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Statistical Brief on the National Agricultural Research System

of

BOTSWANA

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ISNAR INDICATOR SERIES PROJECT: PHASE II

International Service for National Agricultural Research
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ISNAR INDICATOR SERIES PROJECT PHASE II

Decision making in the agricultural research policy area in either domestic, regional, or international fora can only be aided by access to reliable and comprehensive data on these systems. It is for this reason that ISNAR initiated its Indicator Series Project in 1986. The major objective of this project is to collect, process, and analyze reliable and comprehensive time-series data on national agricultural research systems (NARSs) throughout the world in order to identify and report on major trends and emerging policy issues with regard to the development of NARSs. To this end a database has been developed that contains time-series data on agricultural research expenditures and personnel for more than 150 developing and developed countries. These data provide a quantitative basis for more in-depth research policy studies by ISNAR and others.

During the first phase of the project (1986-91), the Indicator Series project team produced two major publications published by Cambridge University Press, namely:

Pardey, P.G., and J. Roseboom. (1989) *ISNAR Agricultural Research Indicator Series: A Global Data Base on National Agricultural Research Systems*, 547 pp.; and

Pardey, P.G., J. Roseboom, and J.R. Anderson, eds. (1991) *Agricultural Research Policy: International Quantitative Perspectives*, 462 pp.

The first publication is a statistical reference volume that provides system-level data on agricultural research personnel and expenditures for 154 countries. The second publication draws on the database to report on the major policy dimensions of agricultural research, with a primary focus on less-developed countries.

Phase II of the Indicator Series Project was initiated in 1992 and seeks to update the database and the policy analyses that accompany it. New ISNAR survey data are being used in conjunction with a large variety of published and "informal" reports in order to produce reliable as well as up-to-date information and statistics about the NARSs.

The country-level data are being published in a series of NARS Statistical Briefs. These briefs include more detailed descriptive information about the institutional structure of the NARS as well as a more comprehensive set of statistics than were reported in the 1989 Indicator Series volume. It is envisaged the country-level data will be assembled and analyzed in a series of regional research reports.

These statistical briefs are not official ISNAR publications; they are not edited or formally reviewed by ISNAR. The information and data presented have been collected and compiled with due care and all reasonable efforts have been made to ensure their accuracy. Comments, corrections, and additions to the material reported in this brief are welcomed. These briefs may be cited with due acknowledgment.

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Acronyms

APRU	Animal Production Research Unit	ISNAR	International Service for National Agricultural Research
BAC	Botswana Agricultural College	NARS	National Agricultural Research System
CGIAR	Consultative Group on International Agricultural Research	NIR	National Institute of Development Research and Documentation
DAR	Department of Agricultural Research	NVL	National Veterinary Laboratory
DB/FS	Department of Biology, Faculty of Science	UBLS	University of Botswana, Lesotho, and Swaziland
DES/FS	Department of Environmental Sciences, Faculty of Science		
FAB	Forestry Association of Botswana		
FRP	Forestry Research Program		
GDP	Gross Domestic Product		

1. Introduction

The primary purpose of this brief is to provide various statistical and institutional details on the development and current status of the public agricultural research system in Botswana. This information has been collected and presented in a systematic way in order to inform and thereby improve research policy formulation with regard to the NARS of Botswana. Most importantly, these data are assembled and reported in a way that makes them directly comparable with the data presented in the other country briefs in this series. And because institutions take time to develop and there are often considerable lags in the agricultural research process, it is necessary for many analytical and policy purposes to have access to longer-run series of data.

NARSs vary markedly in their institutional structure and these institutional aspects can have a substantial and direct effect on their research performance. To provide a basis for analysis and cross-country, over-time comparisons, the various research agencies in a country have been grouped into five general categories; government, semi-public, private, academic, and supranational. A description of these categories is provided in table 1.

Table 1: *Institutional Categories*

Category	Description	Examples
Government	Agencies directly administered by government.	Research department within a ministry
Semi-public	Agencies not directly controlled by government and with no explicit profit making objective.	Research institute under a commodity board
Private	Agencies whose primary activity is the production of goods and services for profit.	Agricultural machinery or chemical company
Academic	Agencies that combine university-level education with research.	Faculty of agriculture
Supranational	Agencies whose mandate covers more than one country.	CGIAR institutes

Note: Adapted from OECD (1981).

The concept of a NARS used throughout this report includes only those institutes that can be classified as government, semi-public, and academic agencies. Where it is useful to do so, private and supranational research agencies have been discussed, but for reasons of comparability they are not included in the NARS data reported here. More detailed information on the definitions and concepts used in this brief is provided in appendix 2.

Section 2 provides a brief description of the institutional development and current structure of the NARS. Section 3 presents a statistical overview of the longer-run investment trends in agricultural research along with a more detailed look at contemporary investment orientations. The appendices provide further descriptive details and present the basic research personnel and expenditure data in disaggregated fashion. For general background information and statistics on Botswana we refer to appendix 1.

2. Agricultural Research Institutions

2.1 Historical Evolution¹

Prior to independence,² most of the institutionalized agricultural experimentation and extension activities in Botswana were centered at Mahalapye, where a crop experiment station was established in the 1930s. Livestock research, which also began in the 1930s, was conducted at Morale, a ranch located in the vicinity of Mahalapye. In 1947, the first systematic research on arable crops commenced at Mahalapye and consisted of a series of cereal varietal selection trials (ISNAR 1990). Initially, agricultural research was undertaken by a division of the Agricultural Extension Services of the Department of Agriculture. During the 1960s the research infrastructure of this division expanded significantly with the establishment of stations at Gabarone in 1959, Mosho in 1962, Goodhope in 1963, Kalahari Sandveld in 1964, Chobe in 1967, and new headquarters at Sebele near Gabarone in 1968. About the same time, the research division was upgraded and renamed the Department of Agricultural Research (DAR) within the Ministry of Agriculture.

Veterinary research in Botswana has for a long time been within the mandate of the Veterinary Services of the Department of Agriculture. In 1958, the Veterinary Services were strengthened with the establishment of a veterinary laboratory at Mafeking, the then- administrative center for Botswana located in South Africa. In 1961, the British Government financed the construction of a new veterinary laboratory at Ramatlabama located just inside the southern border of the future Republic of Botswana. When the new capital was constructed at Gabarone, the veterinary laboratory was moved in 1968 to temporary buildings, which it shared with the medical laboratory in the grounds of Princess Marina Hospital, while the Ramatlabama facilities were transferred to another government department. Although proposals were drawn up in 1972 for a new laboratory, it was not until 1986 that the National Veterinary Laboratory (NVL) moved to its present facilities at Sebele, about 11 kilometers from Gabarone.

At independence most of DAR's research activities focussed on crop production and pastures. Research on livestock was limited. As a response to this situation, the Animal Production Research Unit (APRU) was established in 1970 as a unit within DAR. During the 1970s, APRU's research program and facilities expanded rapidly to ultimately encompass 17 ranch research sites. As APRU grew, two research divisions within DAR were eventually established: the Division of Arable Research and the Division of Animal Production and Range Research.

Throughout the 1970s and 1980s DAR grew considerably, primarily with the support of donor-funded projects, such as the Dry Land Farming Research Scheme (1971-83), the Evaluation of Farming Systems and Agricultural Implements Project (1976-84), the Dairy Development Research Project, the Integrated Farming Pilot Project, the Agricultural Technology Improvement Project (1982-90), and the Ngamiland Agricultural Development Project. The "project driven" nature of this growth made it difficult to develop an appropriately prioritized and integrated portfolio of research activities within the department (ISNAR 1990).

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1. The material presented in this section draws largely from Oland (1980), Kemsley and Mrema (1988), Datta and Avafia (1989), Burley, et al. (1989), ISNAR (1990), and ISNAR (1992).
 2. Botswana became independent in September 1966. Prior to independence it was known as Bechuanaland.

In addition to DAR and NVL, there are organizations other than the Ministry of Agriculture that undertake some agricultural research. One of those is the University of Botswana. The University College of Botswana began operations at Gaborone in 1973 as part of the University of Botswana, Lesotho, and Swaziland (UBLS). Two years later Lesotho withdrew from UBLS. Botswana and Swaziland, however, continued to jointly operate the university and in 1976 established the University of Botswana and Swaziland with university colleges located in both countries. In 1982, the university ceased to operate as a joint venture and both university colleges were reconstituted as autonomous universities.

Although the University of Botswana does not have its own Faculty of Agriculture, two departments within the Faculty of Science conduct research that is relevant to agriculture, namely, the Department of Biology and the Department of Environmental Sciences (previously the Department of Geography). Both departments were established in 1973.

For many years, Botswana relied on the School of Agriculture located at Luyengo in Swaziland for its degree- and diploma-level training in agricultural sciences. This school, which was part of UBLS, opened in 1966. Certificate-level training in agriculture and veterinary science was initiated in Botswana by the Ministry of Agriculture in the early 1960s with the establishment of the Agricultural Training Centre at Mahalapye and the Veterinary Training School at Ramatlabama. In 1966 the school at Mahalapye moved to new facilities at Sebele and was renamed Botswana Agricultural College (BAC). In 1970 the Veterinary Training School also moved to Sebele and merged with BAC, centralizing all certificate-level training in agriculture into one institute. With the dissolution of the University of Botswana and Swaziland in 1982, BAC began providing diploma-level training in that year and degree-level training as of 1988. In 1989 BAC became part of the University of Botswana but remained under the responsibility of the Ministry of Agriculture. Although BAC has always had close links with the nearby central agricultural research station of DAR (ISNAR 1990), its research activities are still very much in their infancy.

The National Institute of Development Research and Documentation (NIR) was founded in 1975 as the documentation section of the University College of Botswana. In 1978 it became a research institute with the establishment of the Environmental Research Unit — the first research department to be created at NIR. Subsequently, three other units concerned with education, health and nutrition, and rural development were established. Research at NIR is carried out by the institute's core staff, staff attached to the institute for the duration of specific projects, research affiliates, and university lecturers. Only a limited proportion of NIR's research (about 25%) is of direct relevance to agriculture. NIR's contribution to Botswana's agricultural research capacity is mainly in the areas of natural resources and forestry research.

In addition to the forestry research undertaken by NIR, a forestry research program was launched in 1986 by the Forestry Association of Botswana — a private, nonprofit organization. Although the Forestry Unit within the Ministry of Agriculture has conducted some ad hoc studies in the past, it has not developed an ongoing program of research nor established any permanent research facilities.

2.2 Present Structure

The present structure of the national agricultural research system of Botswana is presented in table 2. The Department of Agricultural Research (DAR) is the principal agricultural research organization in Botswana with 79% of the country's FTE agricultural researchers. Its mandate

Table 2: Overview of Present NARS Structure

Institutional category	Executing agency			Research focus	Staffed research sites ^a	Number of researchers			
	Supervising agency	Name	Acronym			National	Expats	Total	FTEs
Government	Ministry of Agriculture	Department of Agricultural Research	DAR	crops, livestock, range land, natural resources	26 (4)	31.9	13.7	45.5	45.5
		Department of Animal Production and Health, National Veterinary Laboratory	NVL	veterinary	1 (1)	13.0	6.0	19.0	1.0
Semi-public	Forestry Association of Botswana	Forestry Research Program	FRP	forestry	1 (1)	[1.0]	[1.0]	[2.0]	[2.0]
Academic	Ministry of Agriculture and the University of Botswana	Botswana Agricultural College	BAC	no research at present	1 (1)	[30.0]	[10.0]	40.0	[0]
	University of Botswana	National Institute of Development Research & Documentation	NIR	natural resources and forestry	1 (1)	5.0	3.0	8.0	2.0
		Faculty of Science, Department of Biology	DB/FS	natural resources, crops, and forestry	1 (1)	11.0	5.0	16.0	1.6
		Faculty of Science, Department of Environmental Sciences	DES/FS	natural resources	1 (1)	9.0	9.0	18.0	1.8
<i>Total</i>					<i>32 (10)</i>	<i>100.9</i>	<i>47.7</i>	<i>148.5</i>	<i>53.9</i>

Note: Most of the information in this table refers to 1991. The numbers in square brackets are estimated by the authors.

^a Staffed with researchers and/or technicians. Bracketed sites are permanently staffed with researchers.

includes crops, livestock, rangeland, and natural resources research. Some veterinary research is done by the National Veterinary Laboratory of the Department of Animal Production and Health. Forestry research is not performed by a government institute but by the semi-public Forestry Association of Botswana and the National Institute of Development Research and Documentation (NIR) of the University of Botswana. There is no fisheries research in Botswana.

The academic component of the Botswana NARS comprises several small units, namely, Botswana Agricultural College (BAC), NIR, and the Departments of Biology and Environmental Sciences of the University of Botswana. BAC does not do any research at present but may do so in the future. The research activities of NIR and the two university departments focus primarily on natural resource issues rather than on agricultural production problems.

In addition to the organizations listed in table 2, there are several organizations that engage in some agricultural research, namely, Thusano Lefatsheng (non-traditional crops and commercialization of indigenous plants), Rural Industries Innovation Centre (agricultural engineering and rural energy), Botswana Technology Centre (food technology), and Foods Botswana (food technology).

The organizational structure of DAR, NVL, the University of Botswana, and BAC are presented in diagrammatic form in appendix 3.

DAR has two main research divisions, one for arable research and one for animal production and range research. Each is headed by a chief agricultural research officer who reports to the Deputy Director for Agricultural Research (Gakale 1992).

The Arable Research Division is organized into six program areas: (1) cereals, (2) oilseeds, (3) grain legumes, (4) horticulture, (5) soil and water management, and (6) production systems. Researchers working within a program area form a program committee that oversees the planning and implementation of the program's research. Each of the programs is assigned a program leader who is responsible for drawing up a consolidated research agenda that is then reviewed by the head of the division before obtaining his approval for implementation.

The Division of Animal Production and Range Research also has six program areas: (1) beef, (2) dairy, (3) small ruminants, (4) feeds, (5) range and pastures, and (6) production systems. The organizational hierarchy and reporting channels are the same as those for the Arable Research Division.

3. NARS Statistics

Questionnaire responses were only received from NIR and NVL. Consequently, much of the information in this brief is derived from the secondary sources cited at the conclusion of this report. More detailed institutional level data are provided in appendices 5 and 6.

The expenditure data presented in this brief are based on the actual expenditures as reported by the various institutes. However, institutes systematically underestimate the degree of donor support because they only have information about the donor support that is channeled through their accounting system. Most importantly they often underreport or fail to report the salaries and supplements paid directly to expatriate researchers. To correct for this problem in the Botswana data, we constructed an implicit cost series for expatriate researchers (see appendix 2) and where necessary added this to the expenditures reported by the various institutes. A complicat-

ing factor in the case of Botswana is the distinction between expatriate researchers working under contract to the Government of Botswana and those working under contract to a donor organization. In the latter case we calculated the expatriate researcher costs as described in appendix 2, while in the former case we estimated the salary supplements paid by donors to be one-third of the full cost of an expatriate researcher.

3.1 Long-term development

There was a rapid increase in the number of researchers during the 1960s and 1970s but little growth thereafter (table 3). Agricultural research expenditures peaked in the early 1980s and have declined considerably in real terms since then. This decline is due mainly to a decrease in donor-funded projects and in the number of expatriate researchers.

Table 3: *NARS Researcher and Expenditure Series, 1961-91*

	1961-65	1966-70	1971-75	1976-80	1981-85	1986-90	1991	annual growth rate ^a
								%
Researchers (FTEs)	2.1	9.2	20.1	33.4	49.6	45.6	53.9	12.5
Expenditures (millions 1985 Pulas per year)	0.252	0.998	2.171	3.783	7.312	5.813	5.834	13.2
Expenditures (millions 1985 PPP dollars per year)	0.415	1.643	3.573	6.227	12.036	9.567	9.603	13.2
Expenditures per researcher (1985 PPP dollars per year)	191,000	182,000	177,000	183,000	244,000	212,000	178,000	0.6
Number of farmers (millions)	0.197	0.201	0.211	0.223	0.241	0.262	0.276	1.2
Researchers per million farmers	10.8	45.9	94.9	149.1	206.6	174.0	195.1	11.2
AgGDP (million 1985 PPP dollars)	107.4	119.3	235.5	292.6	230.0	285.0	352.6	4.1
Expenditures as a % of AgGDP	0.35	1.15	1.35	2.28	5.28	4.47	3.58	10.5

Source: See appendices 5 and 6.

Note: Includes DAR, NVL, FPR, NIR, and the Departments of Biology and Environmental Sciences. Expenditure figures were only available for DAR and NIR. DAR's expenditures per researcher are presumed to be representative of the other research agencies when constructing the expenditure series.

^a Least squares growth rate for the 1961-91 period.

Expenditures per researcher have been relatively high throughout the period reported here although they have been declining since the mid-1980s. This primarily reflects a considerable decline in the amount of donor funding over the past few years (ISNAR 1990). Several major donor-funded projects were completed in the late 1980s and have not been followed by new projects. In spite of this recent decline, the number of research staff and the real expenditures on research grew, respectively, by 12.5% and 13.2% per annum during the period 1961-91.

The number of researchers per million farmers increased dramatically during the past three decades. In the early 1960s, Botswana had only 11 researchers per million farmers compared with an average of 15 across all countries in sub-Saharan Africa. However, within two decades the number of researchers per million farmers in Botswana increased to more than 200, while the sub-Saharan African average increased to 42.

A similar pattern of development took place regarding agricultural research expenditures relative to AgGDP. From a relatively low level in the early 1960s, Botswana's research intensity ratio (i.e., research expenditures relative to AgGDP) increased rapidly to a level that is high even by developed-country standards. The country experienced particularly high intensity ratios during the 1980s, which in part reflects the coincidence of a peak in research funding and a series of droughts between 1981 and 1986/87 that caused a dramatic decline in agricultural output. The recent decline in this intensity ratio reflects a real decline in research expenditures coupled with a recovery in the agricultural sector.

To put this high amount of investment in agricultural research into perspective, it is significant to note that Botswana has one of the highest GDPs per capita in sub-Saharan Africa, principally due to the revenues earned from diamond exports. Moreover, agricultural production accounts for only 6.9% of GDP although the sector employs nearly two-thirds of the economically active population (appendix 1). Finally, Botswana is a small country in population terms (1.3 million in 1991). Thus Botswana's exceptionally high agricultural research intensity ratio is consistent with the evidence of Pardey, Roseboom and Anderson (1991) and Alston and Pardey (1993). They showed that there is a general tendency for research intensity ratios to be relatively higher in countries with small populations and in those countries with higher per capita incomes. It is also noteworthy (with respect to Botswana's level of agricultural research investment) that the local research agencies attempt to serve the technological problems of farmers covering a vast area of agricultural land (34.4 million hectares), of which 96% is permanent pasture. At 1.7 researchers per million hectares of agricultural land, the Botswana ratio is well below the 7.0 average for sub-Saharan Africa in 1981-85.

3.2 Human Resources

Degree and Nationality Status of Researchers

Table 4 presents long-run data concerning the country's agricultural research staff. At independence in 1966, all of the research positions were held by expatriates. This situation changed little until the second half of the 1970s. Since then the number of national researchers has increased rapidly, while the number of expatriates began to decline in the mid-1980s. The education level of national researchers has also increased markedly over the past 15 years. In line with many other countries, the academic institutes generally have a more degree-intensive staff profile than the non-academic institutes.

Gender

In 1984, 17% of the national researchers at DAR were female. At NIR and the Departments of Biology and Environmental Sciences women represented 35%, 17%, and 0% of the national research staff working in these respective institutes during the latter half of the 1980s.

Table 4: *Educational and Nationality Status of Researchers*

Institutional category	Researcher status	1961-65	1966-70	1971-75	1976-80	1981-85	1986-90	1991
		<i>(full-time equivalents)</i>						
Government	PhD	0	0	0	0.4	0.5	2.0	2.9
	MSc	0	0	0.6	1.4	5.2	12.1	17.5
	BSc	0	0.6	0.2	5.2	11.3	8.4	12.1
	Subtotal	0	0.6	0.8	7.0	17.0	22.4	32.5
	Expat	2.1	8.6	19.3	24.5	29.9	17.7	14.0
	<i>Total</i>	<i>2.1</i>	<i>9.2</i>	<i>20.1</i>	<i>31.5</i>	<i>46.9</i>	<i>40.1</i>	<i>46.5</i>
Semi-public	PhD	0	0	0	0	0	0	0
	MSc	0	0	0	0	0	1.0	1.0
	BSc	0	0	0	0	0	0	0
	Subtotal	0	0	0	0	0	1.0	1.0
	Expat	0	0	0	0	0	1.0	1.0
	<i>Total</i>	<i>0</i>	<i>0</i>	<i>0</i>	<i>0</i>	<i>0</i>	<i>2.0</i>	<i>2.0</i>
Academic	PhD	0	0	0	0.2	0.4	0.6	1.7
	MSc	0	0	0	0.2	0.5	1.2	1.5
	Bsc	0	0	0	0.4	0.4	0.3	0.1
	Subtotal	0	0	0	0.8	1.3	2.2	3.3
	Expat	0	0	0	1.1	1.5	1.4	2.2
	<i>Total</i>	<i>0</i>	<i>0</i>	<i>0</i>	<i>1.9</i>	<i>2.8</i>	<i>3.6</i>	<i>5.4</i>
Total	PhD	0	0	0	0.6	0.8	2.6	4.6
	Msc	0	0	0.6	1.6	5.8	14.3	19.9
	Bsc	0	0.6	0.2	5.6	11.7	8.7	12.2
	Subtotal	0	0.6	0.8	7.8	18.3	25.6	36.8
	Expat	2.1	8.6	19.3	25.5	31.4	20.1	17.1
	<i>Total</i>	<i>2.1</i>	<i>9.2</i>	<i>20.1</i>	<i>33.4</i>	<i>49.7</i>	<i>45.6</i>	<i>53.9</i>

Source: see appendix 6.

Staff Composition

Table 5 provides a detailed breakdown of DAR's total staff. Unfortunately for our purposes, most sources only reported researchers and technical support staff and omitted the other categories listed here. Only the data for 1983 are inclusive of all the staff categories identified in table 5, particularly the "other support staff" category (i.e., agricultural laborers, watchmen, and so on).

Table 5: *Staffing Structure of DAR*

Staff category	1969	1970	1977	1980	1983	1984	1986	1988
	<i>(number of personnel)</i>							
Research	11	13	26	40	54	46	34	40
Technical								
Diploma	na	na	13	21	33	32	na	46
Certificate	na	na	58	72	66	62	na	89
Subtotal	26	23	71	93	99	94	117	135
Administrative	na	na	na	15	19	15	28	33
Other	na	na	na	na	328	na	na	na
Total	na	na	na	na	500	na	na	na

Source: 1969: 0175; 1970: 0532; 1977: 0307; 1980: 0104; 1983: 0235; 1984: 0017 & 0003; 1986: 0720; and 1988: 0966.

Between 1969 and 1984, the number of technical support staff per researcher at DAR ranged between 1.8 and 2.7. During this period, the ratio fluctuated considerably with no clear trend. More recently, however, the number of technical support staff per researcher has grown rapidly from 2.0 in 1984 to 3.4 in 1986 and 1988. In addition, the share of technical support staff holding diplomas rose from 18% in 1977 to 34% in 1988. These data indicate that researchers were supported by more, as well as better trained, technical staff during the late 1980s compared with earlier years.

Between 1980 and 1988, the number of administrative support staff more than doubled, while the number of researchers remained virtually unchanged and real research expenditures declined.

3.3 Financial Resources

Expenditures

Table 6 provides time-series data on the institutional structure of agricultural research expenditures in Botswana. It shows the dominance of the government sector which, in 1991, accounted for 88% of the expenditures on agricultural research. Academic research activities did not begin until 1975, while research in the semi-public sector only began in 1986.

Table 6: *Agricultural Research Expenditures*

Institutional category	1961-65	1971-75	1981-85	1986	1987	1988	1989	1990	1991
	<i>(millions 1985 PPP dollars per year)</i>								
Government	0.415	3.573	11.602	10.988	9.922	7.686	7.246	7.428	8.435
Semi-public	0	0	0	0.522	0.405	0.381	0.373	0.394	0.394
Academic	0	0	0.434	0.527	0.454	0.445	0.421	0.645	0.773
Total	0.415	3.573	12.036	12.037	10.781	8.512	8.040	8.467	9.603

Source: see appendix 6.

Table 8: *Research Focus, 1991*

Research focus	DAR	NVL	FRP	NIR	DB	DES	Total	
							FTE	Share
								<i>(full-time equivalents)</i>
Crop	17.8	0	0	0	0.4	0	18.2	33.8
Livestock	15.2	1.0	0	0	0	0	16.2	30.0
Forestry	0	0	2.0	0.5	0.4	0	2.9	5.4
Fisheries	0	0	0	0	0	0	0	0
Natural resources	3.6	0	0	1.5	0.8	1.8	7.7	14.2
Other	8.9	0	0	0	0	0	8.9	16.6
<i>Total</i>	<i>45.5</i>	<i>1.0</i>	<i>2.0</i>	<i>2.0</i>	<i>1.6</i>	<i>1.8</i>	<i>53.9</i>	<i>100</i>

Source: 0966 and 1019.

Note: The “natural resources” and “other” categories include research that could not otherwise be allocated to a specific commodity or commodity group. The natural resources category refers to unallocatable soils, land use, and water research.

Bibliography

This bibliography comprises three different sets of references. The "references" section relates to references cited in the text, the "data sources" to references from which data have been extracted to construct the time series (see appendix 5 and 6), and "other references" to references that have been consulted in the process of data collection but not used.

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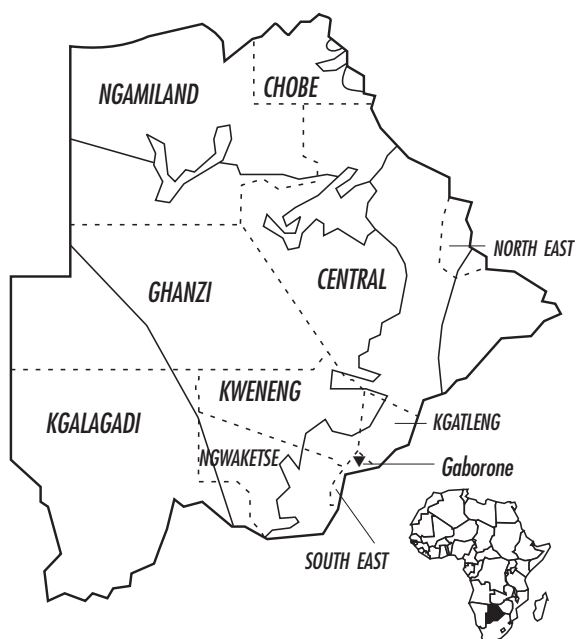
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Appendix 1: Country background information



Geography

Area: 58.2 million ha

Location: Land-locked country in the central part of southern Africa, bordered by Zimbabwe to the north-east, Namibia to the north and west, Zambia to the north, along a very short stretch of the Zambezi river, and South Africa to the south and southwest.

Agroecological features: Botswana is mainly a flat country at 1,000 m, except in the southeast, where the terrain is broken and hilly. A plateau, running north-south, divides the country into two distinct regions: in the east, hilly grasslands (veld) traversed by ephemeral watercourses, and in the west the Okavango swamps and the Kalahari desert. The Kalahari is largely a semi-desert with grass and acacia thorn scrub, and only in the southwest, where there are sand dunes do true desert conditions prevail. Much of the country has a subtropical climate though it has continental extremes. During the winter temperatures may drop below 0°C. Rainfall is unreliable. The annual mean is 460 mm, most falling from December to April, varying from 600 mm in the north to less than 300 mm in the east and southwest.

Population

Total (1991): 1.3 million

Annual growth rate (1981-90)^a: 3.5%

Literacy (1990): 73.6%

Life expectancy (1991): 68 years

Economy (values reported in 1985 PPP dollars)

Gross Domestic Product (1991): 5,133 million dollars

Per capita GDP (1991): 3,891 dollars

Agricultural GDP (1991): 353 million dollars

Share of agriculture in GDP (1991): 6.9%

Annual growth rates (1981-90)^a

GDP: 9.9%

GDP per capita: 6.2%

AgGDP: 3.7%

Trade (values reported in current dollars)

Net surplus total trade (1991): -158 million dollars

Net surplus agricultural trade (1991): -77 million dollars

Percentage of agricultural imports in total imports: 8.8%

Percentage of agricultural exports in total exports: 5.3%

Major agricultural import commodities (1991)^b: refined sugar (26%), fresh milk (9%), and rice (7%)

Major agricultural export commodities (1991)^b: beef & veal (82%), animal fats (10%), and other prepared meat (4%)

Agriculture

Agricultural land (1990): 34.4 million ha

Annual growth rate (1981-90)^a: 0.0%

Percentage arable: 4.0%

Percentage permanent crop: 0.0%

Percentage permanent pastures: 96.0%

Percentage irrigated arable and permanent cropland: 0.1%

Economically active agricultural population (1991): 0.3 million

Annual growth rate (1981-90)^a: 1.7%

Percentage in total economically active population: 62.2%

Fertilizer use per ha arable land (1990): 0.7 kg

Annual growth rate (1981-90)^a: -6.7%

Major crops (in order of importance): sorghum, cotton lint, maize, and seed cotton

Source: Europa Publications (1992), FAO (1993), and World Bank (1992).

^a Least squares growth rate.

^b Bracketed percentages represent value share of the respective total.

Appendix 2: Definitions and concepts

NARS

The construction of quantitative and internationally comparable expenditure, personnel, and related measures of a national agricultural research system (NARS) requires a precise idea of what, in fact, is being measured. Since the term NARS is subject to a variety of interpretations, it is necessary to define rather precisely the NARS concept used here. Our approach adheres, wherever possible, to the internationally accepted statistical procedures and definitions developed by the OECD and UNESCO for compiling R&D statistics (OECD 1981 and UNESCO 1984). For statistical purposes a NARS is defined in terms of the following characteristics:

(a) *National*. The concept of a “national” system used in this report refers to domestically targeted research activities funded and/or executed by the *public* sector of a particular country. A relatively broad concept of the public sector is taken to include government, semi-public, and academic research institutes. However, private, for-profit research as well as the research activities of supranational research agencies that are not executed through national institutes are excluded. Also excluded is research undertaken by short-term development projects.

(b) *Agricultural*. Agricultural research, as defined here, includes crop, livestock, forestry, and fisheries research, as well as research on agricultural inputs, the natural resource base, and socio-economic aspects of primary agricultural production. It excludes, where possible, research concerning the off-farm storage and processing of agricultural products, commonly referred to as post-harvest research and food-processing research. This delineation corresponds with the national accounts definition of the agricultural sector.

(c) *Research*. Research is often performed in conjunction with other activities such as extension, education, and production. To the extent possible, research activities (in terms of expenditures and staff) are differentiated from these other activities. However, if non-research activities were an integral part of an institute’s research activities and accounted for less than 20% of the resources of the institute, it was expedient to classify all the activities of the institute as being research-related.

Full-Time Equivalent (FTE)

A full-time equivalent researcher year is taken to be a person who holds a full-time position as a researcher during the whole year. Adjustments to full-time equivalents have only been made when: (a) a research position was part-time; (b) a research position was not

filled for the whole year; or (c) if the position explicitly involved tasks other than agricultural research. In the latter case an estimate was made of the time spent on agricultural research. No adjustments were made, however, for vacation or sick leave nor for time spent on administration, meetings, travel or other activities that form part of the normal duties required to support a research endeavor. Following this line of reasoning, professional staff in management positions were classified as researchers.

The degree status of researchers is determined on the following basis: 3-4 years full-time university education (BSc), 5-6 years (MSc), and more than 6 years plus doctorate thesis (PhD).

Expatriate Researcher Costs

Many expatriate researchers working on donor-supported projects in NARSs are paid their salaries and living expenses directly by the donor agency. All (or some substantial fraction) of these costs do not get included in the financial reports of the agricultural research organizations. To calculate these *implicit* costs we took the average cost per researcher in 1985 to be 120,000 “1985 PPP dollars” and backcast this figure using the rate of change in real personnel costs per FTE researcher in the US state agricultural experiment station system. This extrapolation procedure makes the assumption that the personnel-cost trend for US researchers is a reasonable proxy of the trend in real costs of internationally recruited staff working in NARSs. Unless otherwise stated, FTE expatriate researchers were costed at \$80,000 “1985 PPP dollars” per researcher for the 1961-65 period, \$85,000 per researcher for 1966-70, \$90,000 per researcher for 1971-75, \$110,000 per researcher for 1976-80, and \$120,000 per researcher for 1981-91.

Deflators and Exchange Rates

All expenditure figures were first compiled in current local currency units (appendix 5). In order to facilitate comparisons over time and across countries these figures are deflated with a local GDP deflator to base year 1985, and then converted to a common currency (US dollars) using the 1985 purchasing power parity (PPP) over GDP. PPPs are synthetic exchange rates that attempt to reflect the purchasing power of a country’s currency. The PPPs used here are derived from the Penn World Table (Mark 5), which is based on the benchmark studies of the International Comparison Project (Summers and Heston 1991). For additional information on currency conversion methods in this context see Pardey, Roseboom, and Craig (1992).

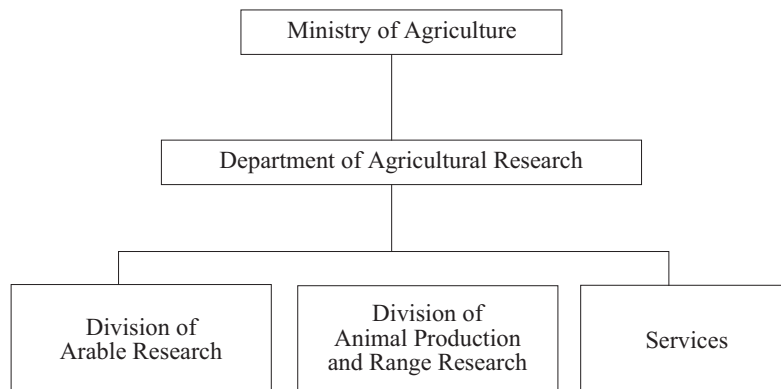
Nomenclature for tables in text

A zero indicates an actual observation of zero, a dash indicates an observation is not relevant (due to institutional mergers, closures, and so on), while “na” indicates an observation that is not available.

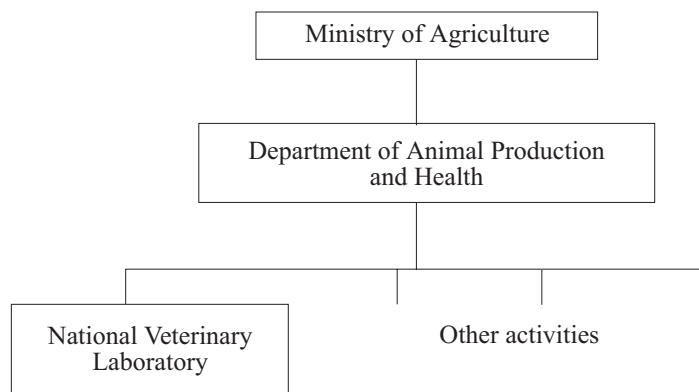
In the text we note any marked deviations from these data compilation norms and include points of clarification if warranted.

Appendix 3: Organizational charts of the agricultural research institutes

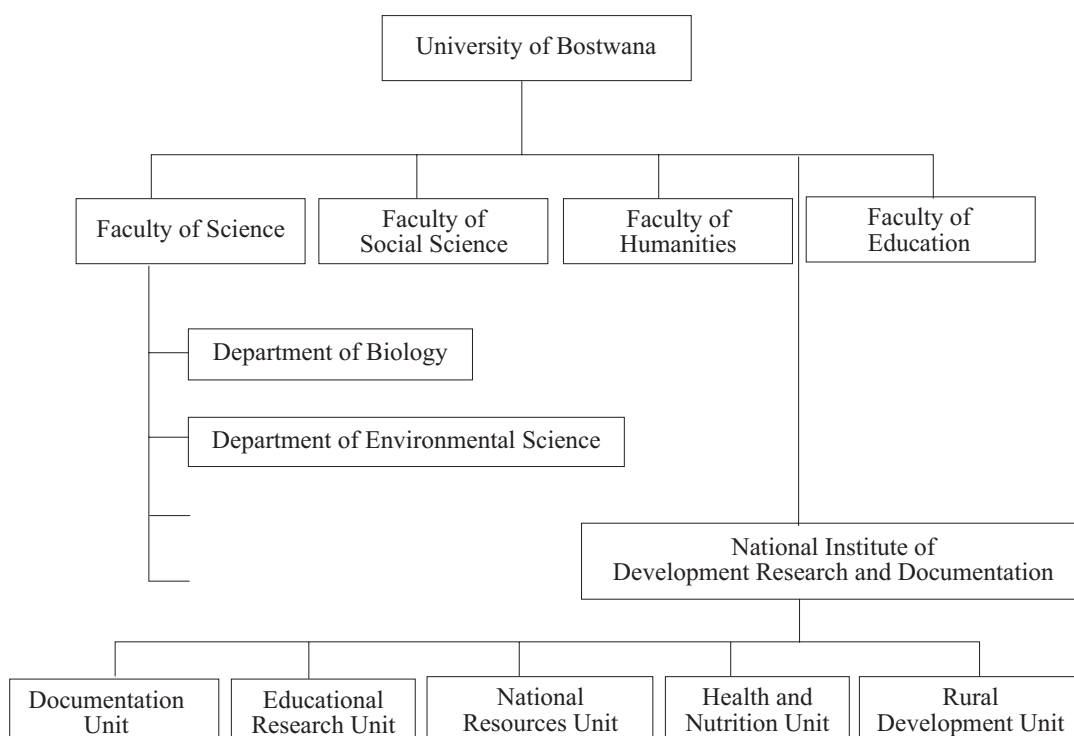
Department of Agricultural Research (1991)



National Veterinary Laboratory (1991)



University of Botswana (1991)



Appendix 4: Addresses of the agricultural research institutes

Director
Department of Agricultural Research
Ministry of Agriculture
Private Bag 0033
Gaborone
BOTSWANA

Principal Veterinary Officer
National Veterinary Laboratory
Department of Animal Health
Ministry of Agriculture
Private Bag 0035
Gaborone
BOTSWANA

Principal
Botswana Agricultural College
Private Bag 0027
Gaborone
BOTSWANA

Dean
Faculty of Science
University of Botswana
Private Bag 0022
Gaborone
BOTSWANA

Director
National Institute of Development Research and Documentation
University of Botswana
Private Bag 0022
Gaborone
BOTSWANA

Director
Forestry Research Program
Forestry Association of Botswana
P.O. Box 2088
Gaborone
BOTSWANA

Appendix 5a: Researcher totals, 1961-91

Total Number of FTE Researchers		1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
Category	Name institute	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
Government	DAR	1.0	1.5	2.0	2.5	3.0	5.0	7.0	9.0	11.0	13.0	16.0	18.0	20.0	22.0	23.3	24.7
	NVL	0.0	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.2	0.2	0.2	0.2	0.2
Semi-public	FRP																
Academic	BAC					0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	NIR																
	DB																
	DES																
TOTAL		1.0	1.6	2.1	2.7	3.2	5.2	7.2	9.2	11.2	13.2	16.3	18.2	20.2	22.2	23.5	24.8
Source						286				175	532	279			244		
Category	Name institute	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
Government	DAR	26.0	30.7	35.3	40.0	44.0	48.0	54.0	46.0	41.0	34.0	43.0	40.0	40.0	40.0	45.5	51.0
	NVL	0.2	0.1	0.1	0.1	0.2	0.2	0.3	0.3	0.4	0.4	0.6	0.8	0.8	0.9	1.0	
Semi-public	FRP										2.0	2.0	2.0	2.0	2.0	2.0	
Academic	BAC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
	NIR		2.0	1.7	1.3	1.0	1.4	1.8	1.8	1.5	1.5	1.5	1.5	1.5	2.0	2.0	
	DB	0.4	0.8	0.6	0.5	0.8	0.8	0.7	0.7	0.7	0.8	0.9	1.0	0.8	1.2	1.6	
	DES	0.4	0.6	0.6	0.5	0.5	0.5	0.5	0.6	0.7	0.8	0.8	0.9	1.1	1.4	1.8	
TOTAL		27.0	34.2	38.3	42.5	46.5	50.8	57.2	49.4	44.3	39.5	48.9	46.2	46.2	47.6	53.8	
Source		243	1000		104	1000	17	235	3	968	720	965	966	999	954	999	1108
		1000			242			1000		1000	976	999	999	1000	999	1000	

Note: Italicized figures represent data that are either constructed or interpolated.

Appendix 5b: Expenditure totals, 1961-91

Total Research Expenditures		Currency: million Pula																
Category	Name institute	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	
Government	DAR	0.019	0.030	0.043	0.057	0.075	0.135	0.167	0.195	0.204	0.339	0.390	0.437	0.626	0.996	0.714	1.013	
	NVL	0.001	0.002	0.003	0.004	0.005	0.006	0.006	0.005	0.005	0.007	0.008	0.007	0.007	0.007	0.005	0.007	
Semi-public	FRP																	
Academic	BAC						0	0	0	0	0	0	0	0	0	0	0	
	NIR																	
	DB																	
	DES																	
Total (current LCU)		0.020	0.032	0.045	0.061	0.080	0.140	0.172	0.200	0.209	0.346	0.399	0.443	0.633	1.004	0.720	1.020	
GDP deflator (1985=100)		18.0	18.2	18.4	18.9	19.7	20.4	20.6	21.1	21.4	22.4	24.6	24.7	29.4	30.4	36.2	41.4	
Total (constant 1985 Pulas)		0.110	0.175	0.246	0.323	0.405	0.689	0.834	0.950	0.973	1.543	1.622	1.796	2.150	3.297	1.988	2.464	
Total (constant 1985 PPP dollars)		0.181	0.288	0.405	0.531	0.667	1.134	1.373	1.563	1.602	2.540	2.670	2.957	3.538	5.426	3.273	4.056	
Expat costs included in the total (constant 1985 PPP dollars)		0.028	0.042	0.057	0.071	0.085	0.141	0.193	0.307	0.379	0.379	0.494	0.572	0.650	0.728	0.828	1.135	
Source		10					589			10	17	17	17	17	17	17	17	

Category	Name institute	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
Government	DAR	1.233	1.554	2.233	3.912	4.497	5.537	5.145	5.885	6.561	8.127	7.924	7.163	8.584	9.310	11.127	
	NVL	0.008	0.007	0.008	0.011	0.017	0.027	0.027	0.036	0.060	0.081	0.105	0.125	0.156	0.211	0.232	
	FRP										0.390	0.328	0.361	0.450	0.506	0.531	
Academic	BAC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	NIR		0.056	0.058	0.055	0.042	0.053	0.073	0.079	0.086	0.083	0.085	0.091	0.096	0.182	0.174	
	DB	0.014	0.036	0.038	0.047	0.077	0.085	0.066	0.073	0.103	0.160	0.146	0.173	0.159	0.275	0.389	
	DES	0.018	0.027	0.032	0.048	0.046	0.057	0.049	0.062	0.098	0.150	0.135	0.158	0.253	0.369	0.478	
Total (current Pula)		1.273	1.681	2.370	4.072	4.679	5.759	5.360	6.135	6.909	8.992	8.724	8.071	9.697	10.853	12.931	
GDP deflator (1985=100)		46.6	46.0	57.5	68.5	71.1	68.1	75.3	81.8	100.0	123.0	133.2	156.1	198.5	211.0	221.6	
Total (constant 1985 Pulas)		2.731	3.657	4.121	5.945	6.578	8.459	7.115	7.501	6.909	7.313	6.550	5.171	4.885	5.144	5.834	
Total (constant 1985 PPP dollars)		4.495	6.019	6.783	9.784	10.828	13.923	11.710	12.346	11.371	12.037	10.781	8.512	8.040	8.467	9.603	
Expat costs included in the total (constant 1985 PPP dollars)		1.585	1.882	2.054	2.232	2.549	2.701	2.851	2.515	2.484	1.866	2.184	1.735	1.510	1.343	1.505	
Source		17	17	17	17	17	17	720	720	720	954	954	954	954	954	954	

Note: Figures in italics have been constructed.

Appendix 6: Research staff development by institute

Department of Agricultural Research																
	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
Nationals																
PhD														0		
MSc														1		
BSc														0		
Subtotal	0	0	0	0	0	0.2	0.5	0.8	1	0.5	0	0.3	0.7	1	2.0	3.0
Expatriates	1.0	1.5	2.0	2.5	3	4.8	6.5	8.2	10	12.5	16	17.7	19.3	21	21.3	21.7
Total	1.0	1.5	2.0	2.5	3	5.0	7.0	9.0	11	13	16	18.0	20.0	22	23.3	24.7
Sources:					286				175	532	279			244		
	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
Nationals																
PhD	0			1			0	0	1	1	2	2				
MSc	1			2			7	7	4	8	11	12				
BSc	3			9			14	10	10	6	7	8				
Subtotal	4	6.7	9.3	12	14.5	17.2	21	17	15	15	20	22	25	28	31.8	
Expatriates	22	24.0	26.0	28	29.5	30.8	33	29	26	19	23	18	15	12	13.6	
Total	26	30.7	35.3	40	44	48	54	46	41	34	43	40	40	40	45.5	51
Sources:	243			104		17	235	3	968	720	965	966		954		1108

National Veterinary Laboratory																
	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
Nationals																
PhD																
MSc																
BSc																
Subtotal	0	0.0	0.0	0.0	0	0	0	0	0	0	0	0	0	0	0	0
Expatriates	1	1.8	2.5	3.2	4	4.2	4.4	4.6	4.8	5	6	5	4	3	3	3
Total	1	1.8	2.5	3.2	4	4.2	4.4	4.6	4.8	5	6	5	4	3	3	3
FTE researchers	0.05	0.09	0.12	0.16	0.20	0.21	0.22	0.23	0.24	0.25	0.30	0.25	0.20	0.15	0.15	0.15
Sources:					286					532	279			244		
	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
Nationals																
PhD									0	0	0	0	0	0	0	
MSc									1	2	2	2	2	2	2	
BSc									1	1	5	8	8	10	11	
Subtotal	0	0	0	0	0.4	0.8	1.2	1.6	2	3	7	10	10	12	13	
Expatriates	3	2.7	2.3	2	2.8	3.6	4.4	5.2	6	5	6	5	5	6	6	
Total	3	2.7	2.3	2	3.2	4.4	5.6	6.8	8	8	13	15	15	18	19	
FTE researchers	0.15	0.13	0.12	0.10	0.16	0.22	0.28	0.34	0.40	0.40	0.65	0.75	0.75	0.90	0.95	
Sources:	243			242					999	999	999	999	999	999	999	

Appendix 6: Research staff development by institute (contd.)

Department of Agricultural Research																
	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
Nationals																
PhD														0		
MSc														1		
BSc														0		
Subtotal	0	0	0	0	0	0.2	0.5	0.8	1	0.5	0	0.3	0.7	1	2.0	3.0
Expatriates	1.0	1.5	2.0	2.5	3	4.8	6.5	8.2	10	12.5	16	17.7	19.3	21	21.3	21.7
Total	1.0	1.5	2.0	2.5	3	5.0	7.0	9.0	11	13	16	18.0	20.0	22	23.3	24.7
Sources:					286				175	532	279			244		
	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
Nationals																
PhD	0			1	1		0	0	1	1	2	2				
MSc	1			2	7		7	7	4	8	11	12				
BSc	3			9	14		14	10	10	6	7	8				
Subtotal	4	6.7	9.3	12	14.5	17.2	21	17	15	15	20	22	25	28	31.8	
Expatriates	22	24.0	26.0	28	29.5	30.8	33	29	26	19	23	18	15	12	13.6	
Total	26	30.7	35.3	40	44	48	54	46	41	34	43	40	40	40	45.5	51
Sources:	243			104		17	235	3	968	720	965	966		954		1108
National Veterinary Laboratory																
	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
Nationals																
PhD																
MSc																
BSc																
Subtotal	0	0.0	0.0	0.0	0	0	0	0	0	0	0	0	0	0	0	0
Expatriates	1	1.8	2.5	3.2	4	4.2	4.4	4.6	4.8	5	6	5	4	3	3	3
Total	1	1.8	2.5	3.2	4	4.2	4.4	4.6	4.8	5	6	5	4	3	3	3
FTE researchers	0.05	0.09	0.12	0.16	0.20	0.21	0.22	0.23	0.24	0.25	0.30	0.25	0.20	0.15	0.15	0.15
Sources:					286					532	279			244		
	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
Nationals																
PhD									0	0	0	0	0	0	0	
MSc									1	2	2	2	2	2	2	
BSc									1	1	5	8	8	10	11	
Subtotal	0	0	0	0	0.4	0.8	1.2	1.6	2	3	7	10	10	12	13	
Expatriates	3	2.7	2.3	2	2.8	3.6	4.4	5.2	6	5	6	5	5	6	6	
Total	3	2.7	2.3	2	3.2	4.4	5.6	6.8	8	8	13	15	15	18	19	
FTE researchers	0.15	0.13	0.12	0.10	0.16	0.22	0.28	0.34	0.40	0.40	0.65	0.75	0.75	0.90	0.95	
Sources:	243			242					999	999	999	999	999	999	999	

Appendix 6: Research staff development by institute (contd.)

Department of Environmental Science, Faculty of Science, University of Botswana		1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
Nationals																	
PhD		0	0	0.7	1.3	2	1.5	1	1.0	1	1.3	1.7	2	2	3.0	4	
MSc		1	1	0.7	0.3	0	0.0	0	0.5	1	1.7	2.3	3	3	4.0	5	
BSc		0	2	1.7	1.3	1	0.5	0	0.5	1	0.7	0.3	0	0	0.0	0	
Subtotal		1	3	3.0	3.0	3	2.0	1	2.0	3	3.7	4.3	5	5	7.0	9	
Expatriates		3	3	2.7	2.3	2	3.0	4	4.0	4	4.0	4.0	4	6	7.5	9	
Total		4	6	5.7	5.3	5	5.0	5	6.0	7	7.7	8.3	9	11	14.5	18	
FTE Researchers		0.40	0.60	0.57	0.53	0.50	0.50	0.50	0.60	0.70	0.77	0.83	0.90	1.10	1.45	1.80	
Sources:		1000	1000			1000		1000		1000			1000	1000		1000	

Note: Previously the Department of Geography. The percentage of faculty time spent on research has been estimated at 10%.

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