial Conservation Officer employed by the NEC will be placed in each provincial planning office (PPO) to give the Council an on-the-ground structure for continued decentralization of the NCS.

Past Interactions between the NCC and Agricultural Programs

Members of the NCC drawn from ministries responsible for agriculture, commerce and industry, health, water, lands, and natural resources are interested in making cross-sectorial analysis of agricultural programs. This interest is shared by non-ministerial members such as NCDP, Commercial Farmers Bureau, National Council for Scientific Research (NCSR), and Wildlife Conservation Society of Zambia (WCSZ). WCSZ and the Commercial Farmers Bureau are interested in introducing game farming to improve the yield from marginal lands.

The Soil Conservation and Agroforestry Subcommittee of NCC deals with issues relating to soil conservation, including water and forest conservation with the following specific functions:

- to monitor and establish some degree of coordination for ongoing projects;

- to identify areas and activities for new projects (some scrutiny of new projects to give technical assistance and ensure harmony with other projects and policies);

- to develop policies and strategies relating to soil, forest, and water conservation for approval of NCC; and

- to otherwise advise NCC on all issues relating to soil, water, and forest conservation.

The Subcommittee provides an excellent forum, and sometimes a think tank, and has successfully staged the first Zambian national agroforestry workshop in April 1989. The workshop was supported by the departments of agriculture, forestry, and NCSR, in collaboration with International Council for Research in Agroforestry (ICRAF), and sponsorship from the Swedish International Development Agency (SIDA), the Food and Agricultural Organization (FAO), and the IUCN.

But what of those activities on marginal lands which do not receive the scrutiny usually accorded to recognized agricultural areas? Let us consider two activities of NCC carried out in relation to:

- wetland ecosystems on the verge of extinction (Dambos); and

- land use implications of EEC-funded regional tsetse and trypanosomiasis control program (RTTCP) of Malawi, Mozambique, Zambia, and Zimbabwe.

In the former case the NCC Secretariat/IUCN commissioned a Zambian botanist from the University of Zambia, Mr Emmanuel Chidumayo, a member of NCC, to prepare a conservation-for-development report on Nyautai Dambo and research a vital ecosystem which is in retreat. In the latter case NCC/IUCN supported my predecessor, Stuart Stevenson, to write a comprehensive report on land use implications of RTTCP and weigh the options between rapid expedition of the program, which would subject the blanket-sprayed and contiguous areas to the land use pattern which would cause attendant high risk to biological support systems and discontinuation of a program which would subject people and cattle in previously cleared areas to an unacceptable risk from trypanosomiasis.

As a supporting exercise members of the NCC visited the scientific and monitoring control group of RTCP and recommended that more indigenous scientists be included and trained.

Another area of concern shared by NCC members and loosely related to our deliberations is EIAs, especially those EIAs which could have an impact on the livelihood of small or subsistence farmers. Here two recent examples might suffice.

Proposed ZCCM Marble Quarry and Processing Plant (West Lusaka). The NCC showed that a marble quarry would be more beneficial to the country than a proposed small-scale industrial estate on the open aquifer which supplies much of Lusaka's water. Coal industries do, and could increasingly, pollute the aquifer, whereas the quarry benefits the Lusaka urban district council's water supplies (given a joint water management plan between LUDC and ZCCM). However, the ZCCM has agreed to accommodate or compensate squatter farmers growing maize and vegetables (mainly beans) on the aquifer for road side sale.

Maamba Open-cast Colliery Pyritic sulphur is the main cause of a series of environmental issues, particularly spontaneous combustion of carbonaceous waste. Pyritic sulphur undergoes bacterially assisted oxidation in air to produce sulphurous gases, sulphuric acid, and iron sulphates. The reaction generates heat, which is sufficient to promote combustion locally if carbonaceous material is also present. The NCC has planned to collect available data on both regional and local conditions to determine how pyritic sulphur affects the area, including local farms. There will be measurements of air quality downwind, especially of sulphurous gases, characteristic of emissions from combustion and pyrolyses with particular emphasis on carcinogenic substances such as hydrocarbons. Acidity in soils, water quality, contamination, and pollution will also be measured on contiguous lands.

Revelation of unusual "agricultural" problems through EIAs is ongoing and one current casė is a proposal to implement the Mbeza irrigation 4 500 ha scheme of Kafue flats, a wetland of international significance. This project could include the following construction: a project centre, intake from Kafue river (including pumping station), a pipeline from Kafue to Mbeza a primary network including service tracks and drainage facilities, irrigation distribution including drop, sprinkler, furrow, fish farms, and crocodile farms. Here the NCC is struggling with the implications of such a large scale commercial farming scheme, adjacent to Lochinvar national park, which could deprive traditional users the land of their customary benefits.

The most exciting aspect of the NCC's work related to this workshop is the interest in game farming, which is not yet widespread in Zambia and possibly requires some legislative adjustment to ensure benefit for commercial and community farmers working marginal lands. Research is needed on this subject in Zambia since it is one feasible alternative to traditional livestock.

Our Zimbabwean colleagues have inspired and supported Zambia during the country's feasibility study of game ranching. To quote Child (1987) "Wildlife is now recognized as an agricultural commodity and a start has been made to providing tools necessary for its development" in Zambia.

Moreover, earlier pioneering work of Lewis et al. on the study of wildlife conservation areas conducted in Lower Lupande Hunting Block, in Zambia, has also led the way to less "agriculturally oriented", local and legal (non poaching), use of game.

A data base like the Zambian Natural Resources Data Centre (NRDC) supports research activities. NCC/IUCN are inaugurating this Centre within the Department of

Biology, University of Zambia. The Centre will have IBM/PC clones working as a dedicated system as follows:

- a natural resources bibliographic system;
- a geographic information system (GIS) on which biogeographic information may be superimposed in map form (the Department of Biology wishes this system to start with recording the nation-wide survey of mosses done by Dr Patrick Phiri with Kew Gardens and the British Museum);
- a desk top publishing system; and
- a general purpose PC for scientific analysis.

This system is managed by a Zambian skilled in hard and software. The Centre is to receive advice on computer formating from the IUCN Conservation Monitoring Unit (CMC), Cambridge, UK. The NCC has been encouraging Zambian entomologists in their long-range research attempts to discover "natural", nonchemical, methods of pest control. This assistance is a small grant, without red tape, to carry out the prefeasibility study.

Future Interactions between NEC and Agricultural Research

NEC has, among other things, a statutory duty to "advise on the need to conduct and promote research, analysis, surveys, studies, investigations, and training of personnel". It may also "identify, promote, and advise on projects which further or are likely to further conservation for sustainable development and environmental protection and improvement". These powers are significant because the Council's funds may "be appropriated by Parliament, be paid to the Council by way of fees, grants, or donation" and the Council may "accept moneys from any source in Zambia" and, "when approved by the Prime Minister, from any source outside Zambia". So, in one body, provision has been made to commission research and, with more than normal freedom from bureaucracy, raise the funds necessary to carry out research. Moreover, the Council may establish the following "inspectorates":-

- water control;
- air pollution control;
- solid waste management;
- pesticides and toxic substances control;
- noise control;
- ionising radiation control; and
- natural resources conservation.

At present, Zambia has an inadequate number of trained professionals to staff the inspectorates. A large program is, therefore, needed for developing human resources with possible donor assistance. But this need should not be discouraging if "The Brundtland report" is not to be viewed historically as well meaning rhetoric.

Early problems which are likely to arise will be about what "standards", viewed in the present light of Zambia's technological and economic capacity, should be adopted by the inspectorates.

Conclusions

The organizers of this workshop have emphasized that "the integration of agricultural and natural resources management research cannot progress without adequately trained manpower". They are right but I have also highlighted in this paper that:

- trained manpower must be able to operate within an institutional structure which will serve and coordinate their efforts (preferably within a National Conservation Strategy);
- there must be commensurate "trained manpower" within the program analysis cadre, the administration, and the organizational machinery and not solely within the ranks of qualified technicians, scientists, and agriculturalists, and
- our efforts should always be analysed to obtain some estimate of external efficiencies of our research and training programs, even when projects are at feasibility stages.

Moreover, I have suggested that recent advances in Zambia are conducive to linking conventional agricultural research to a national conservation strategy. This is a step in which many Zambian and IUCN colleagues firmly believe and which I recommend, with the assurance that the IUCN regional office for Southern African stands by to assist SADCC countries which wish to structure and implement their own national conservation strategies.

THE ROLE OF THE NGO IN RESEARCH AND TECHNOLOGY TRANSFER

Davison J. Gumbo

Introduction

The sudden increase in number and types of non-governmental organizations (NGOs) in the third world in the last decade has been phenomenal. Depending on the policy environment of the country concerned, NGOs have mushroomed all over and all purport to work at the grassroot level. The values and role of NGOs needs not to be over-emphasized but, it is important for people to understand the driving force behind NGOs and their successes and failures.

Historical Perspectives

NGOs grew mainly as welfare organizations whose main objective was to provide goods and services to the needy. This role, carried out in times of severe stress like famine, drought, floods, and so on, is obviously beneficial. Most NGOs in this category have, however, not accepted an added role of providing room for some improvement: the need to provide not goods and services but rather the means to get the goods and services. This does not apply to disasters but certainly applies to annual drought relief cycles where NGOs concerned can put up an irrigation scheme. May be the longterm benefits will actually offset the initial piecemeal effort.

Another category is that of NGOs that view themselves as pressure groups. Such NGOs believe in the provision of support to national governments in the form of criticism. Criticism needs boundaries and requires data for substantiation. In most cases lack of data weakens such NGOs' arguments and there is usually a general lack of proposed solutions. In some cases solutions may be there but may be too outrageous for the government concerned to even consider. Changes to alter a standing land tenure system can be one such innovation that may come from an NGO. Such NGOs operating in the south tend to take their cues from the north but always fail to adapt those cues to realities of their environments and do at most end up as pressure groups whose accusations and interventions are taken lightly.

The third type of NGO is that which has direct northern NGO support both in operational principles and funding. The tendency in this category is to be at loggerheads with national governments as they fail to find a niche in the development spectrum of their host government. It is not surprising that at times the mistrust between the two is so great that the NGOs are often under some kind of surveillance. The failure of such NGOs to recognize the political climate often creates this unfortunate scenario.

The fourth type are NGOs that have attempted wherever they are to supplement government development efforts. They operate in niches where government extension service may not. Such NGOs usually have a clear development policy to improve the general welfare of the people.

NGOs and their Advantages

NGOs have one big advantage over most development institutions - their size. NGOs that have tended to remain small have also tended to be efficient and have been able to realize their targets. Their size has enabled them to remain informed and flexible. Where this flexibility has been used as a means of answering community needs, this has been beneficial. However, sometimes the flexibility attracts funding for which there is no manpower in the NGO.

NGOs tend to have highly motivated people who, by and large are prepared to work at the grassroot level. This is important when it comes to realizing targets. Within this operational framework, of course, is the ability of NGOs to try any new innovations whose approval may take a little longer in Government bureaucratic systems.

NGO Constraints

It is not all easy in the NGO world. Much as their advantages are recognized, the NGOs could do a much better job if the following constraints are noted by individual NGO and are addressed. Since most NGOs tend to be small they also tend to create personality and end up being centralized around an individual rather than NGO performance. When such a person leaves, s/he may leave with both approaches and the donors. Also, NGOs tend to fail to attract well qualified staff, which weakens the institution. This internal weakness means that such NGOs cannot foster linkages with research institutions or governments. Such a failure to foster these links means that the NGO is not only isolated but is also starved of vital information and support.

One of the positive attributes of NGOs is flexibility but if this flexibility is directed externally while internally the NGO cannot function, the flexibility may also turn out to be a big disadvantage, especially in situation where donors keep changing their funding agendas.

NGO networks

As indicated, the NGO world does respond to donor influences; just as there has been a proliferation of networks in research, so has there been an increase in the number of NGO networks. The SADCC region's energy NGOs are trying to put up a network and it is hoped that the necessary support will be provided.

NGOs must as a matter of urgency attempt to address their internal rigidities. Support to do this must come from all national research institutions. NGOs have a role to play but in order for them to play this role they must not be isolated but must be integrated in the general planning strategies. NGOs themselves especially local, must start to develop clear cut policies which they must abide by if they are to prove their mettle. Donors on the other hand should assist in institution build up to NGOs so that these can play a more meaningful role in developing the third world.

LAND AND WATER MANAGEMENT ISSUES

Adam Pain, David Harris, Graham Fry, and Steven Mille

Introduction

To improve agricultural and national resources management, strategies must be made around two fundamental objectives:

- provision of improved and sustainable rural incomes;
- development of management practices that support a sustainable resource base;

Moreover, research must be carried out with the aim of improving the livelihoods of the poor in particular. These are the landless and urban poor whose livelihood comes from wage labour. Their agricultural interests are more as consumers than as producers. Support for rural poor should, therefore, be the major focus for research. If the rural poor are made the target, this will also improve management or rural resources.

Land use changes in Southern African Development Coordinating Conference (SADCC): evidence of land pressure

Data on the extent and rate of extraction of wood from forests and rangelands of the SADCC region is presented in Table 1. It is, however, difficult to draw a relation between increase in rates of extraction and actual decline of forest lands in the absence of detailed figures on national area of forestry, extent of plantation, and re-plantation etc. However, the rate of expansion of cropland within the SADCC region is clear (Table 2).

Expansion of cropped area and a concomitant reduction in forest and range has had two effects. First, the expansion of cultivated land has been into the more marginal rainfall and soil areas. Experience suggests that the more favourable environments are usually occupied first. Secondly, with the expansion of privately-owned, cultivated land, the areas of common land are reduced. It is, therefore, easy to conclude that throughout the SADCC region the resource base is under pressure, worsened by an expanding population, although the scale and spatial variability are unquantified.

The paucity of data within SADCC on land ownership, sources of rural income, rural differentiation, and loss of common land makes it difficult to describe changes in these over the last decades. There is, however, a concentration of over 74% of all communal lands in Zimbabwe in the two least favourable agroecological zones. This concentration is a result of over 45% of arable land in most favourable areas having been given to settlers (Suba, 1989).

Detailed comparative data from India owes much to pioneering work of N.S. Jodha (1983), and while there may be differences in magnitude and time, the lessons from India are applicable to the SADCC region. From field work and use of land records in the State of Rejasthan, India, Jodha drew attention to the gradual loss over time of common lands. He identified major causes for this as commercial pressures (commercial value of forest products for example), private ownership and penetration of a market economy into traditional subsistence communities. He documented how the loss of common grazing lands and common watering points particularly affected landless and very small livestock owners. These people, living in marginal rainfall areas, depended on grazing offered by common lands to maintain their livestock. Evidence from India and elsewhere (National Research Council, 1986) has supported Jodha's view that the rural poor derive the greatest livelihood benefits from common property resources (fuelwood, green manure, forest products); therefore, they are the ones suffering most from the loss of such resources.

Table 1. Percentage change in production of wood products for 1984-86 in contrast to 1974-76 for SADCC region

	Roundwood Charcoal	Fuelwood & Roundwood	Industrial Wood	Sawn
Angola	23	34	-8	-97
Botswana	47	46	49	
Lesotho	28	28		
Malawi	33	34	8	-56
Mozambique	49	54	4	-82
Swaziland	-4	20	-10	39
Tanzania	42	41	51	44
Zambia	29	29	34	43
Zimbabwe	43	41	55	40
Africa	34	35	24	36
Asia	18	17	21	21
Latin America	40	26	90	67
World	21	28	15	11

Source: World Resources Institute, 1988. World Resources, 1988-89. Basic Books, New York.

Relevant material from SADCC region is sparse. One example is Fortmann and Roes (1986) research on private ownership of water sources in Botswana. There is ample visible evidence by the roadside - wood piles, sacks of charcoal, or in stacks of thatching grass - which demonstrates that rural livelihoods are derived from the commons.

Products from commons areas are a major source of sustenance and income to poor people. Yet, it is often argued that the rural poor bear the greatest responsibility for the environmental degradation that has taken place. The colonial conservation policy was based on either belief or prejudice (Showers, 1989) that it is the rural poor who through ignorance and short-sightedness have recklessly destroyed their own resource base.

Table 2. Land area, percentage changes in land use for 1986-1988 over 1964-66 population and population change in SADCC

	Land area (K ha)	Crop land	Forest & Woodland	Population (m)	Annual % change in population
Angola	124670	5.6	-3.1	9.7	2.67
Botswana	56673	32.4	0.4	1.3	3.7
Lesotho	3035	-16.3	0.0	1.7	2.16
Malawi	9408	18.5	-12.8	7.9	3.32
Mozambique	78409	14.8	-12.8	15.5	2.69
Swaziland	1720	7.2	-21.2	0.7	3.14
Tanzania	88604	36.7	-5.8	26.0	3.35
Zambia	74072	6.3	-15.8	7.6	3.43
Zimbabwe	38667	27.4	0.0	10.1	3.16
Africa	2964595	14.0	-8.6	626.0	3.02
Asia	2678827	4.2	-4.6	3009.1	1.63
Latin America	1753454	35.2	-7.3	291.2	2.08
World	13078873	9.1	-2.8	5162.4	1.63

Source: World Resources Institute, 1988. World resources, 1988-89. Basic Books, New York.

Land degradation: explanation and causes

Although there is a connection among land pressure and resource exploitation and degradation, it is also true that conservation policies have not worked.

Blaikie (1984) and Watts (1987) identify three groups of explanations for land degradation. The Malthusian argument is that an area of land has a fixed carrying capacity and that degradation takes place once combinations of human and livestock populations exceed some critical value. This view implies the concept of a critical population density which, if exceeded, lead, to over-population. However, it is difficult to accept this argument as, when technical changes continuously raise the productivity of land, overpopulation becomes relative to available technology rather than to land resources. The predictions of Malthus and his followers cannot therefore be applied, although the increasing scale of land pressure is an important factor. In Malawi there has been a decline in arable land per household from 0.86 ha in 1976 to nearly 0.40 ha in 1987 (Suba, 1989).

Boserup (1965), on the other hand maintains that increasing population pressure is a stimulant and a major determinant of technological change in agriculture, and sees a more extreme version in Simon (1981). Her argument is weakened by identifying population as a major critical determinant. There are plenty of examples where increasing population has not led to the postulated innovation or where innovation has occurred without population pressure.

The other variant is contained in Hardin's thesis (1968) of "the tragedy of the commons". Here it is argued that when common property resource management gets increasing pressure, it leads to individuals seeking to maximize self-interest at the cost of the collective. In other words, collective use of resources will inevitably lead to degradation. Recent research has demonstrated the fallacy of that view of commons' exploitation through evidence of traditional management systems for regulation of the use of commons' resources (National Research Council, 1986). Over-use and degradation of commons that is observed today is a consequence of the breakdown of traditional management systems caused by the penetrating of the market and the centralizing of power.

The third category of explanation is based on the notion of social structures and relationships between various types of producers. This viewpoint is well expressed by Amartya Sen. In his original study of the cause of famines (Sen, 1981), basing his argument on famines in India, he argued that contrary to the general belief that famines arose when there was an absolute dearth of food, careful thought suggested that there were demand factors contributing. Even in times of famine, food was physically available. Ability of different income groups to purchase the available food mattered more. Sen coined the concept of "entitlement" which, based on purchasing power of wages in relation to food prices, indicated that different economic groups had different entitlements. Thus, for a labourer who would normally exchange one day's labour for two days of food, when food prices rose, one day's labour might provide less than a day's food. If such conditions continued, a poor household would be forced into asset disposal; once these were gone, it would starve.

Sen's analysis addresses to most immediate causes of famine. It does not consider how different social groups come to command differing purchasing capacities (Watts, 1987) and the consequences of these on the household's strategy for survival under pressure. We summarize the structural explanation of land degradation as follows:

In all environments, and particularly in semi-arid zones, there are good and bad seasons in terms of rainfall and food production. In low rainfall environments there may be a succession of dry years during which food production falls below levels required to sustain farming households from one season to the next. Households vary in their ability to withstand a poor harvest. For example, Hill (1972, 1977) in her work on Hausaland (Nigeria) identified four distinct economic strata in terms of their ability to withstand drought. These ranged from the rich with large land holdings and the ability to make loans and prosper through off farm income, to the poor with either little or no land, who are deficient subsistence grain producers, indebted, and dependent on wage labour for survival. In Malawi it is estimated that over 55% of the rural households are unable to satisfy their subsistence requirements from home production (Suba, 1989).

In good years the poor are on the margin of survival with sufficient domestic production and wage labour to make ends meet, barring disaster. However, they are also continually working against deteriorating terms of trade of agricultural commodities for items necessary for domestic use purchased through the market. In bad years as household grain production falls well below requirements, wage labour opportunities contract and food prices rise. Survival will depend on further loans where possible or gradual disposal of household assets including, ultimately, land.

Poor households tend often to be located in spatially marginal places: poorer soils, lower rainfall environments, most distant from villages, edge of irrigation systems, higher hill slopes (Blaikie, 1985). They must often rely on village common lands to make ends meet. Under pressure to survive, their options are few and they must, in the words of Blaikie (1985) "destroy their own environment in attempts to delay their own destruction". Poor households in the process reduce their long term chances even further. Chambers and Leach (1989) graphically illustrate this in the case of a Bangladesh landless labourer who, in desperate straights, is finally reduced to disposal of his last household asset - an immature mango tree which is chopped down with roots and all for sale as firewood.

These illustrations suggest that legislation to bridge the gap between rich and poor is limited however, price structures in favour of producers would redress part of the long term imbalances between urban and rural sectors, although at a cost to grain deficit producer households (Lipton, 1977). There will always be poorer households in rural communities who must sell their labour and exploit the limited private and communal resources they have. Research in agricultural production must, therefore, focus on income generating possibilities that provide reliable income sources and obviate the need for the poor to undermine their own long term survival through enforced short term expediency.

There are two other aspects to the dynamics of poverty which are commonly neglected but may be important. The first is the seasonal dimension. The existence of the hungry period is well known: the highest food prices and greatest scarcity of work are before the first harvests. It is a time, too, when malnutrition is common. The issue of seasonality is discussed extensively by Chambers et al. (1981). It suggested that one of the major objectives of seeking to support the rural poor must be to create income generating opportunities or sufficient food and income reserves to tide them over this crucial period.

Secondly, poor people have few assets. In marginal environments where risks of production failure are greatest, disposable assets provide survival opportunities. The operation of many pastoral systems is based on survival (Dahl and Hjort, 1976) of the poor in the community. Chambers and Leach (1989) have indicated, trees offer a unique opportunity to the poor to accumulate assets at a rate of return that is unobtainable elsewhere.

We can, therefore, conclude that seeking to improve livelihoods of poor people by a simple production approach is unlikely to lead to more favourable outcomes in terms of food availability to poor people. Many poor people are not full-time farmers and depend on labour income to ensure household survival. Accordingly, raising household income must be a primary objective of any technical intervention. Poor people live in marginal places and are often forced through circumstance to undermine their own long term survival. Strategies that offer reliable, productive, alternatives are the only means by which resource depletion can be avoided.

Technical options for improving rural income and research needs

We suggest three ways in which poor people's livelihoods from direct agricultural activities can be constructively addressed:

Raising wage labour opportunities

One of the hoped for benefits from the introduction of modern varieties (MVs) was to create greater labour demand through intensifying demand on a seasonal basis (e.g., a shift from broadcast to transplanted rice) and through increasing the incidence of double cropping. SADCC region has a single agricultural season per year and with a much smaller area of irrigated land, the potential for marked increase in productivity is limited.

There is, in addition, one important lesson to be learned from the Asian experience of direct relevance to agricultural research here. Opportunities for labour intensification are lost when labour-saving innovations (mechanization, chemical control of weeds, etc.) are adopted by larger farmers.

However, introduction of technologies to increase land productivity in the SADCC region could generate real wage income opportunities. Irrigation has been much neglected within the region and there must be scope to build on traditional irrigation practice. Nevertheless, in drier parts of the region it is difficult to see major opportunities for wage labour developing in the agricultural sector.

Stabilizing production

One of the major characteristics of the 200 - 800 mm zone of SADCC is the year to year variability in rainfall, often plus or minus 20 - 30% of the long term average. Accordingly, drought is not a transient phenomena. Moreover, in the context of one cropping season, a single poor harvest becomes a handicap for the whole year. Stabilizing production in a highly variable environment is a major challenge.

This paper has studiously avoided the words, "integration" and "tree/crop/livestock interactions", reflecting a certain skepticism about the general use of the concept. The case should be argued from first principles. Many have interpreted "integration" as simply integrating research on different production activities at farm level. In other words, nothing more or less than farming systems research. This should ensure relevant and applicable research but it has not always directly addressed household income. However, there is a more fundamental interpretation of integration which focuses on the efficient and sustainable use of physical resources to support various production activities from the land.

From a resource viewpoint, the mixing of plant species of different growth habits and duration (erect and prostrate, annual and perennial) offers the possibility of allowing more efficient use of resources of energy, water, and nutrients over space or time. This opportunity is the basis on which yield advantages of intercropping and multi-storey cropping accrue. The incorporation of perennial species and livestock may also provide partial closure of the nutrient cycle and raise the basal level of nutrient availability.

In the semi-arid areas of Botswana, rates of incident radiation are amongst some of the highest in the world but there is, in arable agriculture, a low efficiency of interception because of constraints of water and nutrients (DLFRS Phase lll, 1985). The potential for increasing efficiency of use is subject to increasing water and nutrient availability. Lack of perennial rivers and the costs of pumping groundwater (and their limited supply and quality) make opportunities for irrigation limited. Accordingly, if production is to be stabilized and reliably increased, it must be through the management of rainwater. Its availability and its efficiency of use by the plant must be increased. If soil water regimes can be stabilized and enhanced, then nutrient availability will quickly become an important constraint.

Before considering whether integration of tree and crops is likely to contribute to increasing nutrient availability, we have to explore what options might be available for improving water availability. There are several dimensions to this research problem which require careful characterizing in the first instance of existing soil water availability. There is no scope within this paper to cover at length these matters, and reference is made elsewhere (L&WMP, 1988a, 1989b, 1989) for fuller discussion. But in outline the aspects that must be considered are as follows:

Rainfall

Rainfall supply characterized on a probabilistic basis for planting opportunities; frequency, timing, and duration of dry spells; frequency of occurrence of events with runoff generating potential, etc., and rainfall/landscape interactions.

(i) identifying of circumstances that give rise to runoff which include *inter-alia*

- storm amount and intensity;
- slope;
- vegetation cover;

and characterizing the runoff generated (peak flows, total volumes etc.)

(ii) characterizing the landscape in terms of water management options

- describing soil water balances according to soil location in landscape, soil texture, depth etc., as currently found to enable prediction of whether additional water would be beneficial;
- investigating the ability of various tillage options to control water supply. These can be grouped according to the distance between the point at which rain falls and the point at which it becomes available to the crop and, classified as:
- retention techniques for improving *in situ* infiltration;
- concentrating techniques for harvesting water over short distances; and
- harvesting techniques for water passing over longer distances.

From our work in Botswana we are not yet ready to provide an integrated picture of soil moisture availability according to soil type, location, and year. We can however, postulate a set of options according to soil depth, available water capacity, rainfall, and frequency of rainfall events that determine potential water management strategies.

The scope for raising soil moisture content by improved infiltration alone is restricted by frequency of rainfall and soil depth. If, for example, a soil of 0.25 cm depth with available water capacity by volume of 10% (and taking available water capacity to be equivalent to accessible water which is usually less) is planted with a 130 day crop and there is an average daily 4 mm soil water loss through crop use and evaporation, then the soil must be topped up with 25 mm every six days or so. With increasing depth (hence greater soil moisture capacity) this requirement is relaxed.

Water concentrating techniques require greater soil depth to be effective and given a combination of greater soil depth and concentrating abilities, is more effective than infiltration techniques in establishing satisfactory soil moisture reserves in lower rainfall regimes.

Water harvesting techniques are also dependent on soil moisture storage capacity to be effective, and probably require greater soil depths and finer soil textures. If greater soil depths are available, they may be effective as water management strategies for annual cropping in lower rainfall regimes. However, there is probably a cut off point in higher rainfall environments where handling water harvesting volumes would require skillful engineering, and might exceed soil moisture storage capacities. In such a situation, water harvesting would not necessarily be the most sensible form of water management.

Botswana, on its eastern side, has modal seasonal rainfall values of between 400 and 520 mm. Potentially all these water management strategies might come into play. But analysis of rainfall from three rainfall stations in Botswana (Table 3) indicates that the frequency distribution of maximum dry periods in 4 successive 30 day periods after a planting event (taken to be the first 40 mm in 4 days event after 1 September) might limit the effectiveness of infiltration management techniques alone for shallower soils.

In an environment where soil depths rarely exceed 2 m and are more commonly 1 m and where accessible water is likely to be 7 or 8% by volume, water harvesting options are likely to be restricted by supply too. Our research (L&WMP, 1989) shows that of the measured runoff from 16 0.4 ha plots over this in 1988, less than 5% of the maximum discharge amounts were greater than 50 m^3, (2.5 mm over the 0.4 ha).

Storm event that triggered runoff were for most cases 10 mm or above and for a number of sites rainfall runoff threshold was closer to 20 mm. Table 4 shows the number of raindays grouped by total and selected amount. For three widely separated sites the modal value of the number of rainstorms of 20 mm or above in a season, those most likely to contribute runoff, was 6-7. This however, does not necessarily mean that water harvesting is a widely applicable and viable water management option throughout Botswana.

This analysis is preliminary and specific to Botswana. It is not a general statement about the viability of water harvesting for SADCC region. But the argument raises two issues of relevance.

Table 3. Dry spells for each succeeding 30 day period after planting, taking the first 40 mm in 4 day as the planting data

	Gaborone	Mahalapye	Francistown
0- 30 d.a.p.			
Minimum	5	4	4
Maximum	20	30	29
Range	15	26	25
Mean	9.5	11.5	12.5
SD	3.5	5	9.5
20th percentile	6	8	8.5
50th percentile	9	11	13
80th percentile	12	14	16
31 - 60 d.a.p.			
Minimum	4	5	3
Maximum	26	39	48
Range	22	34	45
Mean	11.5	13	14.5
SD	6.5	6.5	7
20th percentile	7	8	9
50th percentile	10.5	11	14
80th percentile	15	18	20
61 - 90 d.a.p.			
Minimum	6	4	6
Maximum	44	38	43
Range	38	34	37
Mean	14	14	18.5
SD	7.5	6.5	9.5
20th percentile	9	9	11
50th percentile	12	13	17
80th percentile	19	18	25
91 - 120 d.a.p.			
Minimum	6	5	6
Maximum	63	41	70
Range	57	36	64
Mean	15.5	15.5	24
SD	10.5	8	13.5
20th percentile	8	8	13.5
50th percentile	13	14	21
80th percentile	21	20	34

Table 4. Number of raindays grouped by total and selected amounts.

	Gaborone	Mahalapye	Francistown
Total no. of raindays >0.85 mm			
Minimum	42	28	20
Maximum	97	73	66
Range	55	45	46
Mean	62.5	51	39
SD	12	10	10
20th percentile	50	40	29
50th percentile	61	50	39
80th percentile	74	60	48
No. of raindays >10 mm			
Minimum	7	4	3
Maximum	37	25	27
Range	30	21	24
Mean	16	14	14
SD	6	5	5.6
20th percentile	11	9	9
50th percentile	16	14	14
80th percentile	22	18	20
No. of raindays >20 mm			
Minimum	2	1	0
Maximum	16	13	15
Range	14	12	15
Mean	7	6.5	6.5
SD	3	3	3.5
20th percentile	4	3	4
50th percentile	6	7	6
80th percentile	10	9	10
No. of raindays >40 mm			
Minimum	0	0	0
Maximum	5	7	7
Range	5	7	7
Mean	2	2	2
SD	1	1.5	1.5
20th percentile	0	1	0
50th percentile	1	2	2
80th percentile	3	3	3

- **Where perennial species fit**

Water management: We know next to nothing about the use of soil water by trees in Botswana. However, in terms of increasing water availability and water use efficiency in the face of the constraints of available soil water, it is difficult to see how, within the context of a farmer's field, perennial and annual species can be integrated in a complementary fashion. There is probably insufficient moisture availability to support complementary use of water between annual and perennial species. In the shallow slopes of Botswana (0.1 - 3%) there is little evidence, either, that tree cover will be of value to the promotion of runoff. Indeed, the contrary picture emerges and given the apparently low levels of runoff, one might actively seek to promote it. Tree cover positively discourages runoff. The scope for perennial species is more likely to be on shallow soils where risks of annual cropping are too great.

- **Stability**

There is stability of the physical resource base and stability of income sources. The concept of stability in ecological systems was developed by Holling (1973). Stability refers to the ability of a system to return to a state of equilibrium after a temporary disturbance. The more stable a system is, the smaller are its fluctuations around an equilibrium and the more rapidly it returns to that state after being disturbed. Linked to the concept of stability is resilience, which is an assessment of the ability of the system to absorb changes and maintain relations between components of the system under conditions of instability (Holling, 1977).

The semi-arid environment of Botswana is a system with relatively high resilience but it is also relatively unstable, because of the variable rainfall. The extent of its resilience can be seen through the rapid restoration of grass cover and tree regeneration after the drought in the early 1980s. Yet many have been keen to argue that because of soil erosion, degradation in Botswana is considerable.

The existence of soil erosion, its magnitude and effect are highly equivocal. Cliffe and Moorsom (1979) when writing of rural class formation and its ecological consequences concluded that "large swathes of land around villages... [had suffered]... complete destruction of .. [fertility]". They added that soils had become impoverished, their structure destroyed and their water retention capacity reduced, resulting in increasing run-off and progressive erosion.

In a similar vein, Veenendal and Molefi (1987), despite noting that hardly any quantitative data on soil erosion existed in Botswana, stated that the problem was serious supporting this statement with anecdotal evidence of dust storms, moving sand dunes, measurements of the proportion of bare soil (as an indicator of extent of land degradation), and some calculated examples of sheet erosion expressed in tons of soil lost per hectare per year.

These viewpoints should be set against the results of a recent study in Botswana which expressed its conclusions in terms of productive soil life (Biot, 1988). This study, undertaken on a site near Mahalapye, concluded that the residual economic lifespan for a soil with an average depth of 68 cm was, with "average" rainfall conditions, 428 years. As Biot noted, this was "beyond the usual time scale for financial/economic analysis". With less than average rainfall, a soil life of 204 years was predicted.

It is difficult to decide who is right or wrong owing to the generality of the first two views and the site specific nature of the third. Stocking (1988) discusses in some detail the limitations of techniques and methods that have been commonly used by soil scientists to measure soil erosion. The recent shift towards viewing soil erosion in terms of its effect on soil productivity (the ability of a soil to support sustainable yields) is taking soil erosion research out of its conservationist shell into a wider perspective on resource management.

Tree cover on land adjacent to cultivated lands may act to reduce runoff from such areas. Circumstantial evidence suggests that farmers complain more of runoff damage than water loss to their fields. Incorporation of perennial species could confer stability to the system.

Perennial species and livestock incorporated within the farm boundary and the research perspective will generate income. Perennial species are likely to show greater stability of production. In low rainfall years if there were complete sorghum failure perennials may provide some yield and income for the household. Similarly, the use of perennial species to provide browse for livestock could do much to raise the quality of livestock at farm level, improve income from small stock, and possibly enhance the condition of draft animals to better prepare them for ploughing once rains come. Mopane woodland produces 10 $t.ha^{-1}$. $year^{-1}$ fresh weight material (Tietama, 1989). Even a proportion of this would make a substantial difference to nutrient intake of livestock.

- **Off-farm income generation**

The possibilities for incorporating perennial species and livestock within the farm boundary are applicable also to the opportunities that might arise from management of such resources on commons lands. However, the opportunities must be seen in terms of the buffering capacity that they could provide to vagaries in-farm income and production. An interesting example of off-farm incomes being increased in dry years is to be found in the culling of cocoons of the Mopane worm in Botswana. The cocoons found more in dry years than wet (Southern African Economist, 1989).

Conclusion

- No case can yet be made in Botswana to justify closer spatial integration of perennial, livestock, and annual species on the grounds of improving availability and efficiency of using rainwater. Justifying for integration within and outside the farm boundary comes from stability of income considerations.

- The specific case for Botswana suggests that spatial integration of tree, crops, and livestock must be justified on careful study of the basic physical processes that drive agricultural production, namely energy, water, and nutrients. The analysis of such processes must provide the integration for research and be the basis of it. To proceed in an empirical manner using output (yield etc.) as the major criteria without studying such processes is to restrict the possibility of generalizing about site and year specific results. Such a focus will also not necessarily provide the intended returns to the poor.

- All research must emphasize stability of production. Land management practices must be looked at, not in terms of soil loss, but in terms of effect on soil productivity.

References

Bernstein, H. 1978. Notes on capital and peasantry. Review of African political economy, 10, pp. 420-43.

Bernstein, H. 1979. African peasantries: a theoretical framework Journal of peasant studies, 6, pp. 420-43.

Biot, Y.J. 1988. Modelling productivity losses caused by erosion. Paper given at 5th International soil conservation conference, Bangkok, Thailand.

Blaikie, P. 1985. The political economy of soil erosion. London. Methuen.

Boserup, E. 1965. The conditions of agricultural growth; the economics of Agrarian change under population pressure, Chicago, Aldine.

Chambers, R., Longhurst, R., Pacey, A. eds. 1981. Seasonal dimensions to poverty. Frances Printer, London, U.K.

Chambers, R. Leach, M. 1989. Trees as savings and security for the rural poor. World Development, 17, (3). pp. 329-341.

Cliffe, L., Moorson, R. 1979. Rural class formation and ecological collapse in Botswana. Review of African political economy. 15/16 46 p.

Dahl, G., Hjort, A. 1976. Having herds: pastoral growth and household economy. Studies in Social Anthropology, University of Stockholm, Stockholm, Sweden.

Drinkwater, M. 1989. Technical development and peasant improvement: land use policy in Zimbabwe Midlands Province. J. Southern African Studies 15, (2). pp. 287-305.

Dryland farming research scheme, 1985. Final Report: summary. ODA/Department of agricultural research.

Ehrilch, P.R., Ehrlich, A.H. 1970. Population, resources, environment: issues in human ecology. W.H. Freeman, San Francisco, USA.

Fortmann, L., Roe, E. 1986. Common property resource management of water in Botswana. National Research Council, 1986, pp. 161-171.

Hardin, G. 1968. The tragedy of the commons. Science 162, pp. 1243-1248.

Hill, P. 1972. Rural Hausa: a village and a setting. Cambridge University Press, Cambridge, U.K.

Hill, P. 1977. Population prosperity and poverty: Rural Kano 1900 and 1970. Cambridge University Press, Cambridge, U.K.

Holling, C.S. 1977. Resilience and stability of ecology systems. Annual review of ecology and systematics, 4, 123 p.

Jodha, N.S. 1983. Market forces and erosion of common property resources. Paper presented at the International workshop on agricultural markets in Semi-arid Tropics, ICRISAT Centre, Patancheru, India, 24-28 October.

Land and Water Management Project. 1988a Incoming Review. Private Bag 00108, Gaborone, Botswana.

Land and Water Management Project. 1988b Annual report 1987-88 Private Bag 00108, Gaborone, Botswana.

Land and Water Management project, 1989. Annual report 1988-89 forthcoming. Private Bag 00108, Gaborone, Botswana.

Lipton, M. 1977. Why poor people stay poor: Urban bias in world development. Temple Smith, London, U.K.

Lipton, M., Longhurst, R. 1989. New seeds and poor people. Unwin Hyman, London, U.K.

National Research Council, 1986. Proceedings of the conference on common property resource management. National Academy Press, Washington D.C., U.S.A.

Southern African Economist 1989. Botswana silk industry comes out of its cocoon. 2, (5). pp. 39-40.

Sen, A. 1981. Poverty and famines: an essay on entitlement and deprivation. Oxford University Press, Oxford, U.K.

Showers, K. 1989. Soil erosion in the Kingdom of Lesotho: original and colonial response, 1830s-1950s. Journal of Southern African Studies 15, (2). pp. 263-286.

Simon, J.L. 1981. The ultimate resource. Martin and Robertson, Oxford, U.K.

Stocking, M. 1988. Measuring Land Degradation In: Blaikie P., Brookfield, H. Land degradation and society. Methuen, London, U.K. pp. 49-63.

Suba, R.M. 1989. The land issue: SADCC overview. Political and economic monthly, 5-7. Harare, Zimbabwe.

Tietama, T. 1989. The possibility of management of the Mopane woodland In: Report of the workshop on the Management and Development of indigenous forests in SADCC region. Victoria Falls, Zambia.

Watts, M. 1987. Drought, environment, and food security: some reflections on peasants, pastoralists and commoditization in dryland West Africa. In: Drought and Hunger in Africa ed Glantz, M. Cambridge University Press, Cambridge, U.K. pp. 171-212.

GROUP DISCUSSIONS

Group discussions were held during the workshop, and the participants' deliberations focused on the following topics:

GROUP 1

ROLE OF REGIONAL RESEARCH NETWORKS (RRN) IN FACILITATING INTEGRATED RESEARCH

Definition

- Integrated research involves a systems perspective including as appropriate interdisciplinary terms, crop/livestock/tree

- Types of RRN

  a) SADCC countries - sorghum-millets

  b) External beyond SADCC region - PANESA

General agreement

- Importance of systems perspective

- Research priorities should be set by NARCs

- Training: Success of research depends on adequate numbers of trained scientists in NARCs. The networks and SACCAR should encourage support for manpower development. Degree programs should include training in systems approach and integrated research methods. Non degree short courses in systems research should be organized jointly among regional network with SACCAR coordinating.

- Donors: Donor enthusiasm for network approach has led to increased numbers of networks which sometimes compete for scarce resources of NARCs. SACCAR should maintain information base networking in SADCC region. This information base can be used to alert donors to potential for competition among networks and to opportunities for collaboration.

Recommendations:

- NARCs should lead in using integrated systems approach to research, which may involve collaborating among departments, disciplines, and even ministries. SACCAR can encourage enhancing of systems approach among law decision makers in SADCC region.

- Collaboration: Research network tends to form on specific commodities. This formation is important to success of specific research; however, commodity research should be undertaken with a systems perspective. Collaboration among networks should be encouraged. SACCAR may convene periodic meetings of network coordinators to identify opportunities for collaboration.

GROUP 2

COMMUNITY PARTICIPATION IN TREE/CROP/LIVESTOCK INTEGRATED RESEARCH

Introduction:

The main objective of this workshop was to generate ideas on how to improve tree/crop/livestock integrated research. Existing research tended to overlook communally managed lands and areas of low productivity. Also, government organizations tended to emphasize research on land unit allocated to individuals rather than on areas which were communally managed. As a result, information generated from such research tended to be irrelevant and often did not address the needs of the people it is supposed to serve. In order to improve the relevance and effectiveness of research, it is not only necessary but essential to involve the community in planning and execution of research and to extend the research focus to communal and marginal areas. In reaching the farmer at the grassroot level in this effort of integrated research, non-governmental organizations (NGOs) may provide access to the communal areas, since most already work there and, therefore, should be involved.

Constraints

The group identified the following as the main constraints that affected the participation of communities in integrated research, arranged in order of priority:

- Conservative attitude of researchers;
- Insufficient resources;
- Ineffective communication channels;
- Lack of confidence in government recommendations;
- Inadequate onshelf technologies on non-traditional crops and resources;
- Lack of onshelf community participation research methods;
- Complexity of communal systems;
- Lack of incentives to workers at grassroot level to bring about community involvement;

- Suspicion of government motives; and
- Difficulty in simulation of communal management systems on research stations. This leads to community research often being done on communal lands, which, when it fails, leads to farmers' loss of faith in government research.

Recommendations

In order to improve community participation in integrated tree/crop/livestock research, the group made the following recommendations: change in research attitudes should be initiated by:

- Encouraging linkages between researchers and community participatory project staff;
- Developing research related to community needs; and
- Circulating relevant information.

Community participation research methods should be developed by:

- Involving researchers, community workers, farmers, and extension workers in designing of community research projects (CRP);
- Encouraging experimenting with existing FSR/E methods;
- Reviewing the available literature; and
- Emphasizing cost/time efficiencies.

Sufficient resources should be allocated by:

- Putting community participation in the SACCAR agenda;
- Convening separate workshops for research directors, policy makers, and CRP practitioners; and
- Publishing and distributing regional recommendations.

GROUP 3

TRAINING FOR INTEGRATED RESEARCH

Issues

- Target Group (Beneficiaries) is the small scale farmer and indirectly society as a whole.

- Africanizing the curriculum: definite need; higher significance needs to be placed in social sciences than natural sciences; local training does not always mean local materials; and development of local training material.

- Regional vs National programs: truly integrated research programs would cut across national lines; should be no conflict with national priorities, and needs should always be closely studied to determine extent to which a deficiency exists - where are the gaps.

- Short term vs Long term implementation: incorporate (dovetail) integrative approach into ongoing care courses immediately - D&D and Rapid Appraisal Method; institute short courses for in-service training to teaching and research staff and policy-makers, and revision of curriculum for all MSc - PhD courses.

- Policy.

- Need for position paper.

- Role of SACCAR.

Constraints

Conservation

Even though we consider ourselves to be at the frontiers of science we acknowledge that university teaching staff and the agricultural research community and agricultural policy makers are basically a very conservative family. Change will be slow.

Lack of Methods

Where is the strength or expertise in methods?

International Agricultural Research Centres (IARCs), Universities, Ministries.

Policy

- Change needed at national and regional level to enhance the implementation of integrated research approach.

- A major disincentive to research productivity.

- Joint inter-disciplinary and inter-institutional research planning and review sessions needed.

- Integrated research is long term, complicated, and expensive. Lacks proven technology.

- Resources to support integrated research are scarce - hard to come by.

Recommendations

- SACCAR commission a position paper on curriculum development to support and enhance the concept of integrated research in all MSc and PhD academic training programs.

- SACCAR recruit a sponsor for a follow-on educational design project from the position papers.

- SACCAR sponsor the conducting of training the trainers workshops in the near term for teaching staff at faculties and research staff of NARCs.

GROUP 4

POLICY IMPLICATIONS ON INTEGRATING TREE/CROP/LIVESTOCK COMPLEXES TO IMPROVE AGRICULTURAL PRODUCTIVITY AND NATURAL RESOURCES MANAGEMENT IN SADCC REGION

Current Scenario (at national, institutional, and regional levels)

Infrastructure for conducting research is commodity-based and, therefore, decentralized in separate ministries or departments. The three commodities (trees, crops, and livestock) to be integrated belong to departments of forestry, agriculture, or veterinary services respectively. This raises several fundamental problems/constraints to integration:

A. Lack of joint Planning

Because of compartmentalization based on different sectors dealing with the target commodities (trees/crops/livestock) there is no joint planning to:-

- set priorities with respect to program of work on trees/crop/livestock complex;

- formulate program;

- allocate resources, (i.e., funds mobilization) at high level policy making and institutional levels); and

- design implementation strategy (i.e., who are the actors in the integration exercise and what institutions and what operational mandates have they? Are institutional mandates restrictive or accommodating for integration of other commodities?)

B. Lack of clear strategy for human/manpower resource

If integration of trees, crops, and livestock commodities is to be undertaken in research, are human resources available to facilitate the implementing of research? Is the training/manpower development strategy likely to be redesigned to effect such an integration? Stock must be taken of what human resources there are already in place before embarking on a further training strategy.

C. **Lack of a clear policy regarding linkages and collaboration with international agencies and NGOs operating at national/regional level**

In most cases there are no clear guidelines on modus operandi with international agencies. Most of international agencies and NGOs operate with mandates that favour single commodity research. A clear example is the CIMMYT maize program in the region.

D. **Lack of guidelines on coordination and interaction with donor agencies**

Most countries in the region already have master plans that spell out the need for an integrated research strategy. However, the donor community favour commodity research strategy in direct conflict with set national master plans.

E. **Problems of land tenure policies**

At the implementation level (farm and community), it is difficult to implement an integrated approach because of problems of land tenure. In some communal land ownership schemes where individual (simply because s/he has no right to land) may not be motivated to plant trees. Also the technology transfer systems or extension services may not be adequately trained for an integrated approach to agricultural production.

F. **Policy issues related to government's promotion of single commodities**

Most governments in SADCC countries will promote the production of single commodities (for food security reason) such as maize. This promotion usually takes the form of resource allocation as well as pricing policies.

The underlying principle for the integration of trees, crops, and trees is the concept of sustainability. This concept calls for qualitative and quantitative assessment of human resources. It calls for reorientation, training, and provision of incentives (such as travel allowances and local consultancies) to encourage staff to stay. Staff have to be developed to keep the integrated programs. This also calls for a stable resource bases in funds (whether locally generated or from external sources) and land use. A sustainable integration of trees, crops, and livestock must involve readjustments of rights of use of land resources at farmer and community levels. Such readjustment might call for provision of management capacity to those involved in integrated research and those in technology delivery services.

Research priorities

Most of the issues related to policy appear to be institutional and therefore not readily available to research interventions. The only exceptions are:

- Technology assessment can be done at the planning level to assess types of technologies available in trees, crops, and livestock before an integrated research strategy is instituted. Tactical as well as technical information must be gathered in the assessment.

- Optimal organizational structure. The assessment of organizational structure of NEARs must be done so as to understand their response to an integrated research approach.

Recommendations/action plan

- There should be an attempt to review national/strategic plans (in all NEARs in the region) to identify policy constraints to integration. This review must be undertaken by NARCs themselves and by SACCAR. Findings of such a review must be channelled to SACCAR Council of Ministers and the Board of Directors for policy directives and possible policy changes.

- There must be an assessment of available technology packages in crops, trees, and livestock likely to be included in planning and natural resources management strategy. Findings of such an assessment must form SACCAR's data base that should be available and accessible at its secretariat.

- SACCAR must mount a series of workshops at national and regional levels geared to integration. These workshops must involve policy makers in concert with leaders of national research. The workshops must be well focused in nature; issues identified in policy constraints would be used as resource materials.

- A thorough review of functions and mandates of international organizations, particularly the peripheral NGOs operating in the region must be undertaken. This review must stress the need (in their memorandum of understanding) for integration of trees, crops, and livestock with natural resource management; SACCAR in consultation with NARCs should take the leadership. SACCAR technical committee must be involved.

- National governments must review and adapt their land tenure policies to encourage integrated/sustainable agriculture.

- SACCAR should urge governments to have a balanced pricing policy for commodities; such policy must favour integration of crops, trees, and livestock in the farming system.

GROUP 5

The role of NGOs

- Privateness that separates them from government;

- Voluntary basis;

- Not under direct control of government;

- Organizations may group themselves as NGOs or International Centres; and

- Membership: individual - institutions - governments.

Strengths of NGOs

- Freedom of action: fast action, flexibility, catalytic effect, and new initiatives.
- Fill/complement government efforts.
- Small size of staff, small overheads and therefore cost effective.
- Highly motivated staff.
- Effective mobilization and use of local resources.
- Rapid and direct transfer of information/technology.
- Rapid feedback.

Weaknesses of NGOs

Weak institutional structures in local NGOs especially:

- Management: personnel qualifications, personnel numbers, planning, and accountability.
- Isolation (Information): lost government institutions, parastatal institutions, and other NGOs.
- Short term planning/implementing: changing needs (over ambition), funding, and changing staff.
- Funding: individual vs institution, short term, and donor directed.
- Government restrictions.

NGO Types: Variable

- International.
- External.
- Local.
- Mission: relief, promotional, and research and development.
- Discussion on IARCs grouping into NGOs inconclusive.

Philosophy

- Non-profit.
- Variety of missions.

Sustainability of NGOs

International/external NGOs are more sustainable than local NGOs.

- funding base;
- local NGOs dependence on external sources;
- continuity - personnel
  - money;
- networking weak/limited with local NGOs.

Recommendations

General

NGOs should participate more in research and development.

Speciality

- Efforts should be made by NGOs to understand and follow government policy.
- NGOs should understand government and parastatal structure so that they can identify their niche.
- Governments and parastatal institutions are requested to develop policies and guidelines/strategies for NGOs to participate in research and development in view of the weaknesses listed below (local NGOs): structure, personnel, funding, planning, execution, evaluation, and linkages.
- Networking especially among local NGOs at national and regional levels be established.
- SACCAR should facilitate the collection, cataloguing, and disseminating of this information.

GROUP 6

LAND AND WATER MANAGEMENT

Problem statement

- Failure to fully recognize links between physical and socioeconomic environment.
- Lack of characterization of soil and water environment.
- Lack of integration of land and water management into commodity-focused research.

- More focus in short term objective at the expense of long term objectives (or long term productivity).

Constraints

- Lack of understanding of current land-use practices.
- Lack of understanding of the importance of process oriented research at all levels (national, regional, and commodity).
- Lack of manpower to address the issues.
- Lack of appropriate resources to conduct research (financial and physical).
- Compartmentarization of land and water management activities into institutions outside agriculture.

Research strategies

- Analysis and characterization of the agricultural environment in relation to existing land use practices on a uniform basis and relevant scale of detail.
- Emphasis on stability of production in relation to:-

  (i) Temporal variability and long term sustainability (stability & resilience).

  (ii) Household income.

Action plan

- Preparation of research agenda at national level in relation to strategies - NARCs.
- Regional based SADCC projects in collaboration with NARCs must:

  (i) Incorporate process based research into their activities.

  (ii) Establish greater linkage between themselves for the characterization of agricultural environments - SACCAR/NARCs.

- Identifying and developing of resources (manpower, physical, and financial) to accomplish the action plan - NARCs.

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