REVIEW OF BOTSWANA’S AGRICULTURAL RESEARCH SYSTEM
The International Service for National Agricultural Research (ISNAR) began operating at its headquarters in The Hague, the Netherlands, on September 1, 1980. It was established by the Consultative Group on International Agricultural Research (CGIAR), on the basis of recommendations from an international task force, for the purpose of assisting governments of developing countries to strengthen their agricultural research. It is a nonprofit autonomous agency, international in character, and nonpolitical in management, staffing, and operations.

Of the 13 centers in the CGIAR network, ISNAR is the only one that focuses primarily on national agricultural research issues. It provides advice to governments, upon request, on research policy, organization, and management issues, thus complementing the activities of other assistance agencies.

ISNAR has active advisory service, research, and training programs.

ISNAR is supported by a number of the members of CGIAR, an informal group of donors that includes countries, development banks, international organizations, and foundations.
REVIEW OF BOTSWANA'S
AGRICULTURAL
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November 1990
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CAB Descriptors:
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Finally, Mrs. L. Spenceley and Mrs. C. Solinger of ISNAR typed and produced the layout of the report, with graphics and illustrations by Mr. R. Claase.
### Setting a Sustainable Size and Scope for National Agricultural Research in Botswana

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EXECUTIVE SUMMARY

At the request of the Ministry of Agriculture, Government of Botswana, a review of Botswana's agricultural research system was carried out by a three-person ISNAR team in May/June 1990. The ISNAR team worked in close consultation with a national task force from the Department of Agricultural Research (DAR). The Terms of Reference for the review were drafted and agreed with the DAR and approved by the Ministry of Agriculture.

The review linked closely with the ongoing examination of Botswana's national agricultural policy and strategy for the development of the agricultural sector. The research system was covered comprehensively, with visits to nearly all existing and proposed research facilities, stations, ranches and experimental sites. In-depth discussions were held with policy makers, government development agencies, donors, non-governmental organizations, educational, scientific and technical institutions, and other stakeholders and potential partners in agricultural and development-oriented research. This broad overview was to enable DAR to define its strategic role in the organization, management and coordination of agricultural research and in the development of sustainable systems to serve Botswana's agricultural industry.

The diagnosis and analysis of the research system focused on strategic issues in structure and organization, research planning and programming, human resources development, research station and infrastructure development, and linkages for effective interactions with the development process. A fundamental theme was the development of strategies and approaches that would meet the concerns of the Government of Botswana for natural resources management and sustainability of the agricultural production environment.

Agricultural Development Policy and Agricultural Research

Botswana's agricultural development policy responds positively to a contradictory set of circumstances involving an inherently poor natural resource base (soils, water, vegetation, animal life), and high human population pressure in the rural areas, by focussing on environmental management and sustainability. Improvements in agricultural output, food security, rural employment, and the conservation of the natural resources would require production and management technologies that must be developed through strategic, applied and adaptive scientific research in the country. Development policy directives are leading to the development of strategies to promote diversified production, improved land productivity, and conscious and concerted conservation of the natural resource base. Research will need to provide more information on the optimum use of land, water, plant and animal resources in crop, livestock, and game production and conservation.
Historical and current analysis of agricultural research in Botswana indicates that DAR is the key agricultural research institution on which the success of the agricultural sector largely depends. As the principal and leading component of Botswana's national agricultural research system (NARS), it must set a realistic and sustainable size and scope for itself. The analysis indicates that emphasis should be on strategic and applied research in the areas of natural resource management, and on applied, adaptive, and technology testing research in the priority crop and livestock commodities, and production systems. These considerations led to the recommendations that there should be a modest restructuring of the Department and that research be pursued in a limited number of program areas.

Structure and Organization

A modest restructuring has been recommended featuring the creation of the post of Deputy Director to strengthen policy, scientific and technical leadership in the DAR, and the upgrading of the CARO and CAPRRO to Assistant Directors to provide divisional and program leadership in Crop Production Research and Animal Production and Range Research. Each division will be headed by an Assistant Director who will be responsible for the organization and direct supervision of programs of research in crops, natural resources management, animal production and range. The support services, including laboratory, biometrics, library, seed, physical plant, genetic resources, and research extension liaison services, with professional heads, will be under the Director.

Full-dress discussions of existing research activities with research managers and researchers led to the rationalization of research programs in crop and animal production and range research, and the production of a program structure with a reasonable "critical mass" of researchers as follows:

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Programs will be headed by a senior scientist who will provide program leadership in the initial planning, formulation and review of programs. The crop and livestock-based production system programs will work closely together and may be fully integrated under one program leader, with a focus on crop/livestock improvement and production in the context of optimum natural resource and environment management. In many program areas only adaptive and technology testing research would be appropriate, and the Senior Technical Group comprising the Director, Assistant Director, and Program Leaders, should set up systematic mechanisms for priority setting and program formulation that would ensure that DAR’s research is responsive to Botswana’s development policy and needs.
Programming Procedures

Programming procedures are indicated for the three levels of the research system. The Agricultural Policy Committee at the top will provide broad guidance on research priorities, resource allocation, and commodity and systems emphasis. It is recommended that special attention be given to this function by devoting attention to the formulation and periodic review of research policy. At the second level a National Research and Technical Committee, comprising DAR research managers, the Planning and Statistics division; the Crop, Forestry and Animal Health and Production divisions; and the Botswana Agricultural College, is recommended as the Senior Technical Group of researchers and users of research results. This group will consider and approve program priorities and program thrusts and provide guidance to the programs. The third level are the multidisciplinary Program Committees for Arable Crops, Animal Production and Production Systems Research. Extension services and development departments will interact with scientists at this level in formulating programs that would respond to the needs of clients and the environment. It is important that each level should provide clear guidelines and feedback to lower levels and that lower levels respond to these guidelines in articulating and executing program proposals.

Human Resources Development and Infrastructure

There are at present 39 research scientists and 12 expatriates in Botswana NARS. Qualification and experience profiles of the national researchers indicate that Botswana would need to invest substantially in human resources development in the next five to ten years. With the rationalized programs, it is envisaged that Botswana should attempt to attain an estimated sustainable number of 60-65 researchers and 200 technicians in the next ten years.

Human resources development should pay specific attention to career development and the retention of trained staff through rewarding career structures and the proposed improved scheme of service. The scheme of service provides for career development and progression without diversion into line management positions.

Funding of agricultural research is currently adequate, with a good balance between personnel (56%) and operating expenses (44%). However, in view of declining donor contribution to the development budget, DAR would need to assure a stable base of funding for its core programs from Government and external sources in the next five to ten years.

DAR will need to decentralize its research services to three regional stations:

- North Eastern - Francistown
- North Western - Maun
- Western - (Ghanzi, Tshane or Kang);

and to consolidate and develop the Central Agricultural Research Station at Sebele to supervise and operate Mahalapye and Pelotshetlha, and develop and consolidate 16 ranch research sites in the East (12) and West (4).
These developments will require development funds to make the stations fully operational and provide viable centers of research for a "critical mass" of scientists.

**Linkages**

The Department of Agricultural Research needs to develop and maintain effective linkages in the planning, organization and management of its research and the testing and dissemination of its research results. Among the linkages considered crucial and which need strengthening are those to policymakers, technology transfer systems (extension services and development agencies - both public and private), technology users (farmers and producers), and collaborative programs and agencies (national, regional and international). These linkages must reflect the appreciation of a research continuum that goes from conceptualization and development of priority programs, through the organization, execution and management of programs, to the testing and validation of results at the farm level, and the provision of feedback to research.

A specific recommendation is made in respect of the placing of the Research Extension Liaison Officer (RELO) in the DAR for effective linkage with and influence on research. He should be able to function effectively under support services that recognize complementarity between research and services in responding to the needs of the agricultural sector.

The Botswana Agricultural College (BAC) is identified as a special linkage institution for human resources development, teaching, research and service. The consolidation of this linkage should strengthen the input of higher education into research as a service to the agricultural industry. A memorandum of understanding is recommended as a formal basis for this linkage. Other important linkages are to the University of Botswana, donor and technical agencies, and non-governmental agencies.

**Conclusion**

The review concludes that the above elements should provide the DAR with the required inputs in developing and defining its vision in a strategic plan for the next decade. Such a strategic plan should focus on the more efficient use of resources and more relevant and effective outputs.

In view of the specific significance of natural resource management and sustainability in the harsh and largely marginal environment of Botswana, a special annex on "Sustainable Natural Resource Management in Botswana" is provided. The annex discusses the constraints in the present management of natural resources and identifies major problems, including:

- degradation due to overgrazing
- increasing numbers of domestic livestock
- degradation due to crop agriculture
- degradation due to the collection of forest and range products
- degradation due to wildlife numbers.
The attempts to improve the management of natural resources in relation to rangeland, cropland and water are reviewed, and suggestions are made for an expanded scope and emphasis on long-term effects of management systems; long-term agro-ecological zones studies; effects of interventions on soil/water/plant/animal relationships; and investigations on new production systems. Many of these investigations are location-specific and should be conducted in Botswana.

In the long run, it would require the holistic and multidisciplinary programs, in conventional crop and animal production, soil/water management, as well as new production systems involving crops, livestock, forests and wildlife, to create a sustainable agricultural production environment. This would require the collective will of the Government and people to work for and develop a sustainable agricultural production system in Botswana.
INTRODUCTION

Origin of the Mission

On the request of the Permanent Secretary, Ministry of Agriculture of the Government of the Republic of Botswana (GOB), an ISNAR exploratory mission was undertaken in July 1989 to determine the nature of the assistance required by Botswana in reviewing its national agricultural research system. Dr. T. Ajibola Taylor, while on this mission, held a series of consultations and discussions with policymakers in the Ministry, senior scientists and research managers in the Department of Agricultural Research (DAR), and members of the donor community supporting agricultural research in Botswana. The result of these consultations was the development of a comprehensive terms of reference which formed the basis of the GOB's formal request to ISNAR later in the year. ISNAR agreed to undertake the review and planning exercise in close collaboration with a team of Botswana research scientists and managers.

Terms of Reference

The following Terms of Reference were agreed as the basis of the review exercise:

1. review the National Agricultural Research System (NARS) in order to identify its strengths and constraints in addressing the agricultural research and development needs of Botswana;
2. recommend short- and medium-term measures for strengthening the national research system in the performance of its functions in national development;
3. study, in depth, policy, organization, and management issues in the Department of Agricultural Research (DAR) and in its relationships with policymakers, the agricultural education system and other clients of research;
4. assist in the preparation of a strategic plan for national agricultural research with a timeframe of 10 years, with particular reference to the development of an adequate scope and size of research; the integration of research projects into the national agricultural research plan; the requirements for the development of human resources and programs; and the generation of effective outputs and contributions to the national development process;
5. recommend the development of a national, sustainable agricultural research capacity and the linkages required to ensure productivity and impact of that capacity.

The major issues highlighted by the terms of reference pertain to the diagnosis of the strengths and weaknesses of the system; the recommendation of measures to strengthen the national research system; policy, organization, and management issues; determination of an appropriate scope and size for research; human resources and program development; strategic planning inputs; analysis of linkages; and the development of a sustainable national agricultural research capacity. The mutual understanding is that this review is not a strategic plan, but the basis on which the research system can develop the "vision" for the preparation of a strategic plan with or without external assistance.
The mission in the country was undertaken by a three-man team (two ISNAR senior staff and one consultant) from April 18 to May 8, 1990, and the report was completed in The Hague in July/August 1990.

The ISNAR Review Team comprised:

- Prof. T. Ajibola Taylor - Senior Research Officer, ISNAR (team leader)
- Dr. P. Eyzaguirre - Research Officer, ISNAR
- Dr. W.J. Payne - Consultant, ISNAR (Animal Production)

and the DAR Task Force comprised:

- Dr. L. Gakale - Director, DAR
- Dr. L.L. Setshwaelo - Chief Animal Production and Range Research Officer (CAPRRO)
- Mr. O.B. Mmolawa - Acting Chief Arable Research Officer (CARO)
- Mr. M.F. Molapong - Head, Laboratory Services
- Mr. B.W. Muke - Chief Technical Officer
- Mr. B.M. Samunzala - Head, Estate Management Unit
- Dr. D. Norman - Team Leader, ATIP Project

The ISNAR Review Team held intensive discussions with the local Task Force at the beginning, during, and towards the end of the review exercise. The team was accompanied by some members of the Task Force during the travel and visits to the ministries, other research and development organizations, research stations, ranches and substations, and research related activities throughout the country. Other discussions were held with senior researchers in DAR during the review and analysis of the research programs in which they were involved. Specific discussions were held with the development departments, projects and agencies of government as major stakeholders and clients, client groups in the agricultural industry and in the private sector, and with collaborating institutions in the areas of research, training and agricultural development. Worthy of special mention is the Botswana Agricultural College (BAC), the National Institute of Development Research (NIR) of the University of Botswana, the Department of Planning and Statistics of the Ministry of Agriculture, the Arable Lands Development Project (ALDEP), the Thusano Lefatsheng, and representatives of several donor agencies. A list of organizations and persons visited by the team and with whom discussions were held, is presented in Annex III.

This report summarizes the results of the mission and the discussions held on developing a needed, viable research capacity, and on focusing the strategy of agricultural research in Botswana on the development process. Special note was taken of the comprehensive national efforts made in developing objective policies for the agricultural sector, in critically assessing sectoral issues, and in indicating future strategy for development. The focus has therefore been to contribute to DAR's efforts in the strategic planning and implementation that would articulate and consolidate agricultural research as a basis for the development of the sector. The recommendations should strengthen the directions already initiated to orient the programs and plans of the department towards a national development focus, and strengthen the linkages of research with other organizations and clients in the agricultural sector. Adoption of the recommendations should lead to the development of an appropriate scope and size of research activities that could be realistically implemented and which would in the long run provide a sustainable basis for continuing contributions to the national agricultural development strategy.
CHAPTER 1: AGRICULTURE IN BOTSWANA

General Features

Botswana, approximately 58 million ha in total land area, and sharing borders with Namibia, Zambia, Zimbabwe, and the Republic of South Africa (RSA), is a landlocked country situated at an average height of about 1000 m above sea level. Although there are low ranges and isolated rocky hills, the generally featureless topography of seemingly endless savanna only changes radically in the northwest and north of the country. In these regions the Okavango River, flowing from the Angolan Plateau, forms a large inland delta, from which in times of high rainfall, flood water flows into a network of small lakes, waterways, and pans. In addition there is the Chobe River, which flows into the Zambesi, but was in historical times connected to the Okavango Delta system of waterways. Ecologically these regions are very distinct from the remainder of the country.

The climate of Botswana is continental and semi-arid. The major constraint on the biological natural resources base and determinant of the most suitable agricultural systems is rainfall. Mean annual rainfall varies from 250mm in the southeast to 650mm in the northeast. Rain occurs between October and April, but this "rainy season" has three distinct periods: an early period from October to December, a mid-season that includes January and February, and a late period from March to April. The mid-season rains frequently fail, and available rainfall data show that rainfall variability within season is greater than between seasons, with variability increasing at lower annual rainfall. In addition, rainfall is spatially erratic in distribution. In summer, when ambient temperatures may exceed 40°C, potential evapotranspiration could be as high as 2000 mm per annum. Such a climate favors domestic and wild animal production and discourages intensive crop production, except where some form of irrigation is possible.

The Natural Resource Base

The natural resource base for Botswana's agriculture comprises the available soils and water sources, indigenous vegetation and wildlife, and introduced plants and animals that thrive in the environment. These are in general rather limited and act as a restraint on the development of a productive agriculture; particularly crop agriculture.

Soils

Sandy soils, known as sandveld, cover at least 70% of the surface of Botswana, including the Okavango Delta region. They vary in depth from 3m to more than 100m, in texture, color, chemical composition, and geological origin and are sometimes underlain by varying thicknesses of calcrete. All are geologically old, highly leached, poorly structured, and inherently infertile.
In the east a comparatively narrow strip of more fertile soils known as hardveld, with a higher clay and silt content than the sandveld soils, extends from south to north. Hardveld soils are characterized as low fertility sandy loams and loamy sands that become stony and shallow around hilly areas.

There are also smaller areas of other soils, such as the vertisols of Mpandamatenga and elsewhere, the saline and alkaline soils of the Makgadikgadi and other pans, and some clayey soils on the western perimeter of the Okavango Delta.

The fertility of Botswana's generally poor soils is probably decreasing due to soil erosion caused by overgrazing and poor crop husbandry, lack of rotational husbandry systems, and very limited application of both organic or inorganic fertilizers.

Water

Water is the most critical natural resource in Botswana. It has been cited as a major constraint to the natural resource base.

The Okavango and Chobe rivers are by far the largest surface-water sources, comprising 95% of Botswana's total supply. Other rivers are not perennial, but there are a few large dams (Gabarone, Mopipi, and Shashe) and a larger number of small-scale seasonal dams on the rangelands.

About half of the 10,000 registered boreholes are operational, mainly providing water for domestic use and livestock. Data on the extent of groundwater and its recharge are very limited.

Major consumers are livestock (36% of total supply) and irrigation (35%) compared with urban and village consumers (17%). Intensification of the livestock industry is not likely to require a major expansion of water supplies, but any expansion in irrigation would increase demand dramatically.

Supplies of surface water and the recharge of groundwater sources ultimately depend upon the scant and erratic rainfall; hence the importance of long-term planning of water use in agriculture in order to assure future supplies.

Indigenous vegetation

The natural vegetation has been well described and documented by several authors (Arntzen & Veenendaal, 1986). The major part can be classified as grass, shrub (bush), or tree savannas, but among these there are many variations. Relatively small areas of grassland savanna occur at Laoe Ngami, around the Okavango Delta, and at the Mkgadikgadi Pans. Very large areas of bush savanna occupy the south and southeast of the country, part of the west and central Kalahari. Different types of tree savanna are found in the northern region of the Kalahari, in Ngamiland, the hardveld regions in the east, and the Mopane areas of the northeast hardveld. In the Chobe District there is a region of Miombo (dry deciduous forest), while the Okavango Delta exhibits a distinct ecology, savanna and forest alternating with aquatic grasslands.
Approximately half of the total area of natural vegetation is at present available for the grazing of domestic livestock, that are estimated to receive some 95% of their feed supply from this source. The major part of the remaining natural vegetation occurs in national parks, wildlife reserves and wildlife management areas, and is utilized primarily by game. There are, in addition, forest reserves in the north and rangelands in the drier areas that can only be seasonally grazed, because there is no perennial supply of water.

At present about one quarter of the rangelands are degraded to a greater or lesser extent (Edwards et al., 1989). Degraded ranges are mainly, but not entirely, in the communal grazing areas and in the Tribal Grazing Land Policy (TGLP) ranches. Freehold ranches and game areas are not, however, entirely free of degraded areas. The major cause of degradation is overgrazing. Experience elsewhere in Africa suggests that if overgrazing ceased, most degraded areas would recover very quickly, although limited areas may be lost due to excessive erosion.

**Indigenous wildlife**

Partly due to the fact that almost 40% of the total area of the country has been zoned as National Park, Game Reserve, or Wildlife Management Area (WMA), and partly due to the diversity of habitats, Botswana is particularly rich in wildlife, with 156 species of mammals, 500 species of birds, and 157 species of reptiles identified.

No data on total numbers of game are available, although there is evidence of substantial decreases in number during the 1980s, with dramatic declines in the Kgalagadi District. This may not be entirely due to drought but also to the gradual expansion of commercial farming in the southern and central regions, and of livestock husbandry in western and northern regions. The construction of veterinary fences that has hindered game migration and the cutting of tracks for mineral exploration, that have facilitated poaching, may also have contributed to the decline. There is, however, no conclusive evidence that wildlife numbers will not increase again, at least to levels that can be supported by that area of the country set aside for wildlife.

**Introduced plants**

Since crop agriculture occupies about 2% of the total land area and only half of this is planted in any one year, introduced crops have not made a major impact on the environment.

Apart from irrigated areas, into which a wide variety of field, vegetable and fruit crops could be introduced, introductions into dry land farming areas have been naturally selected for their ability to survive under water stress, rather than for rapid growth and high yields.

The introduction of tree species for forestry or agro-forestry purposes has not to date been an unqualified success. This is due in part to inadequate research on the suitability of exotic tree species to the environment.
**Introduced domestic livestock**

All domestic livestock have been introduced; sheep and goats probably at an earlier date than cattle. Nevertheless, the *Bos taurus* x *Bos indicus* types of cattle that were first introduced into southern Africa are well acclimatized and are now considered indigenous. Three breeds of this type of cattle were developed by the Department of Agricultural Research (DAR). There is not the same variety of sheep and goat types and breeds and it may yet be necessary to introduce others.

The cattle population increased dramatically from 0.5 million in 1921 to 1.0 million in 1950, 2.0 million in 1969 and 3.0 million in 1979. In 1988, the population was 2.4 million, a substantial decrease from the 1979 pre-drought peak. On the other hand, sheep and goat numbers have doubled since 1979. While total grazing pressure in 1988 was less than it was in 1979, it was undoubtedly still too high.

**The Agricultural Industry**

The contribution of the agricultural sector to the Gross Domestic Product (GDP) has fallen dramatically, from approximately 40% at independence to about 4% in 1987/88. At the same time, the sector's percentage contribution to formal employment has also declined. Nevertheless, 76% of the present 1.3 million population of Botswana live in rural areas and continue to depend to a greater or lesser degree upon agriculture for food, income, employment, and investment opportunities. In addition, through beef and other livestock-related exports the sector contributes to Botswana's balance of payments. The existing structure of the industry has been mainly determined by the climate, actions of the Government of Botswana (GOB) in support of specific sectors, and the pattern of land ownership. As stated previously, the climate favors animal rather than crop production, livestock accounting for 80% of total agricultural production and 40% of rural income.

The GOB supports in various ways both livestock and cropping sectors. Support to the livestock sector is mainly in the form of services that enable it to continue to export beef, particularly to the European Economic Community (EEC). On the other hand, support for the cropping sector, though aimed at improving self-sufficiency in the major staple crops, building a capacity to deal with future drought, and maintaining a minimum acceptable diet for rural families, has enabled the poorest section of the rural population to survive.

The pattern of land ownership is that 6% of the total land is held as freehold, 23% state-owned, and 71% communally (tribally) owned. Freehold land is located in specific, defined areas. State-owned land includes national parks, game reserves, the Molopo ranches, and a small area that has been redesignated as TGLP ranchland. Tribally owned land includes communal, village, crop and rangeland, TGLP ranches, and WMAs.
Communal land is allocated by land boards that have assumed a function previously exercised by chiefs. These boards also allocate land for TGLPs and mediate in disputes over grazing and water rights. Under customary law all families are entitled to land for their own use but do not acquire exclusive or perpetual rights, although, in practice, rights can remain with a family indefinitely. Grazing rights are not exclusive, but ownership of a borehole provides de facto rights to the water and surrounding grazings.

The Tribal Grazing and Land Policy was formulated in 1975, and major support for it, both in the establishment of ranches and technically, was accorded by the Second Livestock Development Project. The development of TGLP ranches was designed to improve grazing and livestock management within tribal land, prevent overstocking with consequent degeneration of the range, and improve the overall productivity of the cattle industry. Tribal grazing land was divided into three areas:

(a) **commercial** - in which individuals and/or groups were leased exclusive rights to a minimum of 6400ha of rangeland for a period of 50 years;
(b) **reserved** - land set aside for use at some future date, for the poorest members of the community and for alternative uses such as WMAs;
(c) **communal** - the remaining area that is grazed communally.

In both the crop production and animal husbandry sectors of the agricultural industry, farmers can be designated as commercial or traditional.

In 1983, of the 360 commercial farmers on freehold and leasehold land, 345 owned cattle and 100 grew crops. They represented 0.4% of all farmers in the country, but they produced 37% of all cereals and pulses and owned 15% of the national cattle herd. It is likely that since the drought of the 1980s, commercial farmers produce a somewhat larger proportion of cereals and pulses and own a higher proportion of national livestock resources (Tables 1 and 2).

Some 99% of all farmers in Botswana are included in the traditional sector, producing some 63% of all cereals and pulses and owning 85% of the national cattle herd. Within the traditional system there are two major groups: those with and those without cattle. Of all traditional farmers, about 6% own more than 100 head of cattle each, while 40% own no cattle, although they may own some smallstock and/or donkeys. Of the 40% with no cattle, a majority do not produce sufficient food grains for subsistence.

**Productivity in the livestock sector**

The cattle population in 1988, recovering from the drought was, as stated previously, about 2.4 million, while the goat and sheep populations were 1.1 million and 0.15 million, respectively. While the cattle population declined during the 1980s drought, from a maximum of about 3 million there was a dramatic increase in the smallstock population; particularly of goats.
Table 1.1: Crop Production in Botswana
1983 to 1988

<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td></td>
<td>Ha</td>
<td>Mt</td>
<td>Ha</td>
<td>Mt</td>
<td>Ha</td>
<td>Mt</td>
</tr>
<tr>
<td>Maize</td>
<td>19600</td>
<td>8495</td>
<td>3300</td>
<td>490</td>
<td>7900</td>
<td>1435</td>
</tr>
<tr>
<td>Millet</td>
<td>6300</td>
<td>435</td>
<td>8300</td>
<td>715</td>
<td>9700</td>
<td>1850</td>
</tr>
<tr>
<td>Onion Dry</td>
<td>60</td>
<td>1000</td>
<td>60</td>
<td>1000</td>
<td>60</td>
<td>1000</td>
</tr>
<tr>
<td>Seed Cotton</td>
<td>1100</td>
<td>3000</td>
<td>1100</td>
<td>3000</td>
<td>1100</td>
<td>3000</td>
</tr>
<tr>
<td>Sorghum</td>
<td>34800</td>
<td>5235</td>
<td>8300</td>
<td>715</td>
<td>9700</td>
<td>1850</td>
</tr>
<tr>
<td>Wheat</td>
<td>200</td>
<td>1000</td>
<td>200</td>
<td>1000</td>
<td>200</td>
<td>1000</td>
</tr>
</tbody>
</table>

Source: FAO data on tapes.

Table 1.2: Livestock Production in Botswana
1980 to 1988
(Time Series by Category of Livestock)

<table>
<thead>
<tr>
<th>Year</th>
<th>Cattle</th>
<th>Goats</th>
<th>Sheep</th>
<th>Swine</th>
<th>Chickens</th>
<th>Donkeys</th>
<th>Horses</th>
<th>Mules</th>
</tr>
</thead>
<tbody>
<tr>
<td>1980</td>
<td>2,911,000</td>
<td>637,000</td>
<td>148,500</td>
<td>5,000</td>
<td>833,000</td>
<td>126,800</td>
<td>21,700</td>
<td>3,000</td>
</tr>
<tr>
<td>1981</td>
<td>2,967,000</td>
<td>621,200</td>
<td>139,700</td>
<td>5,000</td>
<td>1,046,000</td>
<td>123,400</td>
<td>23,600</td>
<td>3,200</td>
</tr>
<tr>
<td>1982</td>
<td>2,979,000</td>
<td>635,500</td>
<td>160,000</td>
<td>5,000</td>
<td>1,146,000</td>
<td>135,100</td>
<td>24,000</td>
<td>3,400</td>
</tr>
<tr>
<td>1983</td>
<td>2,818,000</td>
<td>782,800</td>
<td>164,700</td>
<td>5,000</td>
<td>961,000</td>
<td>142,300</td>
<td>22,400</td>
<td>3,600</td>
</tr>
<tr>
<td>1984</td>
<td>2,685,300</td>
<td>889,300</td>
<td>167,200</td>
<td>7,750</td>
<td>714,000</td>
<td>137,900</td>
<td>22,700</td>
<td>3,800</td>
</tr>
<tr>
<td>1985</td>
<td>2,459,400</td>
<td>1,138,000</td>
<td>199,700</td>
<td>9,000</td>
<td>1,028,000</td>
<td>142,600</td>
<td>23,600</td>
<td>4,000</td>
</tr>
<tr>
<td>1986</td>
<td>2,400,000</td>
<td>1,000,000</td>
<td>210,000</td>
<td>9,000</td>
<td>1,030,000</td>
<td>143,000</td>
<td>24,000</td>
<td>4,200</td>
</tr>
<tr>
<td>1987</td>
<td>2,300,000</td>
<td>1,050,000</td>
<td>215,000</td>
<td>9,000</td>
<td>1,050,000</td>
<td>144,000</td>
<td>25,000</td>
<td>4,300</td>
</tr>
<tr>
<td>1988</td>
<td>2,350,000</td>
<td>1,100,000</td>
<td>220,000</td>
<td>9,000</td>
<td>1,070,000</td>
<td>145,000</td>
<td>25,000</td>
<td>4,400</td>
</tr>
</tbody>
</table>

Source: Original FAO estimates from tapes
Units: (head) for cattle, goats, sheep, swine.
Productivity indicators for cattle in the commercial and traditional sectors are shown below.

Table 1.3: Productivity Indicators

<table>
<thead>
<tr>
<th></th>
<th>Commercial sector</th>
<th>Traditional sector</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calving percent</td>
<td>70</td>
<td>50</td>
</tr>
<tr>
<td>Mortality percent</td>
<td>5</td>
<td>11</td>
</tr>
<tr>
<td>Percent offtake of total herd per annum</td>
<td>17</td>
<td>8</td>
</tr>
</tbody>
</table>

These data indicate that the commercial cattle sector is significantly more successful technically than the traditional sector and more productive on a per-animal basis. Data from smallstock suggest a similar situation. It is possible, however, that the traditional sector is more productive on a per-hectare basis. Unfortunately, data are not available to properly assess the facts, although elsewhere in semi-arid environments there is data showing that communal areas are more productive than ranch areas on a per-hectare basis. Whatever the production situation, there is agreement that degradation of pastures is more extensive in the traditional than in the commercial grazing areas. Problems of range degradation are discussed in some detail in Annex I.

During the last two decades there have been significant developments in the poultry industry, Botswana now being nearly self-sufficient in poultry meat and eggs. At present the country is about 25% self-sufficient in milk and milk products, but the availability of suitable feeds is a major constraint on further development.

Production in the cropping sector

The average area planted to crops between 1967 and 1988 was 243,000 ha, or less than 1% of the total area of land. Over 70% of this area was cropped with sorghum. Average production was $< 400 \text{ kg per ha}$ and overall productivity has been more or less stagnant for the last 20 years. Commercial farmers produced approximately twice as much per hectare as traditional farmers.

In some years, domestic sorghum production has been sufficient to meet the nation's requirements. This has not been so for maize and pulses, or for horticultural crops, of which about 20% of total needs are met from local production.

Major constraints in Botswana agriculture

The overall structure of the industry indicates and emphasizes the constraints under which it operates. Some of these are:

(a) low, seasonally variable and erratic rainfall, and a general shortage of surface and groundwater that favors extensive animal husbandry rather than crop production;
(b) a fragmented farming structure in which a small proportion of the farming community produces a high proportion of the total output;

(c) a situation in which, although the environment favors animal production, 40% of all farmers own no cattle and practice crop production in communal areas with poor access to draft-power;

(d) probable declining fertility in both cropping areas and rangelands; certainly extensive degradation of rangelands;

(e) a lack of a highly developed marketing system;

(f) the absence to date of a long-term agricultural research program, with limits defined to a considerable extent by the constraints imposed by the natural resource base.
CHAPTER 2: AGRICULTURAL DEVELOPMENT POLICY IN BOTSWANA

Major Considerations in Agricultural Development Policy

Botswana's agricultural development policy has to respond to a contradictory set of circumstances. First, there are inherent limitations on agricultural production resulting from the semi-arid environment and intrinsically infertile soils that characterize much of the country; and the contribution of agriculture to the gross domestic product is relatively small (approximately 4%). Second, the national policy must take into account the fact that the majority of the population, 76%, live in rural areas and are to a considerable extent dependent upon agriculture for their well-being. Botswana's geographical location and the need to reduce the economic dependence upon the Republic of South Africa were also important considerations in formulating the National Food Strategy aimed at self-sufficiency in basic grains.

In response to these conditions, the Government of Botswana has set long-term policy objectives to develop the agricultural sector.

Botswana's agricultural policy objectives are:

i) to provide adequate and secure livelihoods for those involved in agriculture;
ii) to increase agricultural output;
iii) to increase food self-sufficiency;
iv) to conserve agricultural land resources and the environment;
v) to meet the employment demands of a growing labor force.

In order to implement this policy, the Government of Botswana has made significant investments in agriculture and rural development to promote the well-being of the majority of its people. The economic return of these investments in agriculture, however, has been quite low. For some staple crops such as maize, the cost of production with government subsidies (under ARAP) is twice the import cost. For the arable crop sector, the strategic goal of food self-sufficiency has been impossible to achieve despite considerable Government investment in price subsidies and technical support (with the exception of the agricultural year 1987/88 when 90,000 tons of sorghum was produced).

The livestock sector also receives considerable government subsidies through investments in boreholes, vaccines, veterinary services, trek routes, fencing, artificial insemination, bull subsidies, etc. The livestock producer prices are also set at a high level due to preferential status given to Botswana beef exports under E.E.C. beef import quotas. The comprehensive assessment prepared for the Ministry of Agriculture in 1989 considered the effect of these subsidies on livestock production and the use of Botswana's scarce water and vegetation. (Agricultural Sector Assessment, MOA, 1988) The recent experience has changed the perception that Botswana's agricultural sector should be developed through extensive use of land by both arable and livestock subsectors. There are clear indications that such a strategy may, in the long run, prove resource inefficient and may cause serious environmental problems.
The research and development emphasis within Botswana’s agricultural sector has been on the major staples and livestock; both areas that for quite different reasons have reached a plateau in the potential to increase production. Furthermore, there is a need to redirect both crop and livestock production systems away from strategies that augment production by extensive use of land and increasing consumption of underground water. These important considerations, i.e., making agriculture more productive and economically efficient, increasing the incomes of rural households, and conserving the agricultural resource base, have led to a new direction in the national agricultural development strategy.

New Directions in Botswana’s Agricultural Development Policy and Strategy

The strategy to achieve a balanced and sustainable development of agriculture in Botswana is currently under review and some clear directions are emerging. Because of the high cost of production for many food crops and the limitations of the semi-arid to arid environment, the national policy objectives have shifted away from food self-sufficiency towards food security. This places greater emphasis on a variety of means to increase the incomes of rural producers in order to assure levels of income that will enable families to purchase or produce adequate supplies of food. Furthermore, the incentives to support agricultural production should encourage cost-effective production rather than simply substitute cheap imported food for expensive locally produced food.

Another strategic option for Botswana’s agricultural sector lies in diversifying the production base to broaden the sources of rural incomes and employment. Diversification of agricultural production away from the predominantly cattle and small grains-based production systems could improve food security at both the national and household levels. Finally, the sustainability of the natural resource base has assumed greater importance in the research and development agenda. The Ministry of Agriculture and the rest of the Government now accord top priority to sustainability, resource efficiency, and environmentally compatible production systems and development programs.

As a result of the review of past policies, a new development strategy is emerging which sets forth the following general objectives:

- promotion of a more diversified production base;
- increase the productivity per unit of land;
- devote greater attention to the conservation of the natural resource base.

Current patterns of agricultural production and development are extensive in their use of resources. Only technological change and better information on resource use in agriculture will enable Botswana’s agricultural sector to increase productivity, contribute to national food security, and conserve the natural resource base. Implementing this strategy entails an intensification of technology development and use in Botswana’s agriculture. The emerging national development strategy entrusts the Department of Agricultural Research with the leading role in identifying and providing the new technologies that will allow the agricultural sector to attain the objectives set forth by Government.
Technology development and the national agricultural research system

The strategy for technology development places a clear emphasis on the competition for scarce resources (land, water, vegetation) in Botswana. Government has set some specific goals for technology development in agriculture that promote a more rational use of resources. These include:

i) development of higher-yielding varieties, resistant to pests and diseases and tolerant of drought;
ii) development of both short- and long-season varieties;
iii) improvement of breeding stock for the cattle industry;
iv) improvement of techniques to:
   a) reduce the extensive use of grazing land;
   b) shift from increasing the numbers of livestock towards improving the quality of livestock and livestock output;
   v) introduction of new resource management systems for more efficient use of scarce water, land, and plant resources in the country.

Increasing productivity and resource conservation in agriculture: the role of research

The DAR has been actively working in areas of developing and testing new varieties of crops and in selecting and upgrading the livestock breeds in the country. While this effort remains crucial, the scope of research may need to be broadened in order to meet government objectives for more rational use of land, water, and plant resources. Research will need to provide more information on the optimum use of these resources, given the various competing demands: crop production, livestock production, game production, and conservation. In addition, there is the increasing demand for direct use of these resources by humans, such as in land for housing, water for drinking and industry, and plants for fuelwood, industry, crafts, and building materials. Providing scientific and technical information on the potential uses and maximization of output of these resources lies properly within the scope of a national agricultural research service. This information can then be transformed into technology packages that producers and development agencies can employ to increase the overall productivity of the agricultural sector.

Diversification of agricultural production and the implications for agricultural research

Diversification of agricultural production can be accomplished in two ways: first, by introducing new production systems and technologies for the crops and livestock subsectors, and second, by bringing into production new potential areas where a wider range of crops can be grown.

Both approaches will require strong inputs from research to identify and test new crops and varieties that can be integrated into existing production systems or serve as the basis of new crop production systems. Any new areas being brought into production will also require that research be able to assess the potential productivity of the land, and to identify the production systems that would be economically viable and environmentally sustainable.
The potential areas being developed are Mpandamatenga, Maun (Ngamiland), and the Gumare-Nokaneng-Habu axis. The DAR has modest facilities in the Maun area and at Mpandamatenga but no facilities in the western region. If these areas are to be developed, the research capacity in these regions, particularly in Maun and the Western region, will need to be upgraded. The same applies to the agriculturally important northeastern region, where the DAR has only a modest research capacity in place. The diversification of agricultural production into new areas will therefore require an expansion in the regional coverage of the DAR. The organizational implications and physical resources required are detailed in Chapters 4 and 6.

**Setting a Sustainable Size and Scope for National Agricultural Research in Botswana**

The role assigned to research in Botswana's Agricultural Development Strategy is both crucial and large. Given the vast expanse of the national territory, the fragile environments, and the severe resource limitations placed on agriculture, the Department of Agricultural Research has many demands placed upon it. It will be expected to address a large number of highly varied and complex problems. The size of the research system will, however, be limited by the inherent size of the agricultural sector and the number of trained personnel that can realistically be deployed to address these problems.

In the medium to long term, the agricultural research system is expected to grow to between 60 and 65 national scientists, with corresponding technical and support staff. The size of the research system would thus remain relatively small, and the scale of national research effort which is sustainable over the long term will therefore be limited.

Given this scale, Botswana has the potential to have a highly effective national research service. The scope of research - the number and type of research programs - will need to be consistent with this capacity in order to be sustainable over the long term. The DAR will therefore need to evaluate its scope of work and focus on those priority programs that respond to the major problems facing the agricultural sector. Not all production problems can be solved by research; the DAR will have to select areas where research can provide solutions, technology, and information that will have the greatest impact.

The current program organization of the DAR tends to be along disciplinary lines, particularly in the Arable Crops Division. Experience has shown that with less than fifty researchers covering the range of topics present in the crop and livestock sectors, it is probably not advisable to organize research on a disciplinary basis. This is particularly true when addressing production constraints of farmers and livestock producers. At present, some disciplinary units in the Department have only one national scientist. It is therefore not worthwhile to execute research along disciplinary lines - and it may be extremely difficult for a scientist in one disciplinary unit to provide the required input to the research activities based in the other disciplinary units.
The preferred emphasis should therefore be on ensuring that the appropriate disciplinary inputs are available for work in integrated programs that address the major production constraints to production, and generate outputs that are relevant to the needs of the agricultural producers.

The DAR will also need to design its research programs to match the needs of farmers and the agricultural industry. Setting research objectives and generating outputs that are relevant to producers' needs are more easily done when the research effort is organized around commodity factor or production systems programs. The thrust of each program will to a large extent be determined by the nature of the production problems. The mix of disciplines that go into solving each problem will therefore be different between the various programs. This reorientation of the programs is explained in Chapter 5.

Another issue to be resolved in setting a sustainable scope for the DAR is the absorption by the DAR of many of the research activities that take place in special donor-funded projects with expatriate staff. As these fixed-term projects come to an end, the DAR, in consultation with Government, will need to determine which of these activities need to be continued as integral parts of national programs. Due consideration can then be given to the relative priority of the projects and programs as well as Government's ability to provide the additional financial and human resources or to mobilize external resources to cover the expanded scope of activity. At the current level of funding and staffing, it is unlikely that the DAR could expand its scope to include the activities of all donor-funded projects and remain effective in both its core programs and the project activities. Where possible, donor-supported projects should be integrated into the core programs of the DAR. This will facilitate the planning of a sustainable national scope for agricultural research.

Finally, a key, if often undervalued, function of agricultural research is to advise government on the possible alternative uses of natural resources in agriculture and the potential benefits of these alternatives. In a country which even in the medium to long term is likely to have a small research service of about sixty scientists, and where the agricultural resource base is fragile and limited, this role assumes an even greater importance.

Government clearly recognizes that the new development strategy requires a strengthened Department of Agricultural Research. As a component of the new development strategy the DAR will develop an Agricultural Research Policy and Strategy that responds to this mandate. This is best accomplished with a strategic plan that presents a clear set of objectives, along with the plan of activities and resources that will be required in order to attain them. Government can then mobilize the national and donor resources to establish a capacity that will enable the DAR to cover the major priority areas in terms of commodity and factor programs, production systems, and development regions. In order for research to be effective, this size and capacity of the research system will need to be sustained over time. To identify the medium to long term objectives of the research system and the resources and intensity of effort needed to attain them will be the key elements of the strategic plan for national agricultural research.
CHAPTER 3: DEVELOPMENT OF AGRICULTURAL RESEARCH

Historical Development of Agricultural Research in Botswana

Prior to independence, agricultural extension and any investigational work was centered at Mahalapye, where a crop experiment station was established in the 1930s. Livestock investigations, which also began in the 1903s, were conducted at Morale, a ranch in the vicinity of Mahalapye. In 1947, the first systematic research on arable crops commenced at Mahalapye and at four sub-stations, with the organization of cereal varietal selection trials. The seeds of a few superior selections were multiplied.

When the post-independence era began in 1967 most agricultural research and training activities of the MOA were centered at Sebele. Since then Sebele has become the administrative centre for all research activities, and the major center for agronomic research with sub-stations at Good Hope, Mahalapye, Motopi, and Mos'otleng (Maun). Investigations conducted at Sebele and sub-stations have included trials on dry-land crop varieties, fertilizers, soil fertility, crop rotation, tillage systems, horticultural crops, and plant pathological and entomological problems.

The 1970s through the 1980s was a period in which agricultural research, and particularly crops research, expanded considerably, primarily as the result of donor projects. The FAO funded a fertilizer project in which a number of fertilizer trials were conducted on farmers' fields between 1969 and 1975. The Dry Land Farming Research Scheme (DLFRS) began in 1969, with the objective of investigating the possibility of improving water availability to crops by suitable soil and plant management and was one of the major arable research activities until 1983. Cereal varietal trials continued at Sebele and at Good Hope, Mahalapye, and Maun substations, with emphasis on the selection of dry-land varieties of sorghum and millet (cooperative program with ICRISAT), wheat as a winter crop, and maize varieties for supplementary irrigation systems.

The Evaluation of Farming Systems and Agricultural Implements Project (EFSAIP) also commenced during this period, with the aim of evaluating farm implements and management methods in four different agricultural systems, ending in 1984. As agricultural research and its services expanded, an effort was made within the DAR to organize new divisions, estimate future manpower requirements, and develop a methodology by which research priorities could be established (Oland, 1979). These efforts were only partially successful.

A detailed livestock program commenced in 1970 with the establishment of an Animal Production Research Unit (APRU). Through the 1970s the APRU research program and facilities expanded to ultimately include 17 ranch research sites and 6000 head of beef cattle, as well as sheep, goats, and dairy cattle. At first, baseline data such as reproductive performance, growth rate, mortality, and productivity in beef cattle herds were collected and analyzed using a computerized system, the general emphasis being on the development of a technical base for the commercialization of the beef industry.
In 1973, range monitoring commenced, and by 1976 monitoring sites had been developed in all major ecological zones, but the work was abandoned in the early 1980s. A pasture improvement program began in 1977 with the introduction of grasses and legumes at Sebele. Experimental crossbreeding for beef production started in the 1970s, as did beef cattle production system modelling in cooperation with staff from Texas A&M University in the USA and the International Livestock Center for Africa (ILCA). Sheep (Tswana and Dorper) and goat (Tswana and Boer) breed comparisons and experimental crossbreeding commenced in the 1970s; while in 1979 research began on dairy production systems. Two systems were compared during the 1980s: zero-grazed purebred Friesians at Sebele and partially milked Tswana and Tswana x Simmental cows at a ranch research site. During the 1970s and in the early 1980s the APRU was supported by UNDP/FAO, World Bank and other agencies. Slowly APRU's overall emphasis on investigating the problems of the commercial beef industry began to change and by 1980 more attention was being devoted to livestock management problems in the communal grazing areas and to other types of domestic livestock. This trend has continued.

The Department of Agricultural Research

Since the merger of crops and livestock research, the Department of Agricultural Research has become the principal and leading component of Botswana's National Agricultural Research System (NARS). It has the national mandate to conduct research on all crops and livestock of importance to the agricultural sector. Its mandate also includes research and monitoring of the natural resources for agriculture; soils, water, and vegetation. The DAR maintains and staffs soils and biological laboratories that are used to support crops and livestock research as well as provide direct laboratory services to farmers and development projects.

A significant shift in the emphasis of GOB agricultural policies from the livestock to the crop sector also occurred towards the end of the 1970s. At about the same time the MOA adopted a farming systems approach to crop research, with particular reference to the problems of the small resource-poor farmer. As a consequence of this shift in attitude, two farming system projects were organized within an extension department of the MOA and one within the DAR.

The Integrated Farming Pilot Project (IFPP), a combined agricultural research and integrated rural development programs, was established in the southeast of Botswana in one of the areas where the pilot phase of ALDEP was implemented. The Molapo Development Project was organized in the Okavango Delta in 1982, and formulated its program using data obtained from surveys of the agricultural potential of the Okavango Delta made by FAO in 1972.

The Agricultural Technology Improvement Project (ATIP) also commenced operations in 1982 within the DAR. This project aimed to provide farming systems research (FSR) recommendations relevant to the needs of resource-poor farmers. Multidisciplinary teams were established at Francistown and Mahalapye, and these are still in place. Although the major FSR effort has been crop related, limited studies have been made of systems that included livestock.
A new player entered the stage during the 1980s. The Southern Africa Centre for Co-operation in Agricultural Research (SACCAR) was established at Sebele. This organization is responsible for strengthening regional cooperation in agricultural research and documentation. Three projects of major importance to Botswana have been organized to date: the Regional Sorghum and Millet Program centered in Zimbabwe; a Grain Legume Improvement Program centered in Malawi (ground nuts), Mozambique (cowpeas) and Tanzania (field beans); and a Land and Water Management Research Program centered in Botswana.

**Analysis of the Present Situation**

The administrative matrix, human resources, research programs, infrastructure, and financial resources of the present DAR are not the result of clearly defined and planned decisions, but of a fortuitous mixture of past decisions by MOA administrators, DAR staff and international donors. As a result, DAR constitutes a solid base for Botswana's National Agricultural Research system; and it has accomplished useful research work during the last two decades.

An analysis of the historical development undoubtedly suggests that agricultural research in Botswana has to a considerable extent been "project activated" as well as "project driven". One of the major influences that the MOA has had in the past on DAR research policy has undoubtedly been through the selection of donor projects whose objectives more or less parallel its own development objectives.

Difficulties encountered in a partially "project driven" research organization are that:

(a) projects with the same basic objectives may not always be conducted in the same department of the MOA, possibly on account of donor preference;
(b) selected projects may satisfy the broader development objectives of the MOA but not the more specifically defined objectives of a national research program;
(c) unless donors provide sufficient funds for adequate training, withdrawal of donor support at the end of a project may leave a void that cannot easily be filled by the research service;
(d) donor allocation of resources to various programs may not be in accordance with or may distort national priorities;
(e) donors may not be willing to fund certain areas of the research program, creating a potential for unbalanced programs;
(f) donors may provide infrastructure that cannot be maintained once the project has been completed.

Most of these difficulties could be solved once the DAR formulates a series of integrated research programs, into which potential donors could be invited to "slot" proposed projects.
The "project driven" nature of the present research system is not, however, the only major problem. The system lacks procedures by which policy priorities of the GOB can be translated, if necessary, into research priorities that can be incorporated into or developed as the basis of the national research programs. At the same time no satisfactory system of peer review of research proposals and the research results of individual researchers has evolved. These issues are discussed in later chapters.

**The DAR and the National Agricultural Research System (NARS)**

In Botswana there are several institutions, agencies, and projects that contribute to or engage in agricultural research. With coordination and a set of common goals, the various contributing organizations comprise a National Agricultural Research System (NARS) in which the DAR plays the central role. The review considered the range of relevant research activities outside the DAR, in the national scientific and educational community, in development agencies and projects, and in the governmental organizations and the private sector. With effective linkages, these other institutions and agencies can enhance the scale of the national research effort.

While it is clear that the DAR will remain the agency principally responsible for agricultural research as required in Botswana, it should not be expected to work in all areas that may be required or are of potential benefit to Botswana's agriculture. The DAR should, however, play a key role in coordinating the efforts of other institutions within Botswana that conduct agricultural research or contribute to the research activities under way. The establishment of systematic links with other contributors or components of the NARS will enable the DAR to cover the essential programs without dispersing its resources by attempting to expand the scope of its efforts beyond its level of resources.

**University-based research activities**

The College of Agriculture (BAC) of the University of Botswana is based at Sebele adjacent to the headquarters of the DAR. It has recently been upgraded to a degree-granting institution and is a constituent college of the University; the first intake of B.Sc. students was in 1988. The BAC will be a major contributor of trained manpower for research; this will help to alleviate one of the major constraints to agricultural research in Botswana.

The BAC and DAR share many facilities, and under the current shortage of teaching staff, some DAR researchers also teach at the college. As the BAC develops its staff, it will require the faculty to conduct some development-oriented research. The College will also have research funds available.

There are several areas of potential complementarity between the BAC and the DAR. For example, some of the more basic research on plant and animal physiology, soil chemistry and physics, water balance and ecology can best be undertaken in a university setting at either the BAC or the Science Faculty of the University of Botswana. These can contribute to the production- and development-oriented research of the DAR.
The present climate of cooperation that exists between the DAR and the BAC can be reinforced and formalized in a memorandum of agreement or understanding as the scope of the BAC grows and the DAR increases the intensity of its activities.

The National Institute of Development Research and Documentation (NIR) of the University of Botswana is also a contributor to agricultural research and should be taken into account in the planning of the national research capacity. The NIR has conducted several ecological and socioeconomic studies of agriculture and the natural resource base that are solid foundation for DAR research projects related to specific production problems (Arntzen and Veenendaal, 1986). The NIR has also recently conducted some studies on forestry and natural resources in Botswana.

Given the fact that the DAR has a limited capacity to carry out socioeconomic studies, the NIR can make an important contribution to the national research capacity. The linkages between DAR and NIR would need to be strengthened and in some cases formalized at the level of specific programs. This will ensure that there is complementarity and efficiency in the use of scarce resources. Socioeconomic research, and environmental and ecological studies are key areas where the NIR and the Department of Environmental Sciences, University of Botswana, can contribute to the NARS.

Development agencies and projects

Development agencies and projects are important contributors to Botswana's Agricultural Research System. Two development agencies are direct participants in research, the Botswana Development Corporation (BDC) and the Rural Industries Innovation Center (RIIC).

The Botswana Development Corporation has as its mandate in agriculture the promotion of large-scale commercial production with technical inputs. The BDC has been most active in introducing irrigation and mechanized production in the Chobe District, Tuli Block, and Pandamatenga. It also promotes the introduction and improvement of high-value commercial crops such as fruits and vegetables. Among the commodities included in BDC projects are: bananas and horticulture (vegetables) at Chobe; commercial maize, cotton, and potato production in the Tuli Block; citrus production under irrigation and beef cattle in the Tuli Block; and dairy farming and vegetables in the agricultural perimeter of Gaborone. The BDC has provided direct financial support to the DAR's research program on mechanized commercial production of maize and sorghum at Mpandamatenga.

There are opportunities to strengthen the linkage and complementarity between the work of the DAR and BDC. This is most evident in the area of testing of agricultural inputs, mechanization, and irrigation, and commercially available crop varieties that may be appropriate to conditions in Botswana.
There are many new varieties and new crops that may be environmentally suitable and economically viable in Botswana. With its limited core of resources and small staff, the DAR cannot reasonably be expected to test and monitor all the potentially valuable cultivars, inputs, or livestock production techniques. To attempt to do so in response to this demand would weaken the DAR's ability to work on the priority programs that are of strategic importance to the development of Botswana's agricultural sector. The BDC can provide the facilities for testing new available technologies and crop varieties, with guidance from the DAR. The BDC has well-placed holdings throughout the country, and some research trials by the DAR could be conducted on BDC farms. It would be able to contribute information on the response to inputs, of adaptability of new varieties or crops, and data on economic viability. Also, the monitoring of pests and diseases under conditions of intensive commercial cropping can be done jointly with the BDC on their farms. The BDC can also contribute to the determination of priorities and identification of new research opportunities.

In the area of high-value crops and agricultural inputs, the private sector will play an important role in the provision and dissemination of new technology. An example of this direct collaboration is in the area of wheat research, where the Bolux Milling Company has provided financial support to DAR trials of wheat under irrigation in Ngamiland. As a parastatal, the BDC can provide an effective linkage between private sector research and development and the DAR. This would enhance the overall research capacity of Botswana's agricultural research system without dispersing the core resources or distorting the priorities and scope of the DAR's research programs.

The Rural Industries Innovation Centre (RIIC) has had a long-standing and fruitful relationship with the DAR. The RIIC has designed and tested agricultural implements and post-harvest machinery that are relevant to the commodities on which DAR research focuses. The research programs on tillage, for example, provide valuable information to RIIC for the design of new implements. These are then tested and evaluated with the help of the DAR and particularly its farming systems and tillage trials programs. There is currently very little research under way on post-harvest technologies. It would be difficult for the DAR to enlarge its own scope to include this very important area of research. Strengthening the linkage with RIIC would enable Botswana to increase the level of research in post-harvest technologies such as dehulling, milling, and storage that are of particular concern to low-resource farmers. In some areas of farm production, the key constraints may not be solved by varietal improvement, or improved agronomic techniques, but rather by the reducing of the labor inputs and improving post-harvest technology. In such cases RIIC can provide crucial advice on the content and scope of DAR programs.

Other non-governmental organizations such as Thusano Lefatsheng, a non-profit foundation, can contribute to research in the areas of non-traditional crops and commercial production of indigenous plants. The DAR has in the past assisted the work of Thusano Lefatsheng in commercial development of indigenous plants (veld products), by providing laboratory support services. In the area of ecology and resource conservation such NGOs can also contribute by supporting work that is of long-term value to the environment and of particular value to particular groups in less-favored regions of the country.
In determining its own priorities the DAR has to allocate its resources in areas where it is likely to have the biggest impact on national agricultural development as a whole and in accordance with national development policies. The work of non-profit NGOs can provide some research and development coverage of areas and topics beyond the scope of a relatively small service such as the DAR.

NGOs could benefit from technical guidance and support from the DAR on conducting of trials and selection of improved varieties. This type of collaboration, while desirable, may require additional resources.

Several donor-supported agricultural technology development projects are housed in the Ministry of Agriculture that are both clients of and contributors to research. The Botswana Agricultural Technology Improvement Project (ATIP), the Agricultural Development - Ngamiland Project (ADNP), the Dairy Development Research Project (DDRP), and the Pandamatenga Farm are the principal donor-supported projects based in the Department of Agricultural Research.

ATIP has been in operation since 1982, with funding from USAID. Its objectives are to develop and extend farming systems relevant to the needs of small farmers. ATIP objectives also include the institutionalization of farming systems research programs within the DAR. The project has provided training equipment and expertise in these areas, as well as funding for development of some basic infrastructure. ATIP has concentrated its efforts in the zones near Francistown and Mahalopye. ATIP project professionals have been the mainstay of research activities in farming systems.

There are also three other donor-supported projects in the area of farming systems research. The Farming Systems Southern Region (FSSR), supported by ODA, is being phased out. The Molapo Development Project, supported by GTZ, and the Agricultural Development Ngamiland Project (ADNP), financed by CIDA/SAREC, are complementary farming systems research in Ngamiland - Okavango watershed. These projects are currently being phased out or will conclude in the near future. Fortunately, key elements of the farming systems approach have been institutionalized in DAR.

The array of farming systems projects has contributed many resources to research as a whole. Project professional staff have been the mainstay in implementing research activities in the sites and substations outside of Sebele. The level of resources available to the projects is not likely to be sustained when or if these activities are transferred directly to the Department. What is to be avoided is the past practice of increasing the structure and scope of research by mere accretion of project activities, as donor-supported projects are phased out. In the current situation DAR can consolidate the farming systems research activities in a single coherent national program that is less likely to disperse the resources of the department. This is explained in more detail in chapters 5 and 6.
Other donor projects have been of shorter duration, but serve to illustrate the effective marshalling of donor resources by DAR. USAID provides training and financial and technical support through its collaborative Research Support Program (CRSP), particularly in beans, cowpea, sorghum, and maize. The UNDP has supported the development of germplasm storage facilities and the purchase of vehicles. The EEC has supported seed breeding and biological control of weeds programs and is financing the development of a research facility at Pandamatenga. IDRC of Canada has supported dairy development research. These various projects have been successfully integrated into DAR core activities.

Clients of research

The mission of DAR is to develop and test appropriate technologies to increase food and livestock production. Emphasis has been placed on technology development that benefits small farmers. These are the ultimate clients of research. A major set of intermediary clients are the development units and projects within the Ministry of Agriculture. Principal among these are the Department of Crop Production & Forestry (formerly the Department of Field Services) and the Department of Animal Health and Production which are entrusted with the transfer of technology and providing support to production. As major clients of research they also have a role to play in contributing to determining priorities and opportunities for research. Finally, Government policymakers are also clients of research; and the DAR should continue to advise Government on issues of sustainable agricultural development, and on science and technology policy.
CHAPTER 4: STRUCTURE AND ORGANIZATION OF THE DEPARTMENT OF AGRICULTURAL RESEARCH (DAR)

The Department of Agricultural Research (DAR) is the "core" agricultural research organization of the Botswana national agricultural research system. Although it is one of the seven departments/divisions in the Ministry of Agriculture (the others are Planning & Statistics; Crop Production & Forestry; Animal Health & Production; Veterinary Services; Cooperative Development; and the Botswana Agricultural College, it is the only one specifically charged with the responsibility for planning, execution, and coordination of agricultural research in the country. The other departments are mainly development and services oriented, and BAC's major thrust is in the planning and development of human resources at the certificate, diploma, and degree levels (Fig. 1).

The DAR is recognized within the Ministry of Agriculture, by Government and by other parastatal agencies, as the national agricultural research organization. As a result there is a great demand on it to provide leadership and guidance in research-based development of the agricultural sector. Discussions within and outside the Ministry indicate that this demand has grown over the years and is likely to continue to grow as the country faces the challenges of national and household food security, demand for increased agricultural production and rural employment, income distribution and environmental resources management within sustainable arable crops and livestock production systems. It is therefore crucial that the department should be organized to plan and manage agricultural research in such a way as to be responsive to short-, medium-, and long-term priority needs of the development departments, public and private-sector agencies, and the agricultural industry as a whole, in their attempts to attain the development objectives identified in the National Development Plan and the National Food Strategy. In this context, it is important that DAR should carefully determine the scope of research that it can meaningfully pursue so as to continue to generate a flow of improved materials and technologies, resource management techniques, and information required by the agricultural sector.

The DAR is a relatively modest department of agricultural research, with 39 professional staff (11 of whom are currently in training overseas) and a complement of 12 expatriate staff on contract, or associated with projects which in some cases are only partially integrated into the national research program.

The Department has a simple structure of two research divisions (Arable Crops Research, and Animal Production and Range Research) and support units of Administration, Soil and Plant Analytical Services, Seed Multiplication, and Estate Management (Fig. 2). The research divisions are headed by a Chief Agricultural Research Officer (CARO) and a Chief Animal Production and Range Research Officer (CAPRO) who provide scientific leadership and supervision of the research activities in arable crops and animal production and range, respectively, at headquarters and at the field stations and ranch research sites located throughout the country. The support and service units report directly to and are supervised by the Director.
Figure 1. The position of DAR in the ministry of agriculture
Below the divisional level, research is organized principally by disciplines. Program and project development initiatives are taken in accordance with the disciplinary orientation of the individual scientists or groups of scientists. Thus, for example, there are soil science, plant pathology, agronomy, entomology, and agricultural engineering initiatives or projects under Arable Crops Research; and animal breeding, animal nutrition, range management initiatives or projects under Animal Production and Range Research.

Although the DAR comprises a dedicated group of active and productive researchers confronting important and challenging problems of increasing crops and livestock productivity in a "harsh" and unstable environment, the overall productivity and relevance of output of the system is to a certain extent hampered by the structure and organization of research at the departmental, divisional, and program levels. This is further complicated by the fact that many of the ongoing research initiatives and programs are based on projects that are in various stages of incorporation or integration into the department's program, and are not based on careful program planning responding to the needs of the agricultural sector. This phenomenon has been referred to as "project driven" growth and program development in Chapter 3.

The analysis of the performance of the essential research functions within the present structure and organization indicate some important constraints. Although not all these constraints are structural and/or organizational, they are indicated here in order to focus attention on the consideration of measures and recommendations for strengthening the related structural, organizational, research programming, and management mechanisms in the research process as presented in this chapter.

The most important of the constraints are the following.

- Research is largely organized by disciplines at the subdivisional level, making it difficult to achieve interdisciplinary orientations in the development of technologies and other outputs of research.
- Inter-divisional research planning and joint development and pursuit of integrated programs, e.g., crops/livestock production systems are hampered.
- Research within the divisions is based on individual research projects that do not necessarily share common or related objectives and may not generate the required outputs that are relevant to the needs of clients or the agricultural industry.
- Research program development is largely "project driven", leading to departmental growth that overstretches human and material resources and reduces impact.
- There is a dispersion of efforts in an attempt to provide a wide coverage of problems.
- A clear determination of required scope of research is not evident.
- Program and project development within this structure and organization makes it difficult to determine and set clear priorities and allocate resources.
- A "critical mass" of efforts in terms of research scientists' time is often not concentrated on priority problems, thereby diminishing the chances of generating the specific outputs within a specific time-frame.
Figure 2. Current Structure and Organization of DAR

Director

Chief Arable Research Officer (CARO)
- Crops
  - Plant Breeding
  - Agronomy
- Soils
- Entomology
- Plant Pathology
- Horticulture
- Weed Science
- Farming Systems
- Biometrics
- Seed Technology
- etc.

Chief Animal Production and Range Research Officer (CAPRRO)
- Animal Production
- Animal Breeding
- Animal Nutrition
- Pasture & Range Management
- Small Stock
- Ranch Management
- Livestock Economics
- Animal Physiology
- etc.

Administration
- Soil & Plant Analytical Research Services (SPARS)
- Seed Multiplication Unit
- Estate Management Unit (EMU)
- Library Services
Lack of provision for specific linkages between research and technology transfer systems in the structure and organization has led to weaknesses in the timely testing and transfer of research results, information, and materials.

The arrangements whereby five research support services and their heads, as well as heads of research program division report directly to and are supervised by the Director places a lot of pressure on the Director and reduces the amount of time he could devote to the essential functions of policy formulation, research planning and supervision. In addition to providing scientific and administrative leadership to the DAR, the Director because of his position has other major national and regional responsibilities in research policy and management. For example, he is the constitutional Chairman of the Board of SACCAR and has to serve on a number of important national and regional committees.

A small team of researchers, many of whom are inexperienced as in DAR, needs special research leadership with specific focus on personal and professional career development and productive involvement in research programs and program strategy.

The diagnosis and analysis of these constraints leads us to the recommendation of a modest restructuring based on the need to perform the necessary functions in the research process more effectively at the levels of the directorate, the divisions, and the programs. It is recommended that the Department be strengthened by the creation of a post of Deputy Director to assist the Director in all his essential functions of research leadership and direction. In addition, it is recommended that the posts of Chief Arable Research Officer (CARO) and Chief Animal Production and Range Research Officer (CAPRRO) be upgraded to Assistant Director level to head the two divisions of Crop Production and Animal Production and Range. The support services would remain under the Director, each service being headed by a professional in the respective area. Further reorganization should be in the form of programs at the sub-divisional level and around a few key commodities, factors, or production systems on which 'critical masses' of scientists' time can be concentrated. This would be in tune with the commodity teams being proposed under the program reorganization proposals currently under consideration. The Director and the professional staff heading each service unit would then plan and address the needs of research support services and supervise their contributions to the departmental programs and strategy. The services themselves will be headed by "fairly senior" professionally qualified persons. The services to be included will be:

- Laboratory Services (Animals/Soils/Plants);
- Biometric Services;
- Library Services (including a joint DAR/BAC library as the foundation of a National Agricultural Library);
- Seed Services (multiplication, inspection, testing, certification);
- Physical Plant Services (formerly EMU) (including Central, Regional and Substation physical plant services);
- Research/Extension Liaison Services.
- Genetic Resources Management
Map 4.1. Zonal distribution of agricultural and livestock research sites in Botswana, 1990

Source: ISNAR 1990
Figure 3. Proposed structure and organization of DAR

DIRECTOR

DEPARTMENTAL ADMINISTRATION

DEPUTY DIRECTOR

ASST. DIRECTOR
CROP RESEARCH & PRODUCTION

Programs

Program 1. (PL)
2. "
3. "
4. "
5. "
6. "

ASST. DIRECTOR
ANIMAL PRODUCTION RESEARCH AND RANGE

Programs

Program 1. (PL)
2. "
3. "
4. "
5. "
6. "

Support Services

Laboratory services (Animals/Plants/Soils)
Biometric services
Library services
Seed services
Physical plant services (formerly EMU)
Research/extension liaison services
Genetic resources management

PL= Program Leader
The adoption of this recommendation would result in the structure and organization shown in Fig. 3. The details of the program structure in the Crop Production and Animal Production divisions are presented in Chapter 5.

A second element of the organization and structure of DAR is the network of research stations, substations, ranch research and experimental sites located throughout the country (Map 4.1). In nearly all cases these stations and sites represent an extension of research programs and activities based principally at the Central Research Station at Sebele. During the review references were made to several activities located in stations and sites in different parts of the country, and there was no clear distinction between research stations, substations, and experimental sites. Most stations outside Sebele were staffed by technical staff, with the exception of Mpandamatenga, which has one professional staff person, and the farming systems groups at Mahalapye and Francistown. In other words, activities at these stations were generally organized and supervised from Sebele. The team recognized the need for some degree of concentration of program staff at Sebele in view of the need to maintain a "critical mass" of scientists in program areas to facilitate interaction in the planning and execution of programs. It is, however, considered important that there should be a clear distinction between functions that should be carried out from Sebele as the Central Research Station and those that should be carried out in the agro-ecological zones: the research stations network should reflect these. This is important because the regional and production systems focus proposed for the Regional Stations would require that a critical mass of scientists (multidisciplinary teams) be based at regional research stations. It would be inefficient to organize and supervise such teams from Sebele.

Following a review of the existing network, the team recommends that DAR should adopt a revised network of research stations and substations, as follows (Map 4.2):

1. a Central Research Station, Sebele, with substations at Mahalapye and Pelotshetla (also production systems research for the Southern Region);
2. a Regional Research Station at Francistown, with a substation at a suitable location to be identified in the North Eastern area;
3. a Regional Research Station at Maun to serve the Okavango Delta, with substations at Ghanzi and Mpandamatenga. Mpandamatenga is to concentrate on vertisols management;
4. a fourth Regional Research Station to be located in the Western Region;
5. 16 Ranch Research Sites (12 in the eastern part of the country and 4 in the west at the following places: Tsetseku, Malchi II, Mattolakgang, Masama, Lesugo, Sunnyside, Leupane, Morale, Good Hope, Masiatilodi, Musi, Morapedi/Dikgatlhong complex, Seleka, Xanagas; one new site in ecological zone 8, and one new site in the Mkgadikgadi area in ecological zone 1.
Map 4.2. Proposed future location of agricultural and livestock research stations for Botswana

Source: ISNAR 1990
This resulting structure and organization is presented in Fig. 4. Details of infrastructure developments in respect of this network are presented in Chapter 6.

The Regional Research Stations will be expected to focus on research on the production systems in the agro-ecological zones in the North East, the Okavango Delta, and the Western Region. Their research will be largely adaptive, and will focus on developing and testing technologies to improve the productivity of systems of production in these areas. (The production systems team of the South will be based at Sebele and will take up and further develop the work of the Farming Systems Southern Region Project). The regional research stations will emphasize close collaboration between crops, livestock and soil/water management in their holistic and systems approach in the development and execution of production systems programs.
Figure 4. Proposed structure and organization of the research station network

DAR Headquarters

**RESEARCH STATIONS**
- Regional Research Station Francistown (NE)
- Central Agricultural Research Station Sebele
- Regional Research Station Maun
- Regional Research Station Western Region
- 16 Ranch Research Sites
  - 12 - East
  - 4 - West

**SUBSTATIONS**
- Mahalapye Pelotshetlha
- Mpandamatenga (vertisols management) Gomare

**EXPERIMENTAL SITES**
- Bobonong Marapong Mathangwane Matobo
- Makwate Shoshong Makoro
- Boro Matshedi Shorobe
- ?
- ?
CHAPTER 5: RESEARCH PROGRAMS AND PROGRAMMING

Research programs are the vehicles by which agricultural research policies are translated into action plans and activities that enable the research system to respond to the needs of its clients and the agricultural sector for improved technologies. Research programs therefore have long-, medium-, and short-term elements, and these are reflected in their development and planning. For example, program thrusts in terms of commodities and systems may have long- and medium-term implications, whereas experiments and studies within programs are generally of a shorter-term nature and may be subject to annual review and planning.

The development of research programs (research programming) must therefore take these timeframes into consideration in providing for periodic as well as regular reviews of continuing validity, relevance, and contribution of the activities and outputs to the overall program objectives. In other words, while programs constitute the building blocks of a research strategy, they must not be regarded as fixed for all time. Provisions should be made for possible changes in both programs and program elements and perhaps more frequently for program elements as the research problems and constraints are better understood and addressed.

Research programming can be a powerful tool in sharpening the focus of agricultural research activities within a NARS. When carried out effectively, the physical, financial, and human resources allocated to research are better focused on the priority problems and constraints of the agricultural sector. As a result, the outputs are likely to be more relevant to the needs of farmers, producers, and the development agencies.

In this chapter we examine the research programming procedures and mechanisms in the DAR; recommend improvements that would ensure optimal utilization of limited human resources; and establish a more balanced approach to research based on a reasonable and sustainable scope. The goal is to facilitate the generation of appropriate, improved technologies and technology components for the agricultural sector.

Current Procedures

The present programs and activities in DAR are derived from the guidelines provided by the National Agricultural Development Plan, the Agricultural Development Policy, and the National Food Strategy. All of these place emphasis on food security, increased agricultural output, conservation of natural resources, improved employment in rural areas, and the diversification of agricultural production. These broad objectives have not been formally translated into agricultural research policies but are considered as guidelines, both by the Agricultural Policy Committee and the DAR. It is clear from these objectives that for DAR to sharply focus its research activities and resources on the critical constraints in agricultural production there is need for it to develop a strategic plan. Such a plan would define its mission, provide a long-term vision, and establish priorities; it would assess the environment in which it operates; identify the primary clients; and estimate the means required to generate the desired outputs. An integral element of such strategic planning is the determination of the "scope" and "size" of the research system and the long-term programs that would enable it to respond to the needs of the nation.
Current procedures in research programming require the research managers and the scientists to be familiar with the broad Government policy guidelines and to take them into account in their planning and programming activities. However, it is not sufficient merely to take these into account in programming, because several options are available for addressing researchable problems arising from broad policy objectives. Guidance is required with respect to priorities and research thrusts which respond to specific research and development objectives.

In the 'O and M report', the overall objective of the DAR is stated as
"...to provide special agricultural research services pertaining to the design and development of appropriate agricultural technology in order to enhance and ensure sustained agricultural productivity, covering areas such as soil fertility, soil and water conservation, seed multiplication, crop and animal production and improvement, etc."

Specific objectives of the Department, as detailed in the O and M Report, were:
- serve as the national focal point for policy and operational direction and coordination of agricultural research;
- develop and introduce effective research programs in crop and animal production;
- provide adequate laboratory facilities to support crop and livestock research and development;
- provide professional expertise for the conduct of agricultural research and the transmission of findings to users;
- provide professional leadership in basic soil and land-use research, range and forestry research, and the integration of these;
- ensure the efficient management and optimal utilization of the resources allocated to research.

Apart from the further statements on the responsibilities of DAR for research coordination, planning, execution, and management, the translation of national and Ministry of Agriculture development policies into guidelines for agricultural research has only been broadly outlined. It is therefore left for DAR to either obtain further clarification or an elaborated agricultural research policy from the Agricultural Policy Committee, or to attempt to define such a research policy.

In the absence of an elaborated agricultural research policy and a strategic plan, the current practice is for the Director and the senior management of DAR at the divisional levels and perhaps within projects to attempt to provide this guidance. In some cases, input is provided by technical committees or advisory committees at the ministry level, as is the case of the Livestock Technical Committee. In general, it is stated that "research projects are initiated by individual researchers and discussed with heads of divisions to determine the appropriateness of the research in terms of national goals and perceived farmers' constraints". This places the responsibility for program initiation and direction on the researchers and the divisional heads. The Director exercises some guidance through 'guideline statements' and an approval process. A key forum is the Departmental Annual Research Seminar, at which results for the previous year are reported and plans for the ensuing year are presented and discussed.
It is reported that a National Research Priorities Committee which used to discuss research proposals no longer functions. In effect, the research programming procedures are largely internal to DAR.

The outcome of the current research programming procedures is that DAR's research programs, activities, and projects are a collection of individually inspired or individually conceived projects and proposals based on individual interpretations of broad policy and departmental objectives, moderated by divisional advice. In a few cases, lines of research previously undertaken have been adopted as the basis for the development of new program elements, thereby ensuring continuity and some program coherence. In addition to these are the externally funded projects in specific areas that are deemed to contribute to the development strategy of the Ministry of Agriculture and which in time become integral parts of the national research program administered and coordinated by the DAR. In these circumstances, it has been difficult to establish fully coherent or complementary programs with clearly defined objectives, specific program thrusts, and expected outputs that would be relevant to the needs of the clients of research in the public and private sectors and among farmers and producers.

**Weaknesses**

The major weaknesses identified in the current research programs and research programming procedures include:

(i) the absence of clear policy guidance in the development of programs;
(ii) the tendency for programs to be "project driven" or be dependent on individual initiative conditioned by background, specific training orientation, or opportunity;
(iii) the tendency for programs to be largely single-discipline in orientation, resulting in lack of interdisciplinary planning and/or execution of programs;
(iv) the absence of clearly defined program goals and objectives against which output and performance can be assessed;
(v) the absence of "critical mass" of research scientists' efforts on priority problems;
(vi) the dispersion of efforts, resulting in inadequate problem coverage;
(vii) difficulties in setting priorities among commodities, programs, and program thrusts, and in the allocation of resources;
(viii) absence of structured peer review of proposals at the planning stage of programs;
(ix) absence of a structured review of all programs by a senior technical group within the Department or Ministry;
(x) absence of specific provision for inputs from the development departments;
(xi) weak linkages between the arable crops and livestock research in the planning of research and the development of technologies;
(xii) lack of complementarity and overall coherence in the program strategy of the Department;
(xiii) weak linkages between research and development departments in the programming of research, technology testing, transfer and feedback to research.
Despite these weaknesses, DAR has made useful contributions in many areas of arable crops and livestock research and development and has strengthened its position to make further contributions. Some of these weaknesses had been recognized, and proposals were under consideration for the establishment of Research Program Teams (RPTs) and commodity teams that would be multidisciplinary in composition and would introduce mechanisms for interdisciplinary planning, review, and evaluation of programs. Other positive steps were being taken to improve linkages with the development departments and extension, and to effectively utilize the Research Extension Liaison Officer (RELO) position that had been created earlier and was placed in the former Department of Agriculture Field Services. Also, greater consciousness of the need to use systems approaches in research that meets the technology needs of Botswana farmers had been generated; and closer interactions between livestock and arable crops programs were being initiated.

In these circumstances, the Team felt that our recommendations on the program structure and the programming procedures will serve to consolidate trends that are already developing within DAR. The recommendations are designed to:

- sharpen the organization of programs;
- strengthen the scientific and technical leadership of the programs;
- create greater precision in the definition of programs;
- simplify and improve programming procedures.
- introduce systematic priority setting procedures in programming.

The ultimate objective would be to sharply focus research activities on a limited number of priority research programs, create an interactive and productive environment for research, and focus on output and accountability of research to the user community.

Review and recommendations

In reviewing the research programs and program activities in DAR, the team found that only in a few cases were there groups of research activities that could be classified as coherent programs. Many of these were due to historical reasons and not to conscious attempts to develop balanced programs with planned necessary inputs related to clearly defined objectives and expected outputs. The Team, therefore, in consultation with the Task Force and senior scientists in DAR and the Ministry, tried to rationalize the research programs, activities, and services to determine a reasonable scope that could be covered within the resources likely to be available in the near future. These rationalized programs would respond to the priority needs of the agricultural sector in the short to medium term. In doing this, emphasis was placed on the need to:

- clearly define program objectives within the framework of identifiable priority problems;
- assign a "critical mass" of research staff time to priority programs;
- focus the programs on commodities, factors, and production systems, using interdisciplinary teams;
- assure the productivity of the research department in terms of flows of improved technologies and materials relevant to the needs of clients;
- provide for effective linkages to enable the improved technologies and materials to reach the user community.
This process was facilitated by the series of analyses that had been undertaken in the Agricultural Sector Assessment Study and the policies and strategy for the development of the agricultural sector. Given the following conditions: a total of 39 professional staff and 12 expatriates; a scope that must include a number of arable crops and livestock; and the context of a fragile natural resources base that must be managed and conserved for sustainable production, it is recommended that DAR should reorganize its research activities around a few core crop and livestock commodity and systems programs. These programs would be national in scope, and multidisciplinary as required, with clear goals and objectives, relevant to the needs and requirements of producers and national policy, and with "critical mass" of assigned researchers and technical support personnel.

It is estimated that the Department would require in the medium to long term a total of about 60-65 scientists or professional staff adequately supported by technical support staff to plan and execute these programs. This level of staffing is regarded as sustainable in the long term provided the rationalized scope of research proposed in the review report remains valid and is adhered to. It should be pointed out that most of the research that can be undertaken within this scope will be applied and adaptive.

**Rationalized research programs**

It is recommended that a program structure be adopted within the two research divisions in the department. Support to these divisions will be provided by the individual services under the Directorate. It is recommended that in the Crop Production Research Division the programs be reorganized into six commodity, factor, and systems programs as follows:

(i) cereals program  
(ii) oilseeds program  
(iii) grain legumes program  
(iv) horticulture program  
(v) soil/water management program  
(vi) production systems program (crop-based, including agro-forestry).

In the Animal Production Research Division, it is recommended that the programs be reorganized into six program areas as follows:

(i) beef program  
(ii) dairy program  
(iii) small ruminants program  
(iv) feeds program  
(v) range and pasture program  
(vi) production systems program (livestock-based).

In the area of Support Services, it is recommended that the services be developed and operated more or less along the same lines as programs, as far as the determination of objectives (which in this case would be largely service objectives) and resource allocation considerations are concerned.
Each service should have professional leadership that would ensure the effectiveness of the services in support of research and without the need for too much direct supervision from the Directorate. This would permit the Directorate to devote its primary attention to planning, policy, and resource allocation issues, and to scientific direction and leadership of the research programs. The recommended program structure is presented in Figure 5.

In Figure 5 it is indicated that each program will have a senior scientist (MSc. or PhD with at least five years experience) as Program Leader. Initially it is recognized that DAR may not have enough senior scientists (12) to lead all the programs. It is therefore recommended that certain programs be combined, e.g. cereals and oilseeds; beef and dairy; grain legumes and horticulture; feeds and range and pastures; and production systems (crop and livestock-based) and assigned one leader each, until the senior staff situation improves and becomes stable. This would mean that initially only seven program leaders would be needed, and the remaining 44 scientists (including expatriates) could be distributed among the programs according to disciplinary or expertise needs.

It is important to emphasize, as it is schematically done in Fig. 5, that the two Production Systems Programs (crop-based and livestock-based) should be encouraged to plan together and to constantly interact. They have been shown as two separate programs because in certain circumstances the crop commodities or the livestock classes may be the dominant feature of the production systems and there may be a strong case to build or test production systems around these dominant features. Separate programs would ensure some balanced consideration of the contribution of the two areas to production systems strategy and studies. However, depending on the evolution of the initial interactions of the two production systems programs and the further sharpening of the focus and definitions of the problems to be addressed, there may be the need for the amalgamation of the programs into one unified production system program, with the farmer and the environment as focal points and the two broad disciplines (crops and livestock) contributing to the formulation and execution of the program; this is also provided for in Fig. 5.

In this program structure, the program leader will have an important role to play in consultation with the Directorate (Director, Deputy Director, and Assistant Directors). The Director and Deputy Director would provide direct scientific leadership to the programs, help in defining clear objectives for the programs and in identifying essential disciplinary researcher time inputs and client inputs into the planning of the programs. Although the programs will not necessarily be of the same size in numbers of staff, on the average there will be about 4 to 5 scientist years per program. In reality programs such as the Production Systems Programs will probably have more scientist years than programs such as feeds, or crop commodity programs where the emphasis will be more, and rightly so, on adaptive research involving the introduction, selection, and assessment of promising improved varieties under Botswana conditions. The guiding principles in the allocation of person years to programs would be the disciplinary requirements, the nature of the problem, and the concentration of efforts required to generate the required outputs.
Figure 5. Proposed program structure for agricultural research in the DAR

DIRECTOR

DEPUTY DIRECTOR

Support Services

1. Administration
2. Laboratory services
   (Animals/Plants/Soils)
3. Biometric Services
4. Library Services
5. Seed Services
   (multiplication, inspection,
    testing, certification)
6. Physical Plant Services
7. Research/Extension Liaison
   Services
8. Genetic Resources Management

PL= Program Leader. Initially program leadership for two programs may be combined until there are enough senior scientists to provide scientific leadership at the program level.
Research Programs

Adoption of a uniform program structure within DAR with the rationalization and sharpening of the focus of such programs should enable the DAR to improve research productivity and efficiency, as well as the relevance of research products. The determination and initial focus of each of the programs which would be subject to review by the National Research and Technical Committee as a Senior Technical Review Group (with participation from the Development and Extension divisions) would be as follows:

Crops

1) **Cereals Program** (sorghum, millet, maize, wheat)

This program should focus on the objective of improving the contribution of cereals (with sorghum and millet as high priority cereals) to national food security. Emphasis should be on the selection, introduction, and testing of improved varieties and the development of technologies that would make the most efficient use of soil, water, and nutrients. Attention should be given to increasing the flow of materials and technologies to farmers in the various agro-ecological zones of the country. With soil and water identified as the most important constraints in arable crop production, the program will need to collaborate closely with the soil/water management program and other projects such as the Arable Lands Development Project (ALDEP) in the development and testing of agronomic practices that would increase cereal crop production and productivity.

2) **Oilseeds Program** (sunflower, groundnuts, castor, cotton*)

This program should focus on the selection and improvement of high-yielding, drought-tolerant, and disease-resistant varieties adapted to the semi-arid production conditions in the country. It should maintain intensive collaboration with international and regional programs in variety improvement and focus on increasing the contribution of oilseed production and utilization to income generation and employment in rural households. The main objective should be to reduce and ultimately eliminate the dependence of the country on the importation of vegetable oils to meet its needs. (First order of priority to sunflower and groundnuts).

3) **Grain Legumes Program** (cowpeas, pigeon pea, soybeans)

This program should focus on the introduction, selection, and improvement of pest and disease-resistant varieties of grain legumes adapted to growing conditions in Botswana. Emphasis should be on strengthening the contribution of grain legumes to human food and nutrition, to soil fertility maintenance, and to feed and fodder supply in integrated production systems involving arable crops and livestock.

* also a fibre or industrial crop
Close collaboration with regional and international grain legumes programs would be essential, and some emphasis should be given to the integration of grain legume production and utilization in crop rotations and in animal nutrition and management in crop- and livestock-based production systems. (First order of priority to cowpea and pigeon pea).

4) **Horticulture Program** (vegetables, fruits)

This program should focus on the introduction and development of materials and technologies for improved horticultural crop production in the country. Emphasis should be on the selection of a limited number of crops and commodities for which Botswana has some comparative production advantage and which are targeted to meet the needs of both rural and urban communities. The major focus should be on the adaptation and improvement of priority fruits and vegetables and the development of technologies that would utilize the scarce production resources of water and nutrients most efficiently in the context of the Botswana producer. Some of the technologies would include intensive production under irrigated and rainfed conditions. Particular attention should be given to product quality, relevant post-harvest handling, and to marketing. The objective of meeting the nation's needs for fruits and vegetables and some excess production for export should be kept constantly in mind. This program has the potential to contribute to the diversification of agricultural production in some of the major agro-ecological zones of Botswana.

5) **Soil/Water Management Program**

This program will focus on the improvement of the efficiency of the utilization of water and soil resources in crop/animal production. Emphasis will be on the study and management of crop/soil/water relationships and animal/water/soil relationships for maximizing productivity in the different agro-ecological zones. Efficient utilization of water through conservation, water harvesting, tillage practices, and crop diversification will provide the backbone for improving productivity, and close collaboration with the arable crops programs, livestock programs, and the production systems programs will be emphasized. The program will pay special attention to the development, testing, and promotion of natural resource conservation techniques and practices compatible with sustainable agricultural production. Close collaboration will be maintained with regional and national programs on soil/water management and in particular with programs focusing on vertisols and dry-land soil management.

6) **Production Systems Program**

This program will feature a holistic approach to the systems of production in the major agro-ecological zones of the country.

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**Production systems** is used as a preferred term to "farming systems", which tend to have a more restricted meaning and does not fully emphasize the integration of crops, livestock, soil, and water in the context of a sustainable productive environment.
It will integrate crops, livestock, and production technologies in the context of the natural and modified ecosystems and with the focus on improving the productivity and incomes of rural households. This program will incorporate and integrate the lessons and achievements of the farming systems programs currently in operation and advance these for validation and testing at the farm level in the various zones.

Special emphasis will be given to collaboration with development programs such as ALDEP, and to cooperation with the field programs of the Department of Crop Production and Forestry. The program will link up closely with the Regional Research Stations and will serve as the focal point for research/extension linkages and collaboration in the development and testing of improved technologies. New inputs in agro-forestry will be emphasized in the development of improved management of the agro-environment and sustainable production.

**Livestock**

In the Livestock Division the programs will focus on the development of a research strategy that would enable the livestock industry to sustain and improve the quality of production and improve productivity per unit of essential inputs. Six major programs will reflect this strategy as follows.

**Beef program**

To date the focus in beef cattle research has been on breeding. In this program, present long-term breeding plans, particularly the development of a composite breed, must continue, with selection for hardiness, health, and reproductive ability, as well as for meat production. In view of the importance of overseas markets, beef quality must also be considered. In addition, alternative beef production systems will be investigated. The scope for alternative systems is limited, but investigations may show that some form of stratification and/or integration with cropping systems or trees may be flexible. Mixed species grazing systems, mentioned in the small-ruminant program, must also be investigated.

**Dairy program**

The focus of this program is the problems encountered by small-scale and large-scale cattle owners, and milk producers. These are breeding, feeding, management, and health problems, as well as marketing difficulties. One long-term objective of the program must be the provision of a stabilized crossbred or composite breed cow that is hardy and productive. All new feeding, management, and health interventions must not only be economical, but tested in terms of acceptability to the small farmer as well. There should also be close collaboration with animal production and animal health extension staff, and public, cooperative, or private dairy marketing organizations.
Small ruminants program

This program should primarily focus on the role of indigenous sheep and goat breeds in rangeland livestock systems: first, as meat producers, in which productivity can be radically increased by improvements in growth rate, reproductive performance, and lamb/kid mortality; second, as producers of milk and specialized products such as skins, hair, and wool; and third, as specific components of the range ecosystem. In this latter role sheep and goats play very different parts, because sheep are primarily grazers of short grasses, while goats brows on shrubs and will eat the bark of trees. Investigations should include the effects of grazing combinations of sheep, goats, and cattle on range/productivity.

Feeds program

In this program all types of vegetable and animal products and byproducts of them present in Botswana will be investigated to determine (a) their nutritional value - energy, protein, and essential minerals and vitamins, (b) any content of biochemical compounds that individually or collectively could be dangerous to the health of animals, (c) possible feeding value for ruminants and non-ruminants, and (d) economical methods of utilizing those products of nutritional value. In order to avoid unnecessary analytical work, program staff should first ascertain what information is already available, specifically contacting FAO, the international agricultural research centers, and food chemists in countries with semi-arid tropical climates.

Range and pasture program

Stocking rate trials should be continued in the immediate program, but the data must be evaluated to ascertain whether these trials can be terminated and as to how the trial results can be used. The Morale Communal Grazing Simulation Trial should continue in the program as should the evaluation of pasture and fodder species. The most complex task in the program will be to cooperate with the Beef, Small Ruminants, and Production Systems programs in investigating alternative range production systems. Also, the economic and technical feasibility of developing practical range-monitoring systems should be investigated.

Production systems program (livestock-based)

As in the crop-based Production Systems Program to which it will be closely linked, the livestock-based program will take a holistic approach to investigating livestock production systems in all major ecological zones. It will in effect be an integrating program, as it will have to develop particularly close ties with the other five livestock programs, the crop programs, existing farming systems projects, regional research stations, and forestry and wildlife researchers in other ministries. In this program, in addition to investigating possibilities for alternative rangeland systems using all species of domestic livestock on the same range, the development of sylvo-pastoral and agro-sylvo-pastoral systems, and for the integration of dairy cattle and/or goats, or sheep with crop farming, will be investigated. The ultimate objective of the program will be to develop sustainable and productive agricultural systems for all the major ecological zones of Botswana.
Programming Procedures

The adoption of improved programming procedures is fundamental to the development and execution of sound programs capable of contributing meaningfully to research and national development objectives. Although it is recognized that research programming will necessarily be initiated at the level of researchers, the procedures involved will have bottom-up as well as top-to-bottom elements. This means that programming should involve three levels - national, departmental, and programs.

First, it is important that the national policy level at the Ministry of Agriculture (Agricultural Policy Committee) provide guidance on broad research priorities, sub-sectoral allocations and commodity and systems emphasis. To facilitate the performance of this function it is recommended that the Agricultural Policy Committee (APC) should focus attention on the translation of broad agricultural development policies into agricultural research policies. It should also provide improved guidance to the scientific and technical leadership of the Department on the implications of research policies for priorities and program thrusts. The extent to which this level could perform this function effectively would depend on the availability of objective policy and technical information and analyses to be provided by the senior technical group from DAR and other departments of the Ministry, notably the Planning and Statistics Division and the Technical Departments in Crop Production and Forestry, and Animal Health and Production. The APC should at least deliberate on agricultural research policy once a year.

The second level (See Fig. 5) is the National Agricultural Research and Technical Committee, which we propose should comprise:

the Director of DAR (as Chairman)
The Deputy Director (DAR)
the CAPPRO (or Assistant Director Animal Production)
the CARO (or Assistant Director Crop Production Research)
Heads of Regional Agricultural Research Stations
Head of the Division of Planning and Statistics
Director of Crop Production and Forestry Department (or Deputy Director)
Director of Animal Health and Production Department (or Deputy)
Principal, Botswana Agricultural College
Dean of Agriculture, Botswana Agricultural College

This would constitute the Senior Technical Review Group for all research programs proposed for the Department and for projects proposed for integration into the program structure of the Department. This senior technical group should consider and approve program priorities and program thrusts and should recommend the allocation of resources to programs to the senior management of DAR. The group should meet at least twice a year and should deliberate on strategic issues as well as program proposals in order to provide guidance to the program leadership and program staff. It is crucial that the programs and program staff should receive clear guidelines on program priorities and thrusts, as well as regular feedback on proposals from this senior technical review group.
The third level and essential base of this programming procedure pyramid (Figure 6) is the program committees and the researchers who constitute them. Formulated research proposals from researchers and groups of researchers go before these committees. It is here that the program content and orientation is determined and the proposals subjected to evaluation of scientific merit, appropriateness of methodology, and relevance to the objectives of the programs. Program committees should be headed by senior scientists with the requisite knowledge and experience; they should be multidisciplinary in composition, cutting across divisions and programs, and interdisciplinary planning and discussions should be encouraged. It is important for clear program objectives to be set at this level through interactions with the senior technical group and representative of client groups.

As far as possible, the relevant Assistant Director should participate in the deliberations of the Program Committees, and researchers and groups of researchers encouraged to articulate projects, experiments, and studies to respond to program objectives and the research objectives and policies determined at the higher levels. In the case of DAR, it would be necessary to have three multidisciplinary Program Committees - one for Crop Production Research, one for Animal Production Research, and a third for Production Systems Research. Each Program Committee would be required to check and screen the proposals made in respect of each program for relevance and quality and to recommend both long- and short-term programs for consideration and approval by the Senior Technical Group. It is essential that the extension services and the development department be represented at the planning and review of programs at this level.

It is recommended that these programming procedures be worked into the calendar of the Department and the Ministry in such a way as to ensure that the flow of information and guidance influence the program planning and that annual and periodic resource allocations are made in response to the priority and program thrusts articulated on the basis of these guidelines. The research system should utilize these procedures to provide objective advice and recommendations to Government and to orient its activities in line with the overall development objectives of Government and the agricultural industry.

**Project integration and facilities rationalization**

In addition to the introduction of a uniform program structure as a basis of research activities in DAR, it would be necessary to integrate some of the existing projects into the programs of the department. It is proposed that the National Research and Technical Committee to be set up should review all of these existing projects and determine whether and where they fit into the objectives of the agreed programs.

The review should rationalize the current activities in the context of the program structure and determine which activities should continue and which activities should be terminated. Particular attention should be given to the integration of projects such as the Agricultural Technology Improvement Project (ATIP), the ANDP Project (SIDA), the Farming Systems Southern Region Project, the Molapo Farming Project (GTZ), and similar projects into the program structure of the department.
Figure 6. Research policy and program formulation for the DAR

Mechanisms

- Cabinet Committees
- Nat. Dev. Planning Committees

- Directives and Guidelines

- Broad Agricultural Policy Review Group
- Agricultural Research Policy Review Group

- Broad Commodity and Systems Priorities

- Senior Technical Research Group

- Guidelines on Program Priorities and Thrusts

- Program Committees (multidisciplinary composition; interdisciplinary discussion)

Activities

- National Development Plans
- National Development Policy
- Sectoral Allocation of Resources

- Advice and Recommendations

- Agricultural Policies
- Sectoral Dev. Programs
- Sub-Sectoral Allocations
- Agricultural Research Policy
- Research Priorities

- Program proposals responding to policies and priorities
- Analysis of opportunities

- Determination of Program thrusts
  Program priorities
  Allocation of resources to programs

- Commodity/System program proposals
- Experiment and study proposals

- Program content and orientation
  Scientific evaluation

- Experiment and study proposals
It is believed that most of the projects and activities with slight orientation and sharpening of focus will fit into the reorganized program structure. The rationalization of the program structure will define the scope of research and establish the basis for the medium-term and short-term planning and programming of research activities. With a program structure supported by a strategic research plan, it is suggested that all future research projects, whether they are initiated by the Department or through other sources in the Ministry, should be developed with the full knowledge and cooperation of the Department. Preferably they should be integrated into or made complementary to the research activities undertaken within the agreed programs structure.

Although the programs will form the principal basis for the organization and execution of research activities, it is important to point out that some research infrastructure and facilities will have to be provided on a disciplinary basis or for the joint use of disciplines that may be contributing time and expertise to different programs. Such facilities should be shared and not duplicated. It is proposed that for these purposes the following facilities be created and equipped:

(i) A biological laboratory for plant pathology, entomology, and weed science. This would be shared by scientists in the various crop commodity and production systems programs, and would essentially be a major plant protection research and laboratory facility.
(ii) An analytical laboratory for soil and plant analysis; and a small-animal analytical laboratory facility developed for special animal nutrition and other analytical studies that cannot be accommodated in the main analytical laboratory.

These would be in addition to existing facilities at the Sebele Central Research Station.

In addition, it is proposed that facilities be provided for interdisciplinary interactions and focus on production systems at the Regional Research Stations. Such facilities would be used in the planning and coordination of systems research, the interactions with and training of extension personnel and staff of development agencies, and for the demonstration of technologies being developed and tested.

The details of the proposed infrastructure and facilities are presented and discussed in Chapter 6.
CHAPTER 6: INFRASTRUCTURE FOR PROGRAM EXECUTION

The DAR needs to expand and improve infrastructure at its research stations and sites. If, however, the research programs and programming methods proposed in the previous chapter are to be introduced, then some reorganization of the present research station complex is essential, in addition to improvements in infrastructure.

One reason for change is that some of the research programs will be conducted primarily at regional research stations where a critical mass of research workers will be located. Another reason is that variations in soil and rainfall and the distinctive features of the Okavango Delta provide different ecosystems even within regions. This means that a relatively large number of research sites are required. Since Botswana is geographically a large country and most agricultural systems are extensive, proper supervision of the number of research sites required by the proposed programs could not be exercised from one central station and may be difficult even from regional stations. Hence a complex of central, regional, and substations is required, although their number should be kept to a minimum consistent with the requirements of the programs.

A diagrammatic representation of the manner in which stations and research sites could be organized is shown in Fig. 4, while more detailed proposals for reorganization and justifications for any major changes are provided below.

A National (Central) Research Station at Sebele

The DAR presence at Sebele should include:

(a) **Offices of the Directorate**, the headquarters administration, chiefs of divisions, and some specialist scientific staff.

(b) **The research/extension liaison headquarters**. At present a research/extension liaison officer operates from an extension office of the MOA. However, the liaison between research and extension staff could be markedly improved if the officer operated from the DAR headquarters. The advantages are subtle but real. The officer, a trained extension worker, could thereby more easily assist research workers to formulate programs closely related to field realities and when in the regions could help extension workers understand the constraints imposed on research, and effectively bridge the gap in communication between research and extension.

(c) **A biometrics unit**. The biometrics unit will be a research and research-related service. Scientists in the unit will undertake research on improved methodologies for crops, soils, and animal research, and provide services to other researchers. Although the activities of the unit will have a large component of service, researchers within it should be encouraged to undertake collaborative research with researchers in other research programs in such areas as the testing and validation of design and analysis methodologies, production systems analysis and modelling, etc. The balance between the responsibilities in research and service would need to be taken into consideration in assessing the performance of staff in this unit.
(d) Laboratories. An increase in the capacity of soil, water, and nutrition analytical laboratories is planned. However, specialists, such as the entomologist, the plant pathologist, and the animal physiologist urgently require office/laboratory space. The requirements of the animal physiologist can be met by reorganization of existing accommodation within APRRU. It is recommended that additional laboratory/office space be planned and provided for the other specialists.

(e) Herbarium. A small herbarium that is at present located in the forage section of the Animal Production and Range Division will require rehousing as the number of specimens increases and the collection is upgraded. The herbarium should also be able to serve other disciplines such as Weed Science, Crop Science, Genetic Resource Management, etc.

(f) Library/information service. Integration of the DAR library with that of the Botswana Agricultural College (BAC) has been agreed in principle. The DAR library is primarily a research library and it subscribes to an impressive number of journals. It is well managed and well used, but there is a disciplinary imbalance in the availability of journals; more than half are concerned with crop husbandry and only about 10% with animal husbandry. It would be desirable to obtain back numbers of the more important journals, particularly the abstract journals, and to collect, as far as possible, further published information on the history of agriculture in Botswana.

When the DAR and the BAC libraries are integrated the different priorities of the two organizations for library services must be taken into account. Apart from common services, the DAR will require a special current contents information and copying service (for scientists at the regional stations) and a small reading room where the specialist journals are made available, while the BAC will require a large reading room for students and others where current textbooks and general journals are available.

It is recommended that the integrated DAR/BAC library should form the base for a National Agricultural Library to be located at Sebele. Such a library could register, collate, and classify all collections of agricultural books, reports, and papers, at present scattered through departments of the MOA, other GOB ministries, and parastatal organizations.

The library staff are employees of the Ministry of Education (MOE). Upgrading of library facilities will require upgrading of staff, but the DAR and BAC will not wish to train staff who can be posted without consultation from the agricultural library by the MOE. Some form of agreement between the MOA and MOE will be required so that if library staff are further trained by DAR/BAC they will not be moved from the agricultural library without consultation and consent.
(g) The headquarters of a physical-plant development and maintenance unit. Apart from the development and maintenance of the Sebele estate, this unit will be expected to develop and maintain regional research stations, substations, and research sites. Sub-units will be required at the regional research stations.

(h) Seed multiplication unit. The present unit is not part of any research program and is an anachronism in the Crop Research Division, but apparently GOB considers that for the present it is most suitably sited within the DAR. The Division does, however, require a small unit to multiply and distribute the seed of promising varietal selections.

(i) Substations Mahalapye and Pelotshetla. In the reorganization Mahalapye will eventually become a sub-station of Sebele. It is proposed that a second substation be developed from facilities existing at Pelotshetla. Goodhope would then revert to a research site.

Regional Research Stations

The regional research stations will be prime bases for the conduct of production-systems programs at which appropriate services can be provided and where living conditions will be such as to attract and maintain the required scientific staff. Offices and houses will be required.

Strong links should be established between researchers, the extension services, and farmers' organizations, and as these stations develop they may require some replication of services from the national research station at Sebele.

It is recommended that three regional stations be established, one in the Francistown region, one in Ngamiland region (Maun), and the third in the Western Region.

Regional agricultural research station - Francistown

This is a new station that will serve the northcentral and northeast regions. Until such time as the station is developed, regional research programs will be conducted from Mahalapye or Sebele. There will be one substation at Mbadamnetenga and several research sites (some could be horticultural sites).

Regional agricultural research station - Ngamiland (Maun)

There have been DAR and other research activities in the Maun area for some years, and the regional agricultural research station would consolidate and continue some of these activities. They include research into irrigation methods, melapo farming, or the growth of crops on land from which floodwater is retreating and dry-land farming on Kalahari sands. The station will serve the agricultural research needs of Ngamiland, the Okavango Delta region, and at least in the early stages, the northern part of the Western Region.
Initially a substation should be created in the Western Region, but this could be developed quite quickly into a regional research station. In addition, there will be research and ranch research sites.

**A regional agricultural research station in the Western Region**

Western Region includes the Kgalagadi and Ghanzi districts and comprises 40% of the land area of Botswana, but only includes 4.5% of the total national and 6% of the rural population. The region is extremely dependent on livestock, since 88% of the value of subsistence and marketed production is derived from livestock, while a further 6% is derived from wildlife and veld products.

A regional research station could be located at Ghanzi, Tshane, or Kang. Although Ghanzi is located in the middle of a freehold land area, communal land, TGLP ranches, and WMAs surround it. It might possibly be easier to provide appropriate services and reasonable living conditions at Ghanzi, but these will be difficult to provide anywhere else in the Western Region.

A site at Hukuntsi, near Tshane in north Kgalagadi District, has been selected by the MOA as a field-crop station but to date no experiments have been conducted. It would not be a suitable site for a regional research station, but it could be a substation. Until such time as a Western Region agricultural research station is established, Hukuntsi could become a research site attached to and operated from Sebele.

**Substations of regional research stations**

Substations will normally be staffed by technicians and visited regularly by scientific staff. Limited office space, staff housing, accommodation facilities for visiting scientists, equipment for farming and experimental work, and in remote areas electrical generating equipment and radio phones, will be required.

For crop programs the majority of field research sites will be serviced from regional or substations, whichever are more convenient.

Initially, the establishment of four substations is recommended. These are:

*Pelotshetlha*: a substation of Sebele.

*Mahalapye*: when the regional research station at Francistown has become established, this would become a substation of Sebele.

*Mpandamatenga*: when the regional research station at Maun is fully established, Mpandamatenga will become its substation. Until that time it will remain what it is at present, a substation of Sebele.

*A substation in the Western Region*: Tshane, Kang, or Hukuntsi.

**Research sites and ranch research sites**

Crop research sites will normally be serviced from substations, regional research stations or, in some instances, from Sebele. They do not normally require the services of a resident technician, although there may be exceptions.
Ranch research sites are different. At each site there should be an office, houses for the ranch manager and labor, some form of accommodation for visiting scientists, yards equipped for gathering, weighing, dipping or spraying, marketing and examining livestock, together with equipment such as weighing machines, sprays, etc. On account of the isolation of most ranch research sites, suitable transport and a radio telephone should always be available. At present not all ranch research sites are equipped with transport.

The present network of ranch research sites was developed some 20 years ago, with only minor changes in the intervening years. The distribution of sites is very skewed. As will be seen from Table 6.1, 11 out of a total of 17 sites are located in one climatic zone, scattered along the main road and railway in the southeast of the country, in the 400-500 mm rainfall zone, where the majority of cattle were raised 20 years ago. One ranch research site (Tsetsek) is located in a higher-rainfall (450-550 mm) zone in Ngamiland, while the remaining five sites are in lower-rainfall zones although only one ranch research site (Xanagas) is in the lower-rainfall zone of the Western Region that comprises some 40% of Botswana's total land area.

It is recommended that some changes should be made in the ranch research site network, so that it more clearly reflects the distribution of livestock in the different ecological zones of Botswana. These are that:

(a) Impala and Boswelatlou ranches in ecological zone 6 be disposed of;
(b) Morapedi and Dikgatlhong ranches be managed as one unit;
(c) a new ranch research site on a TGLP ranch area be developed close to the main Nata-Maun road in the Makgadikgadi pans area (ecological zone 6, 450-500 mm rainfall);
(d) a new ranch research sites should be developed in the Western Region in the ecological zone 8 (200-400 mm rainfall) or on a TGLP ranch area.

The present method by which the APRRU supervises ranch research sites should also change once development in the research station complex has been completed. At present all ranches north of Sebele are supervised from Mahalapye, and all south of Sebele from an office in Lobatse, while overall supervision is exercised from APRRU in Sebele.

It is recommended that, ultimately, ranch research sites should be supervised from regional agricultural research stations, except for those close to Sebele that can be more easily supervised from that center.
Table 6.1: Current Network of Livestock Research Stations, 1990

<table>
<thead>
<tr>
<th>Zone 6</th>
<th>Site</th>
<th>Livestock Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zone 6</td>
<td>Sebole</td>
<td>Dairy herd Friesian &amp; Simmental; Tswana x Simmental crossbred. 46 farms altogether on dairy project (all around Gaborone)</td>
</tr>
<tr>
<td>Zone 6</td>
<td>Kgatling District Council Masama</td>
<td>Dam breeds: Afrikander, Tuli, Brahman. Sire breeds: Afrikander, Charolais, Brahman</td>
</tr>
<tr>
<td>Zone 6</td>
<td>Central District Leupane near Palapye</td>
<td>Dam breeds: Brahman, Tswana, Tuli. Sire breeds: Brahman, Charolais</td>
</tr>
<tr>
<td>Zone 6</td>
<td>APRU, Sunnyside, off Gaborone Lobatse road</td>
<td>Dam breed: Simmental &amp; Sire breed: Tswana (breeding for dairy project); goats (Tswana) selection program</td>
</tr>
<tr>
<td>Zone 6</td>
<td>APRU, Impala, near Francistown</td>
<td>Tuli sires: dams at SG, Brahman and Tuli</td>
</tr>
<tr>
<td>Zone 6</td>
<td>APRU, Good Hope</td>
<td>Dam breeds: Bonsmara, Tswana, Sire breeds: Bonsmara, Suner, Sheep selection: Tswana, Angora goats</td>
</tr>
<tr>
<td>Zone 6</td>
<td>APRU, Boswelatlow</td>
<td>Bulls for breeding program</td>
</tr>
<tr>
<td>Zone 6</td>
<td>Heli (visited)</td>
<td>Composite herd: comparison with (pure) Tswana, Dam breeds: Composite, Tswana. Sire breeds: Composite, Tswana</td>
</tr>
<tr>
<td>Zone 6</td>
<td>Horapedi (visited)</td>
<td>Line 2 Tswana: 300 cows, 10 sires: selection for yearling weight (adjusted to 540 + 14 days)</td>
</tr>
<tr>
<td>Zone 6</td>
<td>Dikgathlong (visited)</td>
<td>Line 1 Tswana: 300 cows, 10 sires: selection for weaning weight (adjusted to 210 + 14 days)</td>
</tr>
<tr>
<td>Zone 5</td>
<td>Matlakilodi, near Kanyo's</td>
<td>Dam breeds: Tuli, Simmental, Sire breeds: Tuli, Simmental, Range experiments</td>
</tr>
<tr>
<td>Zone 5</td>
<td>Matlalakgang, near Molepolole</td>
<td>Dam breeds: Tswana, Sire breeds: Charolais, South Devon</td>
</tr>
<tr>
<td>Zone 5</td>
<td>Morale, near Mahalapye</td>
<td>Tswana goats: selection program, Range experiment work.</td>
</tr>
<tr>
<td>Zone 7</td>
<td>Seleka, in Tuli strip</td>
<td>Dam breeds: Brahman, Tuli, Sire breeds: Brahman, Santa Gertrudis. Stocking rate trials</td>
</tr>
<tr>
<td>Zone 6</td>
<td>Lesego, between Palapye and Francistown</td>
<td>Dam breeds: Tuli, Tswana, Bonsmara, Sire breeds: Tuli, Tswana, Bonsmara (purebred), Tswana goats, used for management programs</td>
</tr>
<tr>
<td>Zone 5</td>
<td>APRU, Tsatsaiku, 40km from Maun (3)</td>
<td>Dam breeds: Tuli, Tswana. Sire breeds: South Devon, Santa Gertrudis. Pasture agronomy work.</td>
</tr>
<tr>
<td>Zone 5</td>
<td>Animal Health &amp; Production Mantswabe, near Molepolole</td>
<td>Used for performance testing; given to Small Stock Unit. Multiplication ranch</td>
</tr>
<tr>
<td>Zone 8</td>
<td>APRU, Xanagas, on border near Ghanzi</td>
<td>Dam breeds: Sussex Brahman. Sire breeds: Tswana, Brahman. Range experiments</td>
</tr>
</tbody>
</table>
Table 6.1 (cont'd)

<table>
<thead>
<tr>
<th>Zone</th>
<th>Site</th>
<th>Livestock Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zone 6</td>
<td>Broadhurst, near Gaborone</td>
<td>Taken over by city council</td>
</tr>
<tr>
<td>Zone 5</td>
<td>Makhi II, near Serowe</td>
<td>Range experiments (grazing trails) buying in young stock from farmers</td>
</tr>
</tbody>
</table>

No ranches in zones:

1 rainfall 600-700mm
2 rainfall 500-600mm; this is the wildlife region
3 rainfall 450-550mm; the area bordering the Okavango Delta around Maun, an important agricultural area
4 rainfall 450-550mm; the Makgadikadi pans area

Ranches only in zones:

5 rainfall 350-500mm; fine sandy soils (5 stations)
6 rainfall 400-500mm (13 stations)
7 rainfall 350-450mm, Tuli strip (1 station)
8 rainfall 200-400mm, medium and fine sands (1 station)
Table 6.2: Present and Proposed Ranch Research Sites

<table>
<thead>
<tr>
<th>Ecological Zone</th>
<th>Mean annual Rainfall (mm)</th>
<th>Present Ranch Research Sites</th>
<th>Area (ha)</th>
<th>Proposed Ranch Research Sites</th>
<th>Area (ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>600-700</td>
<td>None: Miombo area in the North</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>500-600</td>
<td>None: Wildlife region</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>450-550</td>
<td>Tsetseku</td>
<td>1902</td>
<td>Tsetseku</td>
<td>1902</td>
</tr>
<tr>
<td>4</td>
<td>450-500</td>
<td>None</td>
<td></td>
<td>New site in Makgadikgadi area</td>
<td>n/a</td>
</tr>
<tr>
<td>5</td>
<td>350-500</td>
<td>Malchi II</td>
<td>2340</td>
<td>Malchi II</td>
<td>2340</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Matlholakeng</td>
<td>2130</td>
<td>Matlholakeng</td>
<td>2130</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Masama</td>
<td>4283</td>
<td>Masama</td>
<td>4283</td>
</tr>
<tr>
<td>6</td>
<td>400-500</td>
<td>Impala</td>
<td>1612</td>
<td>To be disposed of</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Lesego</td>
<td>3720</td>
<td>Lesego</td>
<td>3720</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Leupane</td>
<td>2991</td>
<td>Leupane</td>
<td>2991</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Morale</td>
<td>1829</td>
<td>Morale</td>
<td>1829</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Boswelatalou</td>
<td>1642</td>
<td>To be disposed of</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sunnyside</td>
<td>1597</td>
<td>Sunnyside</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Goodhope</td>
<td>2295</td>
<td>Goodhope</td>
<td>2295</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Masiatilodi</td>
<td>2186</td>
<td>Masiatilodi</td>
<td>2186</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Musi</td>
<td>6638</td>
<td>Musi</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Morapedi</td>
<td>3910</td>
<td>Morapedi/Dikgatlhong</td>
<td>6250</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Dikgatlhong</td>
<td>2340</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>350-450</td>
<td>Seleka</td>
<td>2338</td>
<td>Seleka</td>
<td>2338</td>
</tr>
<tr>
<td>(Tuli block)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>200-400</td>
<td>Xanagas</td>
<td>3062</td>
<td>Xanagas</td>
<td>3062</td>
</tr>
<tr>
<td></td>
<td></td>
<td>A new site (in Kgalagadi)</td>
<td></td>
<td></td>
<td>n/a</td>
</tr>
</tbody>
</table>

n/a = not available
CHAPTER 7: HUMAN RESOURCES DEVELOPMENT, FUNDING AND MANAGEMENT OF AGRICULTURAL RESEARCH

The small number of trained scientists is the major factor limiting the capacity of the DAR to address the various problems to agricultural production and natural resources management in Botswana.

There are 39 rational professional staff, of whom 11 are away on long-term training. Twelve expatriate scientists are on contract or in projects based in the department. This number is too small to cover the minimum range of priority programs in crops, livestock, and management of natural resources. Furthermore, only two scientists have PhD-level training, and they must dedicate a considerable amount of time to administrative and liaison activities. Even with the need and potential for growth in the Botswana agricultural research system, it will nonetheless remain a relatively small research service of 60-65 scientists.

In a smaller research organization, the duties required of each professional are varied and complex, and individual scientists have responsibility for large areas of a program or linked programs. The level of training required for this type of activity, including the analysis of external sources of information and new technology for adaptation or introduction into Botswana, is at least an MSc. The establishment of a BSc program in the Botswana College of Agriculture facilitates the upgrading of the training of most professional staff to the MSc. and PhD. levels. This perspective has been consistently expressed in the training plans of the Department, and the review team strongly endorses this point.

In addition to being a small service, the DAR is relatively young in experience. For example, the average length of in-post experience of professionals in the Division of Arable Crops Research is 2.5 years, and none has more than 10 years of in-service professional experience. The current level of motivation is high and the turnover rate is low. There is therefore potential to build a core of experienced professionals if sufficient attention is given to providing rewarding conditions of service and career promotion. Recommendations on an improved scheme of service for professional research staff are made in the proposed scheme of service (p. 81).

The level of technical support staff is adequate in both number and level of training, particularly if all the established technical posts are filled. At present the ratio of researchers to technicians is approximately one to three. The number of technical support staff will have to be increased as the number of professionals increases. Table 7.1 provides figures on the existing staff complement within the DAR, including non-technical staff. The existence of an upgraded Botswana Agricultural College provides a sound basis for planned growth in the number and level of professional and technical staff of the Department.
Table 7.1 - Manpower Development for NARS 1988/93

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>In training</td>
<td>27</td>
<td>28</td>
<td>33</td>
<td>36</td>
<td>42</td>
<td>32</td>
</tr>
<tr>
<td>Arriving*</td>
<td>10</td>
<td>8</td>
<td>6</td>
<td>7</td>
<td>10</td>
<td>3</td>
</tr>
<tr>
<td>departing*</td>
<td>-10</td>
<td>-5</td>
<td>--</td>
<td>-5</td>
<td>-2</td>
<td>-2</td>
</tr>
<tr>
<td>Recruitment</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>3</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Total in post</td>
<td>27</td>
<td>33</td>
<td>36</td>
<td>42</td>
<td>52</td>
<td>54</td>
</tr>
</tbody>
</table>

Note: * Arriving & departing for training. 1988, 1989, and 1990 figures are actual and planned respectively. Others are projections.


A desirable and realistic scenario for institutional growth in the DAR over the next 10 years would be to level off at 60-65 researchers and 200 technicians.

Table 7.2 details the human resources required to sustain the core programs. This model can serve as a basis for the medium-term training plan to produce a stable complement of trained scientists with the desired mix of disciplines and skills to staff the core programs. The current annual training plans could be made consistent with a longer-term 5-10-year human resources development plan, based on sustainable scale and scope of the national research system.

Existing Infrastructure and the Distribution of Staff

As noted in Chap. Four, the DAR currently has a large number of ranches and research sites throughout the country. They do not yet constitute a coherent network and are too many in number, often too widely dispersed or too concentrated in a single region to be adequately staffed. At present, only one Botswana researcher is based outside Sebele, at Pandamatenga. Five technical officers and 29 technical assistants are based outside Sebele, the greater part of these on APRU ranches.

The scientific efforts at substations and research sites outside of Sebele are concentrated in the Farming Systems Programs in the vicinity of Francistown and Mahalapye and in the irrigation and farming systems work near Maun. The professional staff members are largely expatriate and project-based so that the capacity of the DAR to continue work in these sites and deploy its scientific and technical manpower is uncertain once the projects come to term.

The reorganization of the program structure and rationalization of infrastructure proposed in Chapters 5 and 6 provide a basis whereby a viable research team may be posted at regional stations focusing on the production systems specific to the region. The major concern will be to keep a critical mass of scientific manpower in the stations to allow for the interdisciplinary exchange that is required for research on production systems.
Table 7.2 - Human Resources (Professional) for Rationalized Programs (in person years)

<table>
<thead>
<tr>
<th>Arable Crops Research</th>
<th>Horticulture</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Cereals (sorghum/millet, maize, wheat)</td>
<td></td>
</tr>
<tr>
<td>1.0 Breeder</td>
<td>1.0 Breeder</td>
</tr>
<tr>
<td>2.0 Agronomists (dry lands)</td>
<td>1.0 Agronomist</td>
</tr>
<tr>
<td>1.0 Agronomist (irrigation)</td>
<td>1.0 Postharvest scientist</td>
</tr>
<tr>
<td>1.0 Entomologist</td>
<td>0.5 Seed scientist</td>
</tr>
<tr>
<td>1.0 Pathologist engineer</td>
<td>0.5 Entomologist</td>
</tr>
<tr>
<td>0.5 Weed scientist</td>
<td>0.25 Weed scientist</td>
</tr>
<tr>
<td>0.5 Seed scientist</td>
<td></td>
</tr>
<tr>
<td>7.0 person years</td>
<td>4.25 Person years</td>
</tr>
<tr>
<td>2. Grain Legumes</td>
<td></td>
</tr>
<tr>
<td>1.0 Breeder/Agronomist</td>
<td>1.0 Breeder</td>
</tr>
<tr>
<td>1.0 Entomologist</td>
<td>2.0 Agronomist</td>
</tr>
<tr>
<td>1.0 Soil scientist (soil fertility)</td>
<td>0.5 Entomologist</td>
</tr>
<tr>
<td>0.5 Plant pathologist</td>
<td>0.5 Plant pathologist</td>
</tr>
<tr>
<td></td>
<td>0.25 Weed scientist</td>
</tr>
<tr>
<td>3.5 person years</td>
<td>4.25 Person years</td>
</tr>
<tr>
<td>3. Soil &amp; Water Management</td>
<td></td>
</tr>
<tr>
<td>1.0 Soil scientist</td>
<td>2.0 Agronomist</td>
</tr>
<tr>
<td>1.0 Soil physicist</td>
<td>2.0 Agricultural economists</td>
</tr>
<tr>
<td>1.0 Agronomist (tillage)</td>
<td>1.0 Soil scientist</td>
</tr>
<tr>
<td>1.0 Agricultural engineer</td>
<td>1.0 Agricultural engineer, animal traction &amp; tillage systems</td>
</tr>
<tr>
<td>0.5 Weed scientists</td>
<td>0.5 Entomologist</td>
</tr>
<tr>
<td></td>
<td>0.5 Plant pathologist</td>
</tr>
<tr>
<td></td>
<td>0.5 Weed scientist</td>
</tr>
<tr>
<td></td>
<td>0.5 Livestock scientist</td>
</tr>
<tr>
<td>5.5 person years</td>
<td>8.0 Person years</td>
</tr>
</tbody>
</table>

| Animal Production and Range Research                                                |                                                                             |
|-------------------------------------------------------------------------------------|                                                                             |
| 1. Beef Program                                                                     |                                                                             |
| 1.0 Breeder                                                                         |                                                                             |
| 1.0 Animal scientist (production, physiology)                                       |                                                                             |
| 1.0 Pasture & range scientist                                                       |                                                                             |
| 3.0 person years                                                                    | 3.0 Person years                                                           |
| 2. Dairy Program                                                                    |                                                                             |
| 1.0 Breeder                                                                         |                                                                             |
| 1.0 Animal scientist (dairy production)                                             |                                                                             |
| 1.0 Nutritionist                                                                    |                                                                             |
| 3.0 person years                                                                    |                                                                             |
| 3. Small Ruminants Program                                                          |                                                                             |
| 1.0 Breeder                                                                         |                                                                             |
| 1.0 Animal scientist (sheep & goat production)                                     |                                                                             |
| 1.0 Nutritionist                                                                    |                                                                             |
| 3.0 person years                                                                    | 2.0 Person years                                                           |
| 4. Feeds Program                                                                    |                                                                             |
| 1.0 Breeder                                                                         |                                                                             |
| 1.0 Nutritionist                                                                    |                                                                             |
| 1.0 Chemist/analyst                                                                 |                                                                             |
| 3.0 person years                                                                    |                                                                             |
| 5. Range & Pasture Program                                                           |                                                                             |
| 1.0 Range scientist                                                                 |                                                                             |
| 1.0 Pasture Agronomist                                                              |                                                                             |
| 1.0 Animal scientist (production)                                                    |                                                                             |
| 3.0 person years                                                                    | 5.5 person years                                                           |

| Production Systems (crop-based)                                                      |                                                                             |
| 1.0 Animal scientist (production)                                                    |                                                                             |
| 1.0 Nutritionist                                                                    |                                                                             |
| 1.0 Range scientist                                                                  |                                                                             |
| 1.0 Livestock economist                                                              |                                                                             |
| 1.0 Animal health scientist                                                           |                                                                             |
| 0.5 Agronomist                                                                       |                                                                             |
| 3.0 person years                                                                    |                                                                             |
Table 7.2 cont’d

Research Services

- 2.0 Laboratory services
- 2.0 Biometrics
- 1.0 Library services
- 2.0 Seed services
- 1.0 Physical plant services
- 1.0 Research/extension liaison services

...person years

Summary

Arable Crops

- 4.0 Plant breeders
- 8.0 General agronomists
- 2.0 Irrigation agronomists
- 4.0 Entomologists
- 2.0 Weed scientists
- 3.0 Plant pathologists
- 3.0 Soil scientists
- 1.0 Soil physicist
- 2.0 Agricultural engineers
- 1.0 Postharvest scientists
- 1.0 Seed scientists
- 2.0 Agricultural economists
- 1.0 Livestock scientist

20.0 TOTAL

Animal Production & Range

- 3.0 Animal breeders
- 5.0 Animal scientists (production)
- 4.0 Nutritionists
- 3.0 Pasture & range scientists
- 1.0 Pasture agronomist
- 1.0 Chemist/analyst
- 1.0 Livestock economist
- 1.0 Animal health scientist
- 1.0 Agronomist (crop/livestock)

19.0 TOTAL

Career Development and Retention of Staff

The Department of Agricultural Research has four career levels in its roster of posts.

Table 7.3 - Roster of Posts

<table>
<thead>
<tr>
<th>Post</th>
<th>Qualification</th>
<th>Salary Grade</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chief Agricultural Research Officer</td>
<td>PhD or MSc experience</td>
<td>D3</td>
</tr>
<tr>
<td>Senior Agricultural Research Officer</td>
<td>MSc + experience or PhD</td>
<td>D4-C1</td>
</tr>
<tr>
<td>Research Officer</td>
<td>MSc</td>
<td>C2-C3</td>
</tr>
<tr>
<td>Assistant Agricultural Research Off.</td>
<td>BSc</td>
<td>C3-C4</td>
</tr>
</tbody>
</table>

The post of Chief Agricultural Research Officer (CARO), which is held by the heads of the two divisions, entails considerable administrative duties. In effect, it means that the scientific career ladder has only 3 steps. Experienced, highly trained agricultural scientists can reach the top of the scale and remain frozen with few rewards, incentives, or recognition for increasing levels of experience and training. Annex II lists the salary scales for relevant posts. Technical officer posts are classed from C1 to C4 and technical assistants are classed from C4 to B2.
The lower grades of research officer provide inadequate compensation for the level of training and responsibility, and it is possible for staff to upgrade their level of training without any corresponding increase in the level of posting.

In addition to salary, the Department provides car and housing allowances which are important in retaining staff. Unfortunately, there is insufficient housing for the number of staff in need of accommodation. Three assistant agricultural research officers have left the department in the last three years due to the low level of compensation and lack of housing. The central station development project funded by Botswana Government Development Funds includes plans to build more housing for DAR staff, but implementation has been slow.

The creation of an expanded and more rewarding career structure for research will entail changes in the existing departmental scheme of service. To allow for promotion and salary increases between and within posts, an increase in the number of staffing levels is required with an overall upgrading of staff. The need to revise the structure will be increasingly necessary in order to maintain parity with staff at the adjacent Botswana Agricultural College who have an equivalent level of training and experience. The following proposals are made following consultations with the current extensive review by the DAR of its scheme of service. The ISNAR mission believes that this would be a suitable and improved basis for creating and sustaining a career service for highly qualified professional scientists required by the DAR.

**Proposed Scheme of Service**

- The position of Director created at the scale E2 level is appropriate
- The position of Deputy Director to share technical and administrative responsibility with the Director should be created at level D1.
- The present positions of Chief Arable Research Officer and Chief Animal Production and Range Research Officer should be upgraded to Assistant Directors (level D2). This would reflect the administrative and technical responsibility that they have over the programs in the Crop Production and Livestock and Range Research divisions.
- There would be six levels of research officer: AARO II, AARO I, ARO, Senior ARO, Principal ARO, and Senior Principal Agricultural Research Officer (SPARO) (D2). The latter would be a new post that would permit career development for professional staff to the level of Assistant Director without the need to move to or create new Assistant Director positions, or to move senior professional scientists into line management positions.
- The position of Chief Technical Officer: who would be a highly experienced professional technologist with many years service should be upgraded to D4 level.
- That a new post of Principal Technical Officer be created at level C1 to provide improved career prospects for productive and long-serving senior technical officers.
The proposed scheme of service, which is a slight modification of what is currently under review, is summarized in Table 7.4.

<table>
<thead>
<tr>
<th>POSITION</th>
<th>SCALE</th>
<th>POSITION</th>
<th>SCALE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deputy Director</td>
<td>D1</td>
<td>Chief Technical Officer</td>
<td>D4</td>
</tr>
<tr>
<td>Assistant Director of Agricultural Research</td>
<td>D2</td>
<td>Principal Technical Officer</td>
<td>C1</td>
</tr>
<tr>
<td>Senior Principal Agricultural Research Officer</td>
<td>D2</td>
<td>Senior Technical Officer</td>
<td>C2</td>
</tr>
<tr>
<td>Principal Agricultural Research Officer</td>
<td>D3</td>
<td>Technical Officer</td>
<td>C3</td>
</tr>
<tr>
<td>Senior Agricultural Research Officer</td>
<td>D4</td>
<td>Chief Technical Assistant</td>
<td>C4</td>
</tr>
<tr>
<td>Agricultural Research Officer</td>
<td>C1</td>
<td>Senior Technical Assistant</td>
<td>B1</td>
</tr>
<tr>
<td>Assistant Agricultural Research Officer Grade I</td>
<td>C2</td>
<td>Technical Assistant Grade I</td>
<td>B2</td>
</tr>
<tr>
<td>Assistant Agricultural Research Officer Grade II</td>
<td>C3</td>
<td>Technical Assistant Grade II</td>
<td>B3</td>
</tr>
</tbody>
</table>

This expanded structure would allow staff to progress in their careers, improve their level of training and responsibility, with commensurate recognition and reward for their duties. It also allows for progression within research, without the obligation to reward good researchers by moving them into administrative positions.

The Department provides several non-salary benefits which are important in the retention of professional staff. Most important among these are the opportunities for further training and participation in professional meetings. Because of the extensive linkages the department maintains with international research centers, bilateral technical assistance agencies, and foreign universities, the direct costs to the DAR are not high. However, in a small NARS such as Botswana's, the demands of travel by senior researchers may affect the performance and output of programs. The trade-offs between the professional rewards provided by travel and international meetings and the demands of commodity systems research programs will have to be carefully managed by DAR's research administrators.

Given the considerable investment that is made in training agricultural scientists, the Department will need to propose a career structure and conditions of service that will enable it to retain the core staff it needs and provide continuity in its research programs. The ISNAR review team considers that this is entirely possible without major changes in the structure of the Department within the MOA and the civil service in general.
Expenditure and Funding for Agricultural Research

The Department of Agricultural Research receives the bulk of its funding from the Government of Botswana. This demonstrates, in practice, the strong commitment of Government to support agricultural research for development. The annual budget of the DAR is divided into a capital and recurrent expenditure budget provided entirely by Government, and a development budget in which approximately 2/3 of the funds are derived from donors.

The recurrent/capital budget of the DAR has increased in absolute terms.* It is now at a level of 7,854,500 Pula for the budget year 1990/91. At this level of funding, roughly equivalent to 4.25 million US dollars, the funding per national scientist is approximately 109,000 dollars per year.

This gives an indication of the level of resources needed to support the work of an agricultural scientist. Of the total, much of the expense is fixed by salaries and maintenance. The DAR will need to have sufficient operational funding on hand for conducting new research activities. Future growth in the number of scientists will require corresponding growth in funding for research operations. The DAR has made efficient use of the financial resources available to it, and would be in a good position to direct additional funding to develop the research capacity that is needed.

The development budget of the DAR is where most of the external funding is allocated, usually in special projects such as ATIP, Mpandamatenga, or Agricultural Development Ngamiland (ADN). In the budget years from 1983/84 to 1989/90, a total of 7,403,972 Pula has been allocated to this fund. Of this total, 2,433,184 Pula or approx. 33% of the funds has come from Government of Botswana's Domestic Development Funds (DDF); the remainder from a variety of donor agencies, universities, and private institutions. While donor support averaged 828,464 Pula a year, most of the donor projects have ended or will come to term by 1991. The level of donor funding has in fact declined considerably over the last three years. This will require a clear strategy by the DAR to assure from Government and external sources a stable base of funding for its core programs in the next 5 to 10 years.

The mission noted the clear policy statements by Government of Botswana and the MOA; in particular, of the importance of research to agricultural and rural development. This policy can be reinforced by noting the diminishing dependence upon donor funding and the need to maintain a stable level of funding relative to other departments in the Ministry. As shown in Table 7.5, the relative share of MOA funding to the DAR's recurrent budget has declined since 1984. Since the DAR will be called upon to play a crucial role in the new development strategy for Botswana's agricultural sector, this relative imbalance should be corrected. It is, however, realized that the situation may not be as serious as it looks because there are some direct payments made by donor agencies which go into the Development budget but are not necessarily reflected in the MOA development expenditure as shown in Table 7.5.

Table 7.5 - Capital and Recurrent Budget of the DAR

<table>
<thead>
<tr>
<th>Year</th>
<th>Amount in Pula</th>
<th>Recurrent Expenditure</th>
<th>% of MOA Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1983/84</td>
<td>2,662,096</td>
<td></td>
<td>11.3%</td>
</tr>
<tr>
<td>1985/86</td>
<td>3,358,281</td>
<td></td>
<td>10.5%</td>
</tr>
<tr>
<td>1986/87</td>
<td>4,720,588</td>
<td></td>
<td>10.4%</td>
</tr>
<tr>
<td>1987/88</td>
<td>4,468,486</td>
<td></td>
<td>8.9%</td>
</tr>
<tr>
<td>1988/89</td>
<td>5,048,900</td>
<td></td>
<td>8.2%</td>
</tr>
<tr>
<td>1989/90</td>
<td>6,918,810</td>
<td></td>
<td>8.7%</td>
</tr>
<tr>
<td>1990/91 (estimate)</td>
<td>7,854,500</td>
<td></td>
<td>8.8%</td>
</tr>
</tbody>
</table>

Table 7.6 - MOA Contributions to Development Budget of DAR

<table>
<thead>
<tr>
<th>Year</th>
<th>Amount in Pula</th>
<th>Development Expenditure</th>
<th>% of MOA Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1983/84</td>
<td>562,408</td>
<td></td>
<td>5.2%</td>
</tr>
<tr>
<td>1985/86</td>
<td>443,302</td>
<td></td>
<td>1.4%</td>
</tr>
<tr>
<td>1986/87</td>
<td>607,062</td>
<td></td>
<td>.9%</td>
</tr>
<tr>
<td>1987/88</td>
<td>429,636</td>
<td></td>
<td>.5%</td>
</tr>
<tr>
<td>1988/89</td>
<td>33,873</td>
<td></td>
<td>.001%</td>
</tr>
</tbody>
</table>

Average Market Exchange Rate:

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1983</td>
<td>= .82 US$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1985</td>
<td>= .43 US$</td>
<td>1984</td>
<td>= .65 US$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1986</td>
<td>= .44 US$</td>
<td></td>
<td></td>
<td>1985</td>
<td>= .43 US$</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1989</td>
<td>= .54 US$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1988</td>
<td></td>
</tr>
</tbody>
</table>

In the area of management of human and financial resources, the DAR has demonstrated a careful management of resources. As a result, there is a sound basis for the institutional growth that will be needed to address the priority commodity and systems programs that respond to the emerging policy for developing the agricultural sector in Botswana. Implementation capacity of the DAR is a constraint but this is expected to improve substantially in the next five years.
Budget allocations of the DAR in Pula
1990-1991

- Salaries (55.90%)
- Materials (24.29%)
- Special (2.66%)
- Maintenance, Running and Equip. (2.86%)
- General Expenses and Supplies (8.26%)
- Departmental Services (2.71%)
- Travel and Transport (3.06%)
- Training (0.27%)

### Table 7.7 - Ministry of Agriculture - Expenditure - 1989/90
#### Department of Agricultural Research
(All amounts in Pula)

<table>
<thead>
<tr>
<th>Description</th>
<th>Actual Expenditure to 31/3/89</th>
<th>Authorized Expenditure at 31/12/89</th>
<th>Estimate 1990/91</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Personal Emoluments</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Basic Salary</td>
<td>1,414,589</td>
<td>1,782,620</td>
<td>2,014,920</td>
</tr>
<tr>
<td>Allowances</td>
<td>44,112</td>
<td>87,060</td>
<td>67,260</td>
</tr>
<tr>
<td>Industrial Class</td>
<td>1,309,548</td>
<td>1,647,820</td>
<td>1,813,950</td>
</tr>
<tr>
<td>Casual Labor</td>
<td>259,864</td>
<td>361,880</td>
<td>362,920</td>
</tr>
<tr>
<td>Temporary Assistance</td>
<td>8,631</td>
<td>20,810</td>
<td>16,130</td>
</tr>
<tr>
<td>Maintenance of Volunteers</td>
<td>1,672</td>
<td>1,520</td>
<td>2,280</td>
</tr>
<tr>
<td>Training Post Allowances</td>
<td>57,222</td>
<td>65,320</td>
<td>66,730</td>
</tr>
<tr>
<td><strong>Subtotal</strong></td>
<td>3,095,638</td>
<td>3,967,030</td>
<td>4,344,190</td>
</tr>
<tr>
<td><strong>Travelling &amp; Transport (internal)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Transportation Costs</td>
<td>74,981</td>
<td>90,500</td>
<td>94,930</td>
</tr>
<tr>
<td>Subsistence Costs</td>
<td>68,478</td>
<td>69,800</td>
<td>76,470</td>
</tr>
<tr>
<td>Freight</td>
<td>73</td>
<td>2,000</td>
<td>1,000</td>
</tr>
<tr>
<td><strong>Subtotal</strong></td>
<td>143,532</td>
<td>162,300</td>
<td>172,400</td>
</tr>
<tr>
<td><strong>Travelling &amp; Transport (external)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Transportation Costs</td>
<td>5,397</td>
<td>27,950</td>
<td>33,900</td>
</tr>
<tr>
<td>Subsistence Costs</td>
<td>37,392</td>
<td>26,600</td>
<td>30,200</td>
</tr>
<tr>
<td><strong>Subtotal</strong></td>
<td>42,989</td>
<td>54,550</td>
<td>64,100</td>
</tr>
<tr>
<td><strong>General Expenses &amp; Supplies</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Domestic Household Requisites</td>
<td>2,387</td>
<td>2,600</td>
<td>3,000</td>
</tr>
<tr>
<td>Incidental Expenses</td>
<td>1,023</td>
<td>1,500</td>
<td>1,820</td>
</tr>
<tr>
<td>Office Supplies</td>
<td>35,622</td>
<td>40,000</td>
<td>42,750</td>
</tr>
<tr>
<td>Postal Charges</td>
<td>2,601</td>
<td>8,000</td>
<td>8,400</td>
</tr>
<tr>
<td>Service Charges</td>
<td>458,260</td>
<td>516,000</td>
<td>542,500</td>
</tr>
<tr>
<td>Uniforms &amp; Protective Clothing</td>
<td>26,964</td>
<td>34,000</td>
<td>40,000</td>
</tr>
<tr>
<td><strong>Subtotal</strong></td>
<td>526,857</td>
<td>602,100</td>
<td>638,470</td>
</tr>
<tr>
<td><strong>Departmental Services</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Crop Research</td>
<td>25,668</td>
<td>31,900</td>
<td>40,400</td>
</tr>
<tr>
<td>Disease &amp; Pest Control</td>
<td>3,906</td>
<td>16,300</td>
<td>20,000</td>
</tr>
<tr>
<td>Laboratory Supplies</td>
<td>20,514</td>
<td>36,300</td>
<td>40,300</td>
</tr>
<tr>
<td>Livestock Purchases</td>
<td>30,638</td>
<td>43,300</td>
<td>3,750</td>
</tr>
<tr>
<td>Stores</td>
<td>49,756</td>
<td>40,000</td>
<td>49,310</td>
</tr>
<tr>
<td>Range Research</td>
<td>24,143</td>
<td>10,810</td>
<td>16,000</td>
</tr>
<tr>
<td>Dairy Research</td>
<td>19,605</td>
<td>22,000</td>
<td>24,000</td>
</tr>
<tr>
<td>Animal Nutrition Research</td>
<td>---</td>
<td>---</td>
<td>3,000</td>
</tr>
<tr>
<td>Field Investigations</td>
<td>---</td>
<td>---</td>
<td>13,000</td>
</tr>
<tr>
<td><strong>Subtotal</strong></td>
<td>174,230</td>
<td>201,210</td>
<td>209,760</td>
</tr>
</tbody>
</table>
### Table 7.7 (continued)

<table>
<thead>
<tr>
<th>Description</th>
<th>Actual Expenditure to 31/3/89</th>
<th>Authorised Expenditure at 31/12/89</th>
<th>Estimate 1990/91</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Maintenance &amp; Running Expenses (Equipment)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fire Fighting Equipment</td>
<td>---</td>
<td>2,000</td>
<td>2,000</td>
</tr>
<tr>
<td>Heavy Mobile Plant</td>
<td>4,608</td>
<td>11,000</td>
<td>12,000</td>
</tr>
<tr>
<td>Implements, Agricultural</td>
<td>10,941</td>
<td>25,700</td>
<td>29,070</td>
</tr>
<tr>
<td>Radio &amp; Transmitter Equipment</td>
<td>7,601</td>
<td>9,900</td>
<td>12,500</td>
</tr>
<tr>
<td>Static Plant</td>
<td>15,662</td>
<td>19,800</td>
<td>29,800</td>
</tr>
<tr>
<td>Bicycles</td>
<td>394</td>
<td>600</td>
<td>660</td>
</tr>
<tr>
<td>Laboratory Equipment</td>
<td>10,556</td>
<td>14,300</td>
<td>14,000</td>
</tr>
<tr>
<td><strong>Subtotal</strong></td>
<td>49,762</td>
<td>83,300</td>
<td>100,030</td>
</tr>
<tr>
<td><strong>Maintenance &amp; Running Expenses (Other)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Buildings</td>
<td>37,091</td>
<td>54,000</td>
<td>57,750</td>
</tr>
<tr>
<td>Grounds</td>
<td>564</td>
<td>1,500</td>
<td>1,650</td>
</tr>
<tr>
<td>Livestock</td>
<td>76,521</td>
<td>83,700</td>
<td>98,000</td>
</tr>
<tr>
<td>Water Supplies</td>
<td>11,908</td>
<td>26,200</td>
<td>35,400</td>
</tr>
<tr>
<td>Ranches</td>
<td>21,729</td>
<td>24,000</td>
<td>28,000</td>
</tr>
<tr>
<td><strong>Subtotal</strong></td>
<td>147,813</td>
<td>189,400</td>
<td>220,840</td>
</tr>
<tr>
<td><strong>Training</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Allowances</td>
<td>15,961</td>
<td>18,790</td>
<td>21,000</td>
</tr>
<tr>
<td><strong>Subtotal</strong></td>
<td>15,961</td>
<td>18,790</td>
<td>21,000</td>
</tr>
<tr>
<td><strong>Materials and Requisites for Resale</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Purchase of Materials</td>
<td>1,201,735</td>
<td>1,274,650</td>
<td>1,657,550</td>
</tr>
<tr>
<td>Dairy Reference Herd</td>
<td>55,442</td>
<td>75,000</td>
<td>82,500</td>
</tr>
<tr>
<td>Cattle for Makhi II Grazing Cell</td>
<td>32,555</td>
<td>57,350</td>
<td>70,200</td>
</tr>
<tr>
<td>Horticultural Production Economics</td>
<td>17,929</td>
<td>40,000</td>
<td>67,640</td>
</tr>
<tr>
<td><strong>Subtotal</strong></td>
<td>1,307,661</td>
<td>1,447,000</td>
<td>1,877,890</td>
</tr>
<tr>
<td><strong>Special Expenditure</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Agricultural Implements</td>
<td>287</td>
<td>27,000</td>
<td>5,000</td>
</tr>
<tr>
<td>Air Conditioners</td>
<td>5,954</td>
<td>13,200</td>
<td>6,600</td>
</tr>
<tr>
<td>Camping and Weather Protection Equipment</td>
<td>4,942</td>
<td>6,000</td>
<td>2,790</td>
</tr>
<tr>
<td>Furniture and Equipment</td>
<td>9,841</td>
<td>13,000</td>
<td>7,910</td>
</tr>
<tr>
<td>Laboratory Equipment</td>
<td>52,937</td>
<td>26,200</td>
<td>90,500</td>
</tr>
<tr>
<td>Photographic Equipment</td>
<td>575</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Recording &amp; Broadcasting Equipment</td>
<td>10,280</td>
<td>10,000</td>
<td>10</td>
</tr>
<tr>
<td>Rondavels &amp; Site Accommodation</td>
<td>7,844</td>
<td>39,230</td>
<td>30,000</td>
</tr>
<tr>
<td>Scales, Counter and Platform</td>
<td>6,041</td>
<td>9,000</td>
<td>10</td>
</tr>
<tr>
<td>Water Development Equipment</td>
<td>7,716</td>
<td>39,000</td>
<td>20,000</td>
</tr>
<tr>
<td>Fences</td>
<td>8,793</td>
<td>10,500</td>
<td>28,000</td>
</tr>
<tr>
<td>Range Research Equipment</td>
<td>--</td>
<td>--</td>
<td>15,000</td>
</tr>
<tr>
<td><strong>Subtotal</strong></td>
<td>115,210</td>
<td>193,130</td>
<td>205,820</td>
</tr>
<tr>
<td><strong>Grand Total</strong></td>
<td>5,619,413</td>
<td>6,918,810</td>
<td>7,854,500</td>
</tr>
</tbody>
</table>

Source: Republic of Botswana, 1990-1991. Estimates of Expenditure from Consolidated and
CHAPTER 8: LINKAGES FOR AGRICULTURAL RESEARCH

The Department of Agricultural Research, in the planning, organization, and management of research, needs to develop and maintain effective linkages with its environment. In order to be responsive, the DAR should in the first place maintain linkages with policymakers and the policy environment in order to translate Government development and research policies into viable programs of research. Other types of linkages are required to enable it to generate and deliver outputs (information, materials, and technologies) to the users of research results (farmers, and producers) who are the ultimate clients of the research system. Also, given the fact of Botswana's small research system, with a limited scope and size, essential linkages will need to be developed and maintained with regional and international sources of knowledge and relevant technologies that could be selected and adapted for use in the country.

The development and maintenance of linkages costs money and time and therefore it is necessary for a research system to carefully select the linkages which on priority basis are most crucial to the efficient performance of its functions. The most crucial linkages are those that directly influence elements of the research process, such as priority setting and program development, program execution, program results and output delivery, and feedback to research from the immediate and ultimate users of research results. In these cases there is need for effective two-way communication with policymakers, technology transfer systems (mainly the extension services and development agencies), technology users (farmers and producers), and collaborative programs and agencies (both external and internal) in program execution. These linkages must reflect the appreciation of a research continuum which goes from the conceptualization and development of priority programs through the organization and management of such programs, to the generation, testing and validation of results at the farm level and the provision of feedback to research.

One of the features of the Botswana agricultural research and development community is the degree to which consultations take place within it. This in itself creates the opportunity for the development and maintenance of linkages. The linkages should be focused in the critical areas where inputs into the research process are essential. A review of the range of linkages considered important for the Department of Agricultural Research indicates that these fall broadly into two categories. The first category comprises:

- policymakers
- extension services
- the Botswana Agricultural College
- farmers and producers;

and the second category comprises:

- development agencies
- non-government organizations
- regional and international organizations
- the University of Botswana (NIR) and the rest of the scientific community
- donor and technical assistance agencies.
First Category of Linkages

The first category of linkages was considered to be the most critical for the development of the DAR's research programs and orienting them to the priority development needs of Botswana.

The linkages with each of these groups in the first and second categories were reviewed and analyzed by the team in respect of their importance and relevance, and the effectiveness of their inputs into the research process; and recommendations were made as appropriate.

(i) Policymakers

This category covers senior officials with the responsibility for formulating Government agricultural research and development policies. The most relevant group in this category is the Agricultural Policy Committee (APC) chaired by the Permanent Secretary, Ministry of Agriculture. In addition, there are other policymakers in the Ministry of Finance & Economic Planning, Ministry of Commerce & Industry (Department of Wildlife & National Parks), Ministry of Mineral Resources & Water Affairs (Department of Water Affairs), and the proposed Ministry of Natural Resources. DAR requires linkage with this group specifically for providing guidance on national agricultural development policies, their implications for other sectors, and how these policies might be translated into agricultural research policies.

DAR is suitably placed as a Department within the Ministry of Agriculture with organic links to the Ministry and other departments within the Ministry. It could also link with other related ministries through the APC and through the good offices of the Ministry of Agriculture. However, the fact that DAR is a department within the Ministry of Agriculture does not necessarily guarantee effective linkages; neither does it guarantee the flow of inputs from the Ministry and extra-ministerial connections into the research process. Our review indicated that the guidance provided by the Ministry through this linkage has remained at the level of general policy guidelines. The burden of translating these into research policies has therefore fallen squarely on the DAR as a department.

It would seem desirable that an active two-way flow of information and dialogue should be developed as a basis of the policy-research linkage. As a result, the DAR could contribute its ideas on the research opportunities and possibilities; and the APC could provide the DAR with more precise and specific guidance on research policies that contribute to achieving national development objectives. The team has therefore recommended that an Agricultural Research Subcommittee of the APC be constituted to deliberate specifically on the subject of agricultural research policy as a distinct component of development policies. As an alternative, special sessions of the APC could be set aside to discuss and deliberate on the national agricultural research policy.
Such deliberations would only be meaningful and productive if sufficient analytical information on research opportunities and potential are prepared and presented to it by the Directorate of DAR and the other technical departments. The DAR and the DPS are encouraged to take a lead in undertaking this task as part of their contribution to the research policy and program formulation procedures for DAR (Fig.6).

In general, it would not be necessary for the subcommittee to meet more than once a year, except perhaps after the promulgation of new development plans and articulation of new development policies requiring in-depth review of agricultural research policies. The team considers that national agricultural research policies are too important to leave entirely to the scientists. Their development is a joint responsibility of policymakers and researchers. Improved mechanisms for the discharge of this joint responsibility are fundamental for the development of effective linkages between policymakers and the DAR.

**Extension services and the research-extension linkage**

It is generally well accepted that for a research department to effectively address development-oriented problems it is essential to develop effective linkages with the extension services. In many cases, the extension services are seen as separate functional entities whose focus should be the dissemination and diffusion of technologies to the farming community. While this focus represents a large proportion of the functions of the extension services, it does not emphasize the fact that there is a continuing interface between extension services and research which starts from the identification of researchable problems, through the phases of technology development, technology testing and feedback to research which requires very close linkages between research and extension. The research continuum also involves those several phases in which the degree of participation of research decreases as one moves from problem identification through technology design and development to technology testing and demonstration of technologies on farmers' fields. Also in the training of extension staff personnel, and in some cases farmers, research and extension services need to link very closely to ensure that technologies are effectively transferred and feedback is provided to research.

In Botswana, extension services are based in the sister departments of Crop Production and Forestry (formerly the Department of Agricultural Field Services - DAFS) and Animal Health and Production, which maintain a network of field staff in the different agro-ecological zones and regions of the country. These services demand information and improved technologies from research as a basis for their advice to farmers and have always shown the willingness to cooperate with research in bringing the results of research to the users of these results.
Our review showed that linkages between research and extension could be improved considerably for the benefit of farmers and producers. At present, linkages are informal and unstructured; and the interactions in the planning of research programs are very limited. The network of field staff of the extension services also have very limited contact with research staff, and there is no specific provision for formal contacts between research and extension staff in the field or at headquarters. There is often the complaint that research is usually reluctant to release its findings and recommendations for testing by the extension services. While research has, and should have, the vested interest to ensure that it retains the confidence of the users of its results, it would seem desirable that it should cooperate more with the extension services in the testing of technologies at the farm level, even before the improved technologies are considered fully ripe for release. Such cooperation would provide the opportunity for both research and extension services to learn about the farmers' circumstances and the management of technologies at this level, and would provide essential feedback to research. Cooperation of this nature exists in some of the farming systems projects.

In order to improve the linkages between research and extension services at the central and regional levels, it is recommended that the extension services be involved in the planning and review of research programs at the Program Committee and the Departmental Research and Technical Committee levels. Provisions should be made for this participation in terms of time and other resources. At the regional levels, it is recommended that the regional research teams, especially the production systems team, should work closely with the extension services in the diagnosis and identification of researchable problems, the design and development of technologies and the testing of these technologies. As far as possible, DAR should establish its facilities in close proximity to and in collaboration with the regional extension services. The regional research stations should be developed as the focal points for interaction with the regional extension services. Among the important joint activities should be:

- the planning and supervision of technology development, testing, verification, and demonstration trials;

- the organization of the training programs for subject-matter specialists and field extension workers;

- the organization of workshops, seminars, training sessions, and informal discussions for researchers and senior extension and agricultural development staff;

- the review of research results and ongoing research and extension programs to determine ways of strengthening the delivery of research outputs to farmers and producers.
In recognition of the need to strengthen and formalize these linkages between research and extension, the Ministry of Agriculture has created a senior post of Research Extension Liaison Officer (RELO). He was originally placed in the former DAFS, but in view of his multi-departmental functions of liaison and following the recommendations of the Agricultural Sector Assessment, it has been proposed that he should be placed under the office of the Deputy Permanent Secretary who coordinates inter-departmental activities in the Ministry. The mission considered this proposition and concluded that while on the surface it would appear logical to have the RELO in a relatively independent position, such a placement would amount to placing him in "no-man's territory", which would reduce his effectiveness as a liaison officer between research and extension. In view of the fact that research has the primary need for strengthening the linkages with the extension services and with development, the team recommends that the position of RELO be placed in the DAR and supported with specific resources to provide liaison with extension services and development. By this arrangement the office of RELO would not "fall between the cracks" but would have a base from which it could actively provide liaison services between research and the development departments of Crop Production and Forestry, Animal Production Health and, Ministry-based development projects, and other development agencies. If there was no position of RELO, DAR would have had to create this to cater for improved linkages between research and technology transfer systems.

A carefully worked out job description should be prepared for the RELO by the National Research and Technical Committee. This job description should take into account such functions as:

- providing inputs into the planning of research and extension programs;
- organizing training workshops for extension staff;
- organizing a review of research results and the development of technology recommendations;
- organizing cooperative field trials for technology testing and validation;
- producing, or assisting in the production of, training and information materials;
- organizing demonstrations, field days, and other events for the interaction of research and extension staff and farmers;
- organizing joint diagnostic and technology development studies linking research and extension services teams in the various agro-ecological regions.

In the recommended structure of the DAR, the RELO has been placed in the Support Services under the Director. He would be the professional head of a unit of research liaison services to serve research, extension and development. This suggests that the RELO would have his own modest support staff to assist in the performance of the above functions.

The development of this unit to provide an effective liaison between research and extension should be considered an important element of a strategic plan for the development of DAR's research and services.
The Botswana Agricultural College shares research, teaching and service facilities with DAR, and a smooth working relationship has developed over the years between these two departments of the Ministry of Agriculture. Until recently, the College provided middle-level agricultural training at the Certificate and Diploma levels, and its demands on DAR for assistance in the teaching and support programs have been modest. The BAC has now embarked on the BSc (Agriculture) degree program, and the first degree students were admitted in 1988. BAC is evolving into a constituent college of the University of Botswana and a separate parastatal under the Ministry of Agriculture. In addition to the current certificate, diploma, and degree programs, new programs at the diploma level in Agricultural Education and in Agricultural Irrigation/Engineering and short in-service specialist courses are planned in the very near future.

These developments are likely to draw heavily on the DAR for assistance in the teaching and research support programs, certainly in the early years and until additional staff have been recruited and facilities upgraded or built to cater for the new programs. Also, as the degree program staff are recruited, it is believed that there will be an increase in the volume and type of research activities of the staff of BAC, and this will call for improved research facilities and arrangements for collaborative research with the DAR. These are desirable developments in many ways, but they will call for sacrifices on both sides until a stable situation is attained and mutually beneficial and balanced relationships are established. The great strength of this linkage, if it is properly planned and developed, would be efficiency in the utilization of scarce human and material resources in the development of related research and training capacity. Among the facilities that can be jointly developed and shared are the Library, which we recommend should be developed as the nucleus of a National Agricultural Library (See Chapter 6), research laboratories in plant, animal and soil sciences, conference and seminar rooms, etc. In the future, it should be possible for the DAR and BAC to develop a joint M.Sc. program which would further link DAR researchers and the academic and research staff of BAC more intimately in teaching and research, and in the proposed Continuing Education Program.

Since the BAC is to become a separate parastatal under the Ministry of Agriculture, we recommend that a Memorandum of Understanding be developed as a basis of the linkage and collaboration between DAR and BAC. The memorandum of understanding should inter alia cover areas of collaboration in teaching, research, sharing of facilities, planning, and station development, and should explore the possibility of joint appointments. It has been recommended that BAC be represented on the National Research and Technical Committee and on program committees in the reorganized programs structure of the DAR. Reciprocal representation on similar committees of the BAC would facilitate and promote the linkages that must be developed and strengthened as both organizations develop over the next few years.
Farmers and producers

Farmers and producers in arable crops and livestock are the ultimate clients of agricultural research. It is desirable that DAR should establish effective linkage with farmers so as to ensure their inputs into the research planning and programming processes and to obtain valuable feedback from them on the research outputs and the relevance and profitability of these outputs. It would be useful to have a representative of the Farmers' Association on the Departmental Research and Technical Committee and if possible at the Agricultural Policy Committee level in the Ministry. In particular, DAR should encourage the participation of farmers in the research programming exercises of the production systems research at the regional stations. Regional stations should be the focal points of close interaction with farmers, and facilities should be developed to promote the interaction of research staff with farmers at the stations through training workshops, field days, and demonstrations. The involvement of DAR in cooperation with extension in technology testing and adaptation at the farm level would ensure that farmers' views are taken into account in the development and adaptation of technologies. DAR should recognize farmers as one of the most important client groups and should make provision for staff at the Central and Regional Research Stations to interact with them on a continuing basis.

Second Category of Linkages

The second category of linkages considered desirable for DAR fall broadly into National Development Agencies and Projects; Non-Governmental Organizations (NGOs); regional and international organizations; the University of Botswana and the scientific community; donor and technical assistance agencies.

The national development agencies and projects are users of research results and therefore create the demand for research products and outputs that enable them to contribute to rural development. Linkages need to be established and maintained with them, covering specifically the opportunities for them to contribute to ideas about production and development constraints that should be addressed through research, and the opportunities to obtain information and materials that could be tested in their development projects with feedback to research. In nearly all cases these agencies can afford to provide for and fund these linkages and all that is required for research to create the opportunities and access to enable them to benefit from these linkages. Some of the agencies that are important in the Botswana context are the Botswana Development Corporation (BDC), the Rural Industries Innovation Center (RIC), the Botswana Livestock Development Corporation (BLDC), the Botswana Technology Center (BTC), the Botswana Agricultural Marketing Board (BAMB), and the Botswana Meat Commission (BMC).
Non-governmental organizations are generally involved in development activities that require information and materials from research. Occasionally they may also undertake some forms of development research and technology adaptation that could meaningfully complement what DAR is doing. It is important that DAR should keep itself up-to-date in respect of the activities of these organizations and seek complementarity with them. DAR should make appropriate information and materials available to them to stimulate their development activities. These linkages can be forged at very little cost by inviting organizations such as Thusano Lefashong, Botswana Forestry Association, and Kalahari Society, to major demonstrations and information sessions; e.g., open days and field days of the DAR.

Regional and international organizations are crucial to the development of research programs at DAR. They are the major means of access to improved germplasm materials and relevant technologies that should form the basis of DAR's major research thrust in the adaptive and technology-testing research. There is need for selective establishment of linkages with these regional and international organizations that have mandates for the major commodity and systems programs that form the core of DAR's research. Linkage with SACCAR as the major regional research organization in the SADCC region is well developed and has assisted the DAR in addressing issues in the human resources development area, in commodities such as sorghum, millet, groundnuts, and cowpeas, in systems and factor research in soil/water management, and in aspects of farming systems research. Useful linkages have been developed with IITA, ICRISAT, IBPGR, ILCA, and other international agricultural research centers (IARCs); these linkages should be strengthened for inputs into the commodity and systems programs and the development of human resources. In some cases linkages would need to be developed with developed-country institutions and research centers especially in areas such as biotechnology, so as to bring relevant aspects of modern science and results of strategic research to bear on addressing some of the critical problems of research in the country.

The University of Botswana. The National Institute for Development Research (NIR), and other departments in the Faculties of Science and Social Sciences, especially departments such as the Department of Environmental Sciences, Botany and Zoology, and the rest of the scientific community in Botswana have major contributions to make to the conceptualization and review of agricultural and related research in the country. DAR needs linkages with these groups because of the expertise they can bring to research planning and collaborative research. An example is the major study on Environment and Development in Botswana that was undertaken by the NIR and which provides a sound basis for the planning of research on resources productivity and management. Such studies and current programs in the Department of Environmental Sciences help to set the agenda in many areas of natural resources conservation. The most useful way of linkage with the scientific community is through the exchange of information on current and planned research programs, the development of joint study projects, and the participation of representatives from this group in the research planning and evaluation activities of DAR. It is suggested that one way of strengthening the linkage between the NIR, the University of Botswana, and DAR is through reciprocal representation on each other's research committees. DAR should also make provisions for the representation of other major groups of the scientific community on its committees on an ad hoc basis or on the basis of coopted expertise as needed.
Donor and technical agencies have important influences on the development of the research system in Botswana. This influence is exercised mainly through the development of research and research-related projects in collaboration with GOB. DAR needs to recognize these donors and technical assistance agencies as important partners in the development and implementation of the research strategy. DAR should maintain linkages with the most important and active donors in determining priority areas of assistance, in channelling these areas of assistance into strengthening the research programs, and in formulating projects for future areas of growth and development. In order to strengthen these linkages, DAR should provide for a free flow of information on current and planned activities and engage in periodic dialogue on areas and scales of assistance required. Among the donors and technical assistance agencies active in Botswana, the following have provided assistance to DAR: NORAD, USAID, ODA, GTZ, SIDA, SAREC, IFAD, IDRC, EEC, UNDP, FAO, the French Government, and the Netherlands Government. Visits and discussions with many of these donors and agencies indicated that there is a high level of commitment to continuing support of agricultural research in Botswana. A reorganized and strengthened Department of Agricultural Research can create a favorable environment for donor support for both its medium- and long-term strategic plan to strengthen and develop the research system in Botswana.
CHAPTER 9: STRATEGIC PLANNING FOR BOTSWANA'S NATIONAL AGRICULTURAL RESEARCH SYSTEM: OBJECTIVES AND RECOMMENDATIONS

The review team examined all aspects of Botswana's Agricultural Research System focusing on the DAR within the Ministry of Agriculture. The Department has developed considerably over the past decade, and significant advances and contributions have been made, such as the merger of crops and livestock research units. A creditable infrastructure and facilities have been created at Sebele, and a dedicated and well-trained group of scientists and technicians has been assembled.

The thrust of this review is to look to the future to plan the growth of the system, to make the most efficient use of the available resources, and to work effectively to meet the agricultural development goals and the needs of Botswana's crop and livestock producers. A crucial task in the case of Botswana, with its small population, shortage of trained manpower, fragile agricultural resource base, and the large number of valid and competing demands for development resources, is to design a research system whose size and capacity can be sustained in the long run through a combination of government, donor, and private sector support. The Government of Botswana has a demonstrated record of solid support for agricultural research for development. As the DAR is called to address the problems of farmers under the new agricultural development strategy, it will have to work closely with policymakers to assure a level of support and institutional growth that Government can sustain in the long term.

The DAR will also have to focus its efforts more directly on the priority problems by reorganizing its programs and programming process. The result of this will be a scope of research that is consistent with the resources and support available and meets the long-term policy objectives of Government and the needs of the agricultural industry.

A strategic plan would be a logical way to define the vision and mandate of research for the next decade. It would also set forth the size and scope of the NARS. The result will be a system with more efficient use of resources and more relevant and effective outputs.

The ISNAR mission concluded that the current environment in Botswana is very favorable for the strategic planning of agricultural research. The GOB has begun to redefine the strategy for developing the sector as a whole, and has demonstrated strong support and high recognition of the role of research. The DAR has begun discussions to strengthen its own capacity, sharpen its focus, and improve its management.

The key elements of the strategic plan for NARS are to:

- establish a forward-looking vision for the agricultural research system;
- define a clear statement of mission and institutional mandate(s) for research;
- determine an optimum size for the research system that is sustainable and consistent with existing and planned levels of resources;
- identify the major resources - human, financial, and physical - that will be needed and can realistically be obtained and maintained;
- define the organization and structure that is best suited to meet the long-term objectives;
- identify the principal clients and beneficiaries of research;
- set the scope of research: i.e., organize the number of programs, their intensity and focus, that is consistent with the resources and best meets the needs of policymakers and clients.

The overall thrust of the recommendations falls into three broad areas. First, they consider the scope of research in terms of the structure of the programs and the organization of the programming process. Second, they suggest a modest restructuring of divisions within the DAR to better accommodate the sharper program focus. Third, they discuss the organization of linkages between the DAR, policymakers, other components of the research system, clients, and other stakeholders.

The recommendations which follow could be considered as inputs into the strategic planning process or as implementable components to strengthen national research capacity.

Recommendations:

Concerning the organization and structure of research, it is recommended that:

1. the internal structure of the DAR for the development and management of the research programs be modified to allow for the creation of a Deputy Director (D1) position to assist the Director in the scientific and technical leadership of the Department;
2. The position of Chief Arable Crops and Chief Animal Production and Range Research Officers be upgraded to Assistant Directors (D2) (Chapter 4);
3. the divisions be headed by assistant directors to provide scientific leadership and manage the overall research process of the various programs (see Chapter 4);

Concerning the network of research stations and facilities, it is recommended that the rationalization of the research station network be adopted based on a central station, regional stations, and sub-stations (see Chapter 4, Fig. 4); that where possible, activities of both crops and livestock divisions be managed from the same station. The network should consist of:

1. a Central Research Station at Sebele, with substations at Makalapye and Pelotshetlha (including production systems for a Southern Region);
2. a Regional Research Station in the Francistown region, with a substation at a suitable location in the Northeast;
3. a Regional Research Station at Maun, to serve the Okavango Delta with a substation at Mpandamatenga (for vertisols management and intensive cropping systems);
4. a Regional Research Station in the Western Region;
5. a total of 16 Ranch Research Sites (11 in the Eastern part of the country and four in the West at the following places: Tsetseku, Sunnyside, Malchi II, Matlolakgang, Masama, Lesugo, Leupane, Morale, Good Hope, Masiatilodi, Musi, Morapedi and Dikgatlhong complex, Seleka, Xanagas, one new site in ecological zone 8, one new site in the Mkgadikgadi area of ecological zone 4).

The proposed Research Station network is detailed in chapter 4.

Concerning the organization of research programs and programming procedures, it is recommended that:

1. the DAR establish commodity, factor, and systems-based programs, interdisciplinary in nature and oriented towards the production problems of farmers;
2. the DAR regroup its efforts into 12 priority programs - six in crops and six in livestock;
   (i) cereals program
   (ii) oilseeds program
   (iii) grain legumes program
   (iv) horticulture program
   (v) soil/water management program
   (vi) production systems program
       (crop-based, including agro-forestry)
   (i) beef program
   (ii) dairy program
   (iii) small ruminants program
   (iv) feeds program
   (v) range and pasture program
   (vi) production systems program
       (livestock-based)
3. each program or two grouped programs should have a senior researcher to serve as program leader as the manpower becomes available;
4. that there shall be considerable interaction between programs;
5. that a departmental Research and Technical Committee be established, comprising:
   - the Director (Chairman)
   - the Deputy Director
   - the Assistant Director, Animal Production and Range Research
   - the Assistant Director, Crop Production Research
   - three Heads of Regional Research Stations
   - Head of Division of Planning and Statistics
   - Director of Crop Production and Forestry
   - Director of Animal Production and Health
   - Principal, Botswana College of Agriculture
   - Dean of Agriculture, Botswana College of Agriculture
6. that multidisciplinary program committees be established within the two divisions headed by the Assistant Directors, to check and screen proposals for program relevance and quality and recommend long- and short-term projects for consideration by the senior technical group;
7. that the various donor-supported FSR projects be integrated into the production systems programs and that the scope of research that should and can be continued be evaluated;
8. that the biological (plant protection and improvement) laboratories and an analytical laboratory for soil and plant analysis be strengthened to support the work of the programs.
9. that improved programming procedures be implemented, linking research programming to policymakers and clients, as illustrated Chapter 6, Fig. 6.
Concerning linkages, the review team classified them into two categories. The first category comprises:

- policymakers
- extension services
- BAC
- farmers and producers.

The second category comprises:

- development agencies
- non-governmental organizations
- regional and international organizations
- NIR, University of Botswana, and the national scientific community
- donor and technical assistance agencies.

The review team recommends reinforcing the linkages with:

- policymakers through specific interactions on research policy in the existing agricultural policy committee; the workings of this linkage are detailed in Chapter 6 and 8;
- extension and development departments of the MOA, by placing RELO in the DAR, and by providing for closer interaction with the Departments of Animal Production and Health, and Crop Production and Forestry.

In the case of the linkage to Botswana Agricultural College, the relation is close and mutually beneficial. The changing status of the BAC may necessitate a formal agreement of understanding that provides the basis for expanding the collaboration and sharing of facilities. The team also recommends the joint development of the agricultural library in the DAR, leading to the creation of a National Agricultural Library with specialized sections for research and training. The DAR should train its information services staff and formally share responsibility for monitoring the staff with the Ministry of Education.

The team proposed greater involvement of farmers and producers to provide inputs into programming of research and validation of research outputs. The creation of regional stations and substations may deepen this linkage.

In the second category of linkages the DAR should continue to develop the strong record of linkages with development agencies, projects, NGOs, and regional and international organizations and donors, paying special attention to possible dispersion of its efforts which may extend its range of activities beyond the planned and sustainable scope of the Department's research programs.

In the analysis of human resources, the committee recommends a planned growth to 60-65 national scientists trained to the MSc level in order to cover the 12 core programs.

- The review team further recommends a long-term training plan to provide a critical mass of scientists for the core programs. This is detailed in Chapter 7.
The review team proposes the revision of the scheme of service in the DAR to create a scientific career ladder to motivate and retain staff. New categories would be created and upgraded as detailed in Chapter 7.

The review team noted the generally sound management and allocation of financial resources by the DAR. Furthermore, the GOB support of research has been consistent and noteworthy. The review team noted, however, that the relative share of capital and development funds allocated to research within the MOA has been declining. The team recommends that this trend be reversed so that the DAR can develop its structure and capacity to meet the challenges of national agricultural development policy, the needs of farmers, and the need to monitor and conserve the natural resource base.

The review team concluded that with improved programming procedures and sharper focus and given the results of past allocations of resources, investing in agricultural research is a sound investment in Botswana's future.

The team also concluded that special attention should be paid to sustainable natural resource management within the framework of the integrated programs of research and development.
SUSTAINABLE NATURAL RESOURCE MANAGEMENT IN BOTSWANA

Apart from minerals, the natural resources of Botswana are very limited. As described in Chapter 1 the soils are, in general, poorly structured and infertile, while the climate is continental and semi-arid. Rainfall is a major constraint on plant productivity and hence on animal production as well.

Of the 575,000 km² land area, only about 2,000 km² in the north is covered with productive broad-leaved forest, while 56,000 km², mainly in the Okavango region, is classified as swamp. The natural vegetation of the remaining 90% of the country is either grass, shrub, or tree savanna; many different types being differentiated.

About 40% of the total land area, including a major part of the Okavango region, is set aside for wildlife. Most of the remainder is used for arable farming and livestock production. Less than 1% of the total land area is cropped in any one year, but when fallows are included about 2.4% of the total land area (13,600 km²) is being used for arable farming at any one time. This is about half of the total area that is estimated to be suitable for crop farming, which means that in some highly populated districts there is little if any suitable land available for the expansion of crop agriculture. Extensive livestock farming, particularly cattle production, has gradually spread from the tree savanna areas in the east to the bush savanna of the center and southwest, and it is estimated that about half of the total land area is available for grazing domestic livestock. Although there are freehold and TGLP ranches, most livestock (85% of the national cattle herd) are managed in a traditional manner on communal land.

With the consumption of water growing at the rate of 3-5% per annum, the supply may become a constraint to development in some regions in the future. The regional situation varies: the north possesses 95% of Botswana's surface supplies but has a low demand; the west has no surface water, only deep (100 m) groundwater but has a very low demand; in the east, combined surface and groundwater supplies may in future be unable to cope with the high demand. Nationally there is limited scope for the development of surface water supplies, but because detailed data on groundwater sources and recharges are lacking, the possibilities for their development cannot yet be assessed, although 80% of the population rely on bore holes for their water supply. At present, agriculture uses about three-quarters of the available water. The national livestock herds and flocks and the present irrigated area of approximately 1100 ha each use about 36% of the total supply. Demand by the human population and the mining industry is increasing rapidly, however, so that agriculture's share of total supplies is likely to decrease.

Present Management of Natural Resources

There is a consensus that pressures on the fragile ecosystems of Botswana are increasing on account of the expansion of human activities, due partly to a rapid growth in the population (3.3% per annum), partly to a surge of developmental activities, and partly to poor management of resources. Evidence of the degradation of soils in range grazings, wildlife reserves, cropping systems and forests, causing losses in species diversity, soil erosion and a decline in soil fertility, is accumulating.
Degradation due to overgrazing

Most evident and serious is the almost universal overgrazing of communal rangelands. Cooke (1985) stated that in the Kalahari region there is general environmental deterioration on a large scale. Edwards et al. (1989) estimated that on account of overgrazing, 25% of the total range area is becoming degraded. This may prove to be an exaggeration because part of the degradation may be due to the 1980s drought, and experience elsewhere in Africa suggests that the recuperative powers of rangeland are very considerable. Nevertheless, since approximately half of the total land area is grazed by domestic livestock, degradation of even a small percentage of the total area could cause serious local problems. Overgrazing can also occur in the areas set aside for wildlife.

Degradation is a long-term process and overgrazing has many different effects on rangeland, according to its intensity and local environmental factors. The general effect is for perennial grasses to be replaced by annual grasses and herbs and eventually for bare patches of soil to appear that gradually increase in size; and annual grasses being replaced by unpalatable herbs. However, under certain circumstances, and particularly in areas of bush savanna, bush encroachment occurs. Perennial and annual grasses and palatable ground herbs are slowly replaced by an increasing number of bushes. Species diversity is reduced, as is the carrying capacity of the rangeland and, consequently, the productivity of domestic livestock. If bush encroachment does not take place and the bare patches of soil continue to widen, and erosion may occur, especially on those types of flat sandy soils found in Botswana. Ultimately, the vegetation may almost disappear, replaced by sand dunes, as has occurred to a limited extent in southwest Botswana. An alternative scenario is that the run-off of rain water creates first rill and then gully erosion on sloping land. In any case with degradation at this level rehabilitation is difficult and expensive.

The reasons for overgrazing by wildlife may be different from those that cause overgrazing by domestic livestock, and they will be discussed in a later section, but the results are similar, except that bush encroachment should not occur if there is a sufficient diversity of wildlife species.

Cause and reasons for overgrazing

The reasons for overgrazing by domestic livestock and wildlife may be different, although in both cases it is caused by overstocking.

Domestic livestock. Livestock numbers, and particularly cattle numbers, continually increased from early in the century to the 1980s, more or less paralleling the increase in human population (Fig. A1). Each rangeland has an optimal stocking rate that varies in time with the mixture of grazing species used, the type of vegetation, managerial methods, and the climate, particularly the total amount and variability of rainfall. Thus there is a finite limit at any one time to the number of livestock units that rangeland can support. This limit was exceeded in the 1980s, with a considerable degree of overstocking occurring in all regions. This situation continues.

Overstocking leads to overgrazing and, as discussed above, this inevitably leads to a deterioration in range productivity and hence to declining livestock productivity. Why then do livestock owners, particularly those grazing communal land, continue to overstock? There are some reasons specific to Botswana and others common to all pastoralists utilizing communal grazings.
Figure A.1.
Cattle, Smallstock and Human Populations in Botswana

The GOB has provided incentives for cattle production in the form of services, subsidies, and a favorable tax structure. These incentives were considered to be necessary as long as the livestock industry was expanding and there were rangelands to exploit in the north, west, and south-west. The incentives still exist, even though there is widespread overgrazing.

Investment continues in cattle because there are limited possibilities for other forms of investment in rural Botswana, and investment in cattle has yielded good returns for several decades. At the same time, in a pastoral society, cattle ownership confers status; not a minor consideration.

In all pastoral societies, where land is owned communally and livestock individually, there are unspoken motives for owners to maximize livestock numbers, even if they understand that by doing so they will inevitably overstock and ultimately degrade their rangelands. The larger the herd, the larger the share of the communal resource, but more important - the larger the herd, the greater the insurance against disaster - particularly drought. Avoidance of immediate disaster is a priority for pastoralists, as it is for everyone, even at the risk of future disaster. There is an additional reason for many agropastoralists to increase their herds: there is a minimum herd size that provides a sufficiency of working oxen.

Wildlife. If the present areas are retained for wildlife, and the Wildlife Conservation Policy approved by the GOB in 1981 proves to be effective, then overgrazing by wildlife may be a temporary phenomenon. It could be an adjustment to displacement from large areas of rangeland now utilized by domestic livestock, to loss by some species of traditional migratory routes, and to confinement of other species in specific regions. Whatever the situation, in the long term and in some manner, the number of wild animals must be adjusted to the carrying capacity of their habitat.

Degradation due to crop agriculture

Land cleared for cropping, particularly where the soils are sandy and unstructured are, as stated above, susceptible to wind and water erosion. Poor management increases the problem. It must be stressed, however, that since only a very small proportion of the total land area is cropped, degradation due to crop agriculture is likely to be limited compared with that due to livestock overgrazing.

Reasons for soil degradation in crop agriculture

Managing poorly structured, low-fertility soils for crop production in a semiarid climatic environment will always be difficult, so that the majority of farmers shun innovation and risk, managing their land on a 'low-input' system in a traditional manner. Without some form of long-term falling or rotation, which is becoming increasingly difficult to maintain with the rapid increase in population, traditional practices can only lead ultimately to soil degradation. Degradation is furthered by such practices as bare fallowing, clean-clearing land by destumping (advocated by GOB extension agencies), and clearing land in excess of the small farmer's managerial capabilities.
Degradation due to the collection of forest and range products

There is no national problem at present, although there are districts in southern Botswana in which fuel wood is in short supply, where the traditional regulatory mechanisms are no longer effective, and where time spent gathering fuel wood has increased so dramatically that people are using cow dung and crop residues for fuel (Gibson, 1989). Another problem is that ARAP and ALDEP have been promoting destumping programs on arable land without ensuring alternative fuel wood supplies. There is also a problem of ensuring continuous supplies of timber for the kraals and fences required by the livestock industry, that at present consumes half the total volume of timber utilized annually by the whole country.

Overharvesting of some range products gathered in the wild may threaten valuable species with extinction. These include grapple [Harpagophytum procumbens], of which the roots are used, and the Mokolo palm [Hypaenae ventricosa], of which the leaves are used for basket making, and the growing tip is used for alcohol production.

Summary of the present position

Since the major part of the land area of Botswana is used for grazing and browsing by domestic livestock and/or wildlife and over-grazing occurs in all regions, it is likely to be the major cause of natural resource degradation. Overgrazing by wildlife may, however, be a transitory phenomenon because the traditional economic and psychological factors that mitigate against any managerial changes on communal livestock rangelands are absent from the wildlife scenario. Overutilization of cropping land and trees may cause more rapid and serious degradation than overgrazing, but since it is only occurring on a small percentage of the total land area, it must be a less serious threat to the natural resource than is overgrazing.

Attempt to Improve the Management of Natural Resources

Concern in Botswana over the long-term effects of the degradation of natural resources is not new. Some details of proposals for surveys that would reveal the extent of the problems, for research programs that would seek answers to some, and for administrative decisions by the GOB that hopefully would help to solve them, are discussed below.

Rangeland

A system to monitor range vegetation under known conditions of management in order to assess quantitative changes commenced in 1973, conducted by the Division of Land Utilisation of the Department of Agricultural Field Services (MOA); the data obtained being stored and partly analyzed by APRU (DAR). Permanent monitoring sites had been established in 27 locations by 1979, at which time APRU analyzed the first five years of data. Few changes were detected, and APRU challenged the validity of the system. In 1982 procedures were reviewed by a consultant who concluded that the system was of little value for detecting vegetation change. Alternative methods were sought, and it was concluded that ground techniques, low-level aerial photography, and conventional aerial photography were all required. No further action was taken, however, and monitoring ceased.
A broad program of range research was initiated by APRU in the late 1970s. It included stocking rate and grazing system trials and a study of the most appropriate methods of bush control. It was concluded that rotational grazing had no special advantage over continuous grazing, that bush clearing in specific areas could increase livestock productivity by 20%, that 2m-high bush could be controlled by fire at 7- to 10-year intervals, and that goats could drastically reduce bush regrowth from a bush. Data from the stocking rate trials have been used to estimate the potential carrying capacity of the country's rangelands (Arntzen and Veenendaal, 1986).

In the 1980s, with realization of the degree of overstocking on communal pastures, studies of the processes of land and livestock degradation were started within the system and in a ranch-based simulated system. The studies within communal livestock systems were abandoned for technical and financial reasons in 1985. No detailed reports are yet available from the simulation study. During the 1980s the effect on the range of a series of interventions was also studied. No improved practice was evolved.

Although the monitoring study was abandoned, data from the stocking rate trials and other information have been used by APRU to estimate the carrying capacity of the country's rangelands. The estimates suggest that overstocking occurs in all regions. These estimates and observations should be accepted with caution as it is now understood that the production objective of range managers affect estimates of carrying capacity. In general, APRU estimates are for range systems that produce high quality beef cattle, whereas the majority of communal rangeland users are concerned with multiple objectives; the production of meat and milk and the use of cattle for work purposes. A suitable range carrying capacity for the production of high quality beef cattle is in general lower than that required for multiple production purposes, so that range that is considered to be overgrazed for high quality beef cattle production may not be overgrazed in terms of multiple productivity on a per unit area basis. This situation creates much confusion and explains some of the clashes between the views and aspirations of range users and range administrators. Nevertheless, there is no doubt that by any known measure, serious overgrazing with degeneration of the range and a decrease in overall livestock product output is occurring.

Other research results obtained by the APRU could assist livestock owners to improve their overall management, but little can be accomplished on communal grazings until overstocking has been reduced. It would appear, therefore, that only some other actions by the GOB or a complete change in thinking by livestock owners can produce a solution to the problem of overstocking. Researchers can only provide data as to the extent of the problem and as to how best to manage rangeland in a sustainable system once the problem of overstocking has been solved. Action by the GOB could be of a technical, economic, administrative, or educational nature.

Some suggest that an effort could be made to increase off-take by improving the marketing structure and in particular trekking routes and slaughter capacity in times of drought. In addition, price incentives might be improved, although this could lead to an increase in the number of stock of reproductive age on the range and might provide further incentive for investment in livestock. Other proposals are that the authority of the Land Boards should be strengthened so that they can prevent GLP ranchers from also using communal land and generally enforce orders on livestock owners to adjust livestock numbers to the estimated carrying capacity.
The latter idea has been mooted in many African countries, but the practical difficulties are so great that it is doubtful whether such policies could ever be enforced. If, however, Land Boards controlled water rights, they could more easily enforce stocking rates.

Some suggest that livestock owners will only change their attitude when they are better educated, so that educational facilities in the rangelands should be upgraded as quickly as possible. Others suggest that many pastoralists are essentially absentee owners, not living on the range or directly managing their livestock and are therefore irresponsible in their attitude to overgrazing. Still others suggest that if there was some form of insurance for livestock, fears of disaster would be dissipated and owners would not need to maximize herd size.

Possibly, a responsible attitude to overgrazing will only be developed when groups and/or individuals are also responsible for, or owners of, the land utilized.

**Cropland**

Unlike the situation in the rangelands, where overgrazing is highly visible, poor management in crop farming that causes gradual deterioration in the structure and fertility of arable soils is hardly noticeable until there are evident signs of erosion. Poor crop productivity can be blamed on climatic conditions.

Major efforts in crop research have been concerned with the evaluation of crops and crop varieties, the conducting of fertilizer trials, testing tillage and rotation systems, and plant pathological and entomological investigations. Some project research has, however, been specifically directed towards investigation of soil/water/crop relationships. One such project was the Dryland Farming Research Scheme (DLFRS), in which during the period 1971-83 factors that limit arable production were investigated. Some aspects of soil/water/crop relationships have also been investigated in other projects, such as the UNDP/FAO study of swamp dryland soils in the Okavango and the follow-up Molapo Development Project, the Evaluation of Farming Systems and Implements Project, the Agricultural Technology Improvement Project (ATIP), and the INTSORMIL Sorghum Agronomy Project. There do not, however, appear to have been any long-term studies of the degradation of arable soils.

**Water**

There is concern that ultimately there will be insufficient supplies of water to meet total demands, but at present the major problem is the inequitable distribution of available surface supplies. A present increase in the utilization of water for irrigation purposes could create problems at a future date, and it is probable that in general the use of irrigation water should be restricted to horticultural crops.

**Natural Resources Management and the Scope for Research**

As detailed above, considerable investigational work has been conducted on various aspects of the proper management of rangeland and specific arable crops, but not of tree crops. However, there has never been a program detailing the survey and investigational requirements for sustained natural resource management. Some of the more important are:
(1) long-term monitoring of the effects of present managerial systems on livestock productivity, range vegetation, range soils, crop productivity, and crop soils at closely related sites in a limited number of agro-ecological zones (possibly 4);

(2) long-term investigations in a limited number of agro-ecological zones of the effect of present managerial systems on the soil/water/plant relationship in rangeland and cropped land;

(3) investigation of the effect of specific interventions on soil/water/plant relationships in rangeland and cropped land; interventions that could be investigated in rangeland would be the removal of trees and bushes, the use of fire, and heavy stocking with goats; in cropped land there are many interventions that should be investigated that might assist soils to store or save water;

(4) investigations as to the possibility of developing new production systems; these could include:
   (a) the use of mixed species of domestic livestock on rangeland;
   (b) the use of wildlife species together with domestic livestock on rangeland, particularly in drier areas;
   (c) the various possibilities for integrating livestock and crop production, particularly with regard to the production of milk by cattle and small ruminants and meat, skins, hair, and wool by small ruminants;
   (d) the role of trees in rangeland and cropped land and the possibilities for developing any type of sylvo-pastoral or agro-sylvo pastoral system.

It will be argued by many that with the exception of the monitoring proposal, the suggested investigations are too complex and too far removed from conventional agricultural research practices to be conducted in Botswana by the DAR. Even a rangeland monitoring program, somewhat similar in context to that proposed above, was considered too difficult or too expensive for the DAR to conduct almost a decade ago, when the defective monitoring program conceived in the 1970s was halted and never recommenced. However, the reality is that results from the proposed investigations, if conducted elsewhere, are unlikely to closely relate to Botswana conditions, and investigational work would still be required in Botswana to locally verify the recommendations.

If it is agreed that the proposed investigations are essential, then the national policy should be to develop Botswana's research system in such a manner that it has sufficient resources, and staff with appropriate training to conduct the research that is required. This is exactly what is proposed in the: report. The program structure will not only include conventional crop and animal production programs, but also a soil/water management program and crop-based and livestock-based production system programs that are closely linked. One-quarter of all programs will be concerned with the problems of developing sustainable production systems that conserve natural resources. In addition, the new programming system should help the crop and livestock production divisions of the DAR to cooperate in different ways and general imbue the DAR staff with a more holistic attitude towards agricultural research.
The Future

Although it is proposed that the DAR should be reorganized in such a way that research can be conducted in a more holistic manner, the development of appropriate research programs is of itself no guarantee that sustainable production systems will be developed and assimilated into the country's agricultural structure. This requires that the GOB and the general public recognize that there is a major problem, that a collective will exists to do something about the problem, not only in the MOA but also in the farming community, and that the DAR is provided with appropriate staff and resources so that it can ultimately provide the information that extension staff and farmers will require for the development of sustainable systems. It is going to be a long, long process and will only finally be accomplished when the major problems of overgrazing, degradation of arable soils and the integration of crop and livestock systems have been solved.
# ANNEX II

**Government of Botswana**  
**Public Service**

**Grades / Salary Scales 1990**

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* Also entitled to 15% car allowance
ANNEX III

List of Persons and Organizations Consulted

Mr. T.M. Taukobong
Mr. H.K. Sigwele
Mrs. E. Melaku
Mr. J. Benyon
Mr. Macala
Mr. A. Mokgari
Ms. B. Tsimako
Mr. I.K. Saxena
Mr. E. Kemsley
Prof. G.C. Mrema
Prof. Ansu K. Datta
Mr. N. Morapedi
Mr. K.S.W. Tibi
Dr. M.G. Mosienyane
Mr. K.V. Morei
Mr. P. Maribe
Mr. S.S. Gaadingwe
Dr. Martin Kyomo
Dr. Thomas Peterman
Mr. F. Johnston
Mr. A. McPherson
Mr. K. Mmopi
Mr. Inge Tveite
Mr. Riccardo Gambini
Mr. R.E. McCullough
Mr. Gaseitsiwe
Dr. T. Mokoena

MOA, Deputy Permanent Secretary
MOA, Principal Agricultural Economist
MOA, Div. of Planning and Statistics
MOA, Div. of Planning and Statistics
MOA, Div. of Planning and Statistics
MOA, Div. of Planning and Statistics
MOA, Div. of Planning and Statistics
MOA, Finance Officer
BAC, Principal of the College
BAC, Dean of Faculty of Agriculture
NIR University of Botswana, Director
NIR, Agricultural Economist
MOA, Department of Crop Production and Forestry, Director
MOA, Department of Animal Health and Production, Director
RIIC, General Manager
RIIC, Head of Extension
BDC, Manager, Agricultural Division
SACCAR, Director
GTZ, Molapo Development Project
Thusano Lefatsheng, Manager
ALDEP
ALDEP
NORAD, Deputy Resident Representative
EEC, Agricultural Advisor
USAID, Agricultural Officer, Gaborone
Planning Officer, Ministry of Finance and Development Planning
Dean Faculty of Science
<table>
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<tr>
<td>IFPP</td>
<td>Integrated Farming Pilot Project</td>
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<tr>
<td>IITA</td>
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<tr>
<td>ILCA</td>
<td>International Livestock Center for Africa</td>
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<td>INTSORMIL</td>
<td>International Sorghum and Millet Improvement Program (USAID-CRSP)</td>
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<tr>
<td>ISNAR</td>
<td>International Service for National Agricultural Research</td>
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<tr>
<td>LAC</td>
<td>Livestock Advisory Centre</td>
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<tr>
<td>MNR</td>
<td>Ministry of Natural Resources (Proposed)</td>
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<tr>
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<td>Ministry of Agriculture</td>
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<td>MOE</td>
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<tr>
<td>NARS</td>
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<td>NGO</td>
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<td>NIR</td>
<td>National Institute of Development Research</td>
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<td>NORAD</td>
<td>Norwegian Overseas Agency for Development</td>
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<tr>
<td>ODA</td>
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<td>Regional Agricultural Research Station</td>
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<td>RIIC</td>
<td>Rural Industries Innovation Centre</td>
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<td>United Nations Development Programme</td>
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<tr>
<td>USAID</td>
<td>United States Agency for International Development</td>
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<td>WMA</td>
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References


