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EX-POST RATE OF RETURN ON MAIZE RESEARCH AND EXTENSION IN NORTHERN CAMEROON

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EX-POST RATE OF RETURN ON MAIZE RESEARCH AND EXTENSION IN NORTHERN CAMEROON

By

Georges DIMITHE

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ABSTRACT

EX-POST RATE OF RETURN ON MAIZE RESEARCH AND EXTENSION IN NORTHERN CAMEROON

By

Georges DIMITHE

Facing declining output per capita, the Cameroon government has invested heavily in agricultural research and extension. But, since 1985, support to agricultural research has declined, due to the financial crisis. Consequently, the Institute of Agronomic Research needs a basis for allocating this constrained budget among various programs to ensure that future investments by IRA make a significant contribution to national development goals as well as for strengthening its bargaining power vis à vis policy makers. To address these issues, data on maize research and extension in North Cameroon were collected and analyzed for the period 1979-2000, with the general objectives to: (a) estimate the rate of return to investments in maize research and extension, (b) identify the critical factors which have contributed to the expansion of maize production, and (c) draw policy implications. The analysis yielded an 11.7 percent internal rate of return and highlights key factors explaining maize expansion in the North.

With love and caring,

for my wife, Félicité Lydie Nko'o Mebanda,

my sons Franck, Cédric and Loïc, and my daughter Elaida.

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My task during data collection was immensely facilitated by the collaboration of USAID/Yaoundé personnel, researchers and administrative staff at IRA Maroua, Garoua and Nkolbisson. I am grateful to them. I am especially greatful to Dr John Poku and Dr. Doyle Baker, for encouraging and supporting me throughout this endeavor. Their contribution to my training on the job has been extremely rewarding during my program.

Finally, my appreciation goes to my family for the invaluable sacrifices to ensure my education and the suffering they are going through during my absence in Cameroon.

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ABBREVIATIONS

AMP	Agricultural Management and Planning Project
AVA	*Association Villageoise Autogérée*
BCR	Benefit Cost Ratio
BIRD	*Banque Internationale pour la Reconstruction et le Développement*
CAP	Cameroon Agricultural Policy
CBR	Completely Randomized Block Design
CCCE	*Caisse Centrale de Coopération Economique*
CFDT	Compagnie Française de Développement du Textile
CGIAR	Consultative Group on International Agricultural Research
CIF	Cost, Insurance, and Freight
CIMMYT	International Maize and Wheat Improvement Center
CRSP	Collaborative Research Support Project
CV	Compensating Variation
DIRAGRI	*Direction de l'Agriculture*
EEC	European Economic Community
EEVT	Elite Experimental Variety Trial
EV	Equivalent Variation
EVT	Experimental Variety Trial
FAC	*Fonds d'Aide et de Coopération*
FAO	Food and Agricultural Organization
Fcfa	*Franc de la Communauté Financière Africaine*
FEP	Foreign Exchange Premium
FOB	Free on Board
FONADER	*Fonds National de Développement Rural*
FROR	Financial Rate of Return
FSAR	*Fond Special d'Action Rurale*
FSR	Farming Systems Research
GDP	Gross Domestic Product
GVP	*Groupement Villageois Pré-Coopérative*
ICRISAT	International Center for Research in Semi-Arid Tropics
IDRC	International Development Research Center
IFAD	International Fund for Agricultural Development
IFCC	*Institut Français de Café et Cacao*
IITA	International Institute of Tropical Agriculture
IRA	*Institut de Recherches Agronomiques*
IRAT	*Institut de Recherches Agronomiques Tropicales et des Cultures Vivrières*
IRCA	Institut de Recherche sur le Coton en Afrique
IRCT	*Institut de Researche de Coton et des Testiles Exotiques*
IRHO	*Institut de Recherche pour les Huiles et les Oléagineux*
IRR	Internal Rate of Return
IRRI	International Rice Research Institute
ISNAR	International Service for National Agricultural Research

MAISCAM	*Maïserie du Cameroun*
MIDENO	*Mission de Développement de la Province du Nord-Ouest*
MIDEVIV	*Mission de Développement des Semenses et des Cultures Vivrières*
MINAGRI	*Ministère de l'Agriculture*
MSc	Master of Sciences
NCRE	National Cereals Research and Extension Project
NCSM	North Cameroon Seed Multiplication Project
NEB	*Projet Nord-Est Bénoué*
NETP	National Extension and Training Program
NGO	Non-Governmental Organization
NPV	Net Present Value
NVT	National Variety Trial
OAU	Organization of African Unity
OECD	Organization for Economic Cooperation and Development
OER	Official Exchange Rate
ONAREF	*Office National de Regénération des Forêts*
ONAREST	*Office National de Recherches Scientifiques et Techniques*
ORSTOM	*Office de la Recherche Scientific et Technique d'Outre-mer*
PASCA	Pioneer Agrogénétique Cameroon
PCN	*Projet Centre-Nord*
PhD	Doctor of Philosophy
R&D	Research and Development
RCB	Randomized Complete Block Design
ROR	Rate of Return
RUVT	Regional Unified Variety Trial
SAFGRAD	Semi-Arid Food Grain Research and Development Project
SCF	Standard Conversion Factor
SEB	*Project Sud-Est Bénoué*
SER	Shadow Exchange Rate
SEMRY	*Société d'Expansion et de Modernization de la Riziculture à Yagoua*
SOCOOPED	*Société Coopérative de Développement*
SODEBLE	*Société de Développement du Blé*
SODECAO	*Société de Développement du Cacao*
SODECOTON	*Société de Développement du Coton*
STRC	Scientific, Technical and Research Commission
TLU	Testing and Liaison Unit
UCCAO	*Union Centrale des Coopératives Agricoles de l'Ouest*
ULER	*Unité Locale d'Encadrement Rapproché*
UN	United Nations
UNIDO	United Nations Industrial Development Organization
US	United States of America
USAID	United State Agency for International Development

CHAPTER I INTRODUCTION

1.1 Problem Statement and Importance

In most African countries, agriculture is the main contributor to GDP, foreign exchange, and employment. Facing declining output per capita, these governments have invested heavily in agricultural research in order to increase productivity and thereby meet the expanding demand for food. Unfortunately, research investments are expensive. Since these countries have limited financial capacities to support their national research systems, they have relied on donors to support agricultural research.

Despite substantial investment in research, African agriculture appears to be stagnating. A "Green Revolution" is yet to take place, as happened in Asia. As a result, donors are increasingly concerned about the effectiveness of these investments. In addition, recent political events in Eastern Europe and associated requests for foreign aid to promote a free market system have placed increased pressure on African countries to provide evidence of a significant investment impact to convince donors to continue to support agricultural research.

Since 1985, support to agricultural research in Cameroon has declined, as a result of the financial crisis. For example, because of the government priority setting policy, the Institute of Agronomic Research (IRA) budget was reduced by 54 percent from 1985-86 to 1988-89 (IRA, 1989). Moreover, since 1989-90, the government has failed to allocate an effective budget to IRA. Therefore, to strengthen its bargaining power vis à vis policy makers, IRA administration needs documented evidence that research gives high returns. This need is reflected by increased IRA administration's interest in impact studies and the

recent creation of an economic unit within IRA's directorate with a mandate to conduct assessment studies.

In response to the funding crisis, IRA has designed, in agreement with the government, a five year *Action Plan* which called for the government to provide a stable funding at around 4.5 billions F.cfa. But, because of the high cost of maintaining capital investments[1] launched before the economic crisis, only 12.4 percent of this budget will be allocated to research activities. Allocating such a constrained budget among the various research programs will require prioritization, taking into account the relative importance of each program, to ensure that future public investments in IRA make a significant contribution to national development goals. In order to do this, IRA administration needs concrete evidence of the impact of past research investments, as a basis for future budget allocations.

This study analyzes the returns to maize research and extension in the Bénoué plateau in the North Province. The topic was selected in response to the interest of primary users of the study's results (IRA, USAID and NCRE). Initial interviews with administrators, researchers and extension agents revealed considerable interest in better understanding factors contributing to the tremendous expansion of maize in this area. In addition to estimating the returns on the investments made, the study will also identify the critical factors that have contributed to research impact, and generate policy implications to guide the on-going resource allocation debate.

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[1] "From 1976-77 to 1985-86 IRA's budget underwent a rapid expansion. Recurrent costs (including personnel, operations and research) increased by 281 %. During the same 10 years, IRA's investment budget increased by 277 %". (IRA, 1989 p:41).

1.2 Objectives

The general objectives of this study are to: (a) estimate the rate of returns to investments in maize research and extension in the Northern Province of Cameroon, (b) identify the critical factors which have contributed to the expansion of maize production, and (c) draw policy implications. These general objectives are addressed through five specific objectives:

1) Identify and describe institutions that have contributed to the development and expansion of maize production in Northern Cameroon.
2) Estimate the costs incurred and benefits generated by these institutions in performing their respective activities.
3) Estimate the rate of return (ROR) to the maize research/extension investment and the sensitivity of this ROR to reasonable changes of critical parameter values.
4) Determine the key factors that have enabled these institutions to make an effective contribution.
5) Highlight policy implications of the thesis results.

1.3 Hypotheses

The following is hypothesized and used to guide the study:

1) Maize research and extension in the North Province of Cameroon have had a positive economic return -- that is, the net present value is greater than zero.
2) Key factors which have contributed to this positive impact include the favorable agroclimatic environment in the target maize-producing area, strong linkages between support institutions, and recent decline in cotton prices.
3) The IRR is highly sensitive to yield and the adoption rate of maize.

1.4 Thesis Organization

This thesis is organized into five chapters. Chapter I discusses the problem addressed and its importance, defines the objectives of the study and the hypothesis formulated to guide the research. Chapter II describes economic, agronomic and institutional settings of the study. Chapter III reviews the economic theories that guides ROR analysis and the ROR literature. This review provided the basis for formulating the hypothesis tested, selecting the appropriate analytical model, and identifying data required to estimate the ROR. Chapter IV describes how the benefits and costs values are estimated and presents the analytical results, including an analysis of the institutional circumstances which have contributed to the impact level achieved. Finally, Chapter V summarizes the findings, draws policy implications and proposes future research.

CHAPTER 2 PROBLEM SETTING

2.1 *Structure and Performance of Cameroon Economy*

Cameroon is one of the most diverse African countries, with respect to its climate, topography, hydrology, vegetation, animal and soil types. Its extends over 475,000 km^2, with a population of 11.2 millions inhabitants, 61 percent of whom live in rural areas (World Bank, 1990). With a population growth rate (1989) of 3.1 percent (World Bank, 1989_a; 1989_b), agricultural productivity is of critical importance to continued economic growth.

With a GDP of US $920 per capita (1988), Cameroon is classified as a middle income country. Even though Cameroon economy is very diverse, agriculture remains its backbone, accounting for 24.8 percent of GDP (World Bank, 1990). Since independence, Cameroon economy has gone through three distinct growth phases. During the first phase (1960-1978) following independence, the economy grew rather slowly, but the pace picked up in the 1970s.

The second phase (1978-1981) was marked by a rapid growth, as a result of the discovery and exploitation of oil in 1978. From 1978 to 1979, the relative contribution of oil rose abruptly from about 1 to 20 percent of GDP, reducing agriculture's contribution from 72 to 50 percent of GDP.

The third phase started in 1982, when the pace of economic growth began to slow down (Table A.1). Since 1985, Cameroon has experienced a severe recession as a result of both external and internal factors, including the persistent fall in export crop prices, the sliding value of US dollar against the country's currency, declining oil production, and poor management of the economy. From 1987 to 1990, foreign exchange earnings fell by 45

percent, the real GDP decreased by 25 to 30 percent, and government fiscal deficit grew rapidly (World Bank, 1990).

To address these problems, in 1990 the government, in conjunction with the World Bank agreed to implement a structural adjustment program designed for:

> *(a) stabilizing public finances over the medium term (4 years) through improved management of government resources, control over government salaries, improved civil service management and productivity, and increased non-oil tax revenues; (b) restructuring and rehabilitating the public enterprise and banking sectors; (c) stabilizing agricultural financial and marketing structures (para. 2.03); (d) deregulating internal commerce and rationalizing external trade regulations; (e) increasing incentive for petroleum exploration and production; (f) reorienting health and education sectors policies to improve the quality of services; and (g) introducing action programs to reduce the social cost of adjustments (World Bank, 1990; p.1).*

But, an ongoing political crisis seriously jeopardized the successful implementation of the structural adjustment program. Today, Cameroon faces an uncertain economic and political future. With the projected decline in oil reserve and revenues, agriculture is expected to regain its primary role in providing the necessary impetus to the overall economy. The chances for Cameroon to successfully overcome the financial crisis lies not only on a successful implementation of the structural adjustment plan and necessary complementary policies, including appropriate agricultural policies, but also on the government's ability to reestablish a more serene political environment.

2.2 *Characteristics of the Agricultural Sector*

2.2.1 *Importance and Performance*

The agricultural sector in Cameroon has always been the key sector for the economy. In 1990, it employed 75 percent of the working population, accounted for 47 percent of export earnings, and contributed 24.8 percent of the value of the country's total production (World Bank, 1990).

Since independence, Cameroon's agriculture sector growth rate has fluctuated considerably. Averaging 5.2 percent in the 1960s (compared to 1.4 percent growth rate for the overall economy), the growth rate fell to 3.4 percent during the period 1970 to 1975. Between 1975 and 1982, annual growth rate rose to 7 percent, the highest level ever reached, due to expansion of export crop production. After 1983, unfavorable weather conditions, coupled with the decline in world market of export crop[2] prices drastically reduced the rate of growth (1.9 percent from 1982 to 1988 while the economy was growing at 5.6 percent). During 1986-1988, the economy experienced a timid come back. (World Bank, 1990).

*2.2.2 **Production System***

The agricultural sector is made up of three distinct subsectors: a traditional sector, a parastatal sector, and a private sector. The traditional subsector is dominated by small rural holders, who produce over 90 percent of the total agricultural output, and account for 75 percent of the total employment. Although the traditional sector is the dominant contributor to the total production and employment, it has received limited and inadequate investment support from the government. The parastatal sector includes commercial agro-industrial ventures which the government considered to be the engine of agricultural growth. Generally speaking, they have failed to meet government's expectations, despite heavy financial support through public investment. Finally, the private sector is still quit weak and has yet to make a significant contribution to the economy. These are mostly government bureaucrats and retirees' businesses.

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[2] The major export crops in Cameroon are cocoa (14 percent of the total export earnings), coffee (12 percent), timber (5 percent), and cotton (2 percent). In general, while the performance of export crops have been mixed over the past 30 years, it is claimed that, at least until recently, food crop subsector appears to have kept the pace with population growth, and high mortality rates have seriously affected the livestock subsector.

2.2.3 *Constraints*

Due to its agroclimatic diversity, Cameroon has the potential to be self-sufficient in crop and animal productions, and to produce exportable surpluses. Although until recently the country has been self-sufficient in many food crops, agricultural performance has been modest, relative to the natural and human resources available (World Bank, 1990). The bulk of the country's production comes from a shrinking rural population, and in recent years, productivity has failed to keep pace with 3.2 percent population growth rate.

The difficulties experienced by the agricultural sector are due to both internal and external factors; The most important external factors have been declining commodity prices for exports crops. Key internal factors include government policies which have failed to provide adequate and appropriate support to the agricultural sector. These have resulted in an aging farming population, inadequate rural infrastructures, erratic input supply, and inadequate institutional support (e.g. research, credit and extension) to farmers. The poor quality of the infrastructural network contributes to high distribution costs, limited regional coverage, and high post-harvest losses.

2.2.4 *Agricultural Policy*

Cameroon government has sought to promote agriculture through policies designed to support agriculture research and extension, provide farmers subsidized inputs, and create a stable price environment particularly for export crops. Historically, the government began to strengthen agricultural extension during the colonial period after World War II. The goal was to promote a rapid diffusion of export crops (e.g. cocoa, coffee, palm oil, rubber tree, and cotton) through technical support to crop-specific research stations (IFCC, IRHO). To achieve these goals, a training center for extension agents was first created at Ebolowa in the

South Province. Later, a second center was created at Yaoundé to provide more practical training.

Initially, the government extension approach focussed on identifying progressive farmers to serve as pilot farmers for demonstrations. Field visits were organized for neighboring farmers who were expected to strictly follow the instructions provided. The colonial government required that most of the farms be located along the road or behind farmers' houses in order to ensure permanent and easy policing, as well as tax collection. Failure to conform to the instructions was severely sanctioned. In the 1940s, after the practice of forced labor was abolished, the extension service was reorganized, and training centers strengthened. Also, the extension approach shifted to a strategy centered on State-owned structures called *Modernization Sectors*. This marked the beginning of a new era in development philosophy that prevailed until the financial crisis in the 1980s, which forced the government to publicly acknowledge the failure of this approach.

After independence, the government continued to provide extension services through State-owned agencies and the Ministry of Agriculture's traditional extension service, but their nature changed over time. Initially, the extension philosophy was based on the diffusion and community development models that were promoted in most Third World countries. Thus, the first *Five Year Development Plan* relied heavily on the *Modernization Sectors*, alongside the traditional extension service. In 1968, a new law allowed the government to create crop-specific parastatals, which were introduced in the second *Five Year Development Plan* along with the *Modernization Sectors*. Subsequently, *Modernization Sectors* were abolished and 14 parastatals were created, including SODECOTON in the North Province. These parastatals were expected to be the starting point for rapid diffusion of technology.

Since the creation of parastatals, the government has given priority to providing financial support to them, while neglecting the traditional extension service. During this period, agricultural policy focused mainly on export crops as a source of foreign exchange. It was not until the early 1970s that the government began to pay attention to food crops.

By 1980, it became evident that the diffusion and community development models had failed to generate a *Green Revolution* through a rapid increase in agricultural output. In the 1980s, the agricultural extension emphasis shifted towards supporting integrated rural development projects, as reflected in the fourth and fifth development plans. As a result, the traditional agricultural extension service was reformed in 1987, with the creation of ULER (*Unité Locale d'Encadrement Rapproché*) as a way to improve efficiency through better use of extension staff. This was aimed at insuring that graduates from the various professional schools of agriculture were effectively posted in the rural areas so they could provide better technical support to the farmers.

Recent IBRD (1989) and World Bank (1990) diagnoses of the extension services indicated that, except in the North-West Province where only MIDENO (Mission de Développement de la Province du Nord-Ouest) provides extension services, these policies have led to a proliferation of inefficient institutions. Overall, these institutions have proven to be costly, inadequately managed, and operate in a confusing policy environment with overlapping responsibilities and obscure objectives. In addition, their staff are inadequately trained, poorly motivated, lack logistic support, and operate under ineffective rural communication system.

In an attempt to address the above issues, the *National Agricultural Extension and Training Project* (NAETP) was initiated in 1988, with the objective to improve the efficiency of Cameroon's agricultural extension services and harmonize them into a single and less

costly system. The NAETP started as an 18 months pilot project in the North-West and selected areas in the South, East and Extreme-North provinces. Subsequently, it was extended for five years in 26 Departments in the Adamaoua, South-West, Littoral and West provinces. Since the North Province is not included during this first phase, extension activities were left to SODECOTON.

In 1990-91, within the context of structural adjustments, Cameroon government designed a new agricultural policy that focused on five major goals: (1) modernization of the production system, (2) ensuring food security, (3) encouraging and diversifying exports of agricultural products, (4) encouraging domestic processing of agricultural products, and (5) re-equilibrating the majors production channels. The government has placed considerable emphasis (a) restructuring, privatizing or dissolving state-owned agencies previously considered to be the engine of agricultural development and growth, (b) reorganizing the seed production and distribution systems, (c) reforming the fertilizer subsector (with the help of USAID) through a progressive reduction of government subsidies to ultimately achieve total privatization, (d) strengthening the agricultural research system, (e) improving the macroeconomic environment to enhance private investment, increased availability of agricultural inputs and credit, as well as reforming the current law on cooperatives and land tenure, and (f) further liberalizing the domestic market and promoting regional and international markets (World Bank, 1990).

2.3 North Cameroon Farming Systems Overview

2.3.1 Introduction

The North Province became a separate Province in 1984, when the former "big North" Province was subdivided into three Provinces: the Extreme-north, North, and

Adamaoua. The North Province extends over 67,798 km^2 and is subdivided into four Divisions: Bénoué, Faro, Mayo-Louti, and Mayo-Rey (Figure 2.1). Recent population data estimate the Province has 599,000 inhabitants unevenly distributed across the Province. The Province area and population represent 14 and 5 percent of the national statistics, respectively.

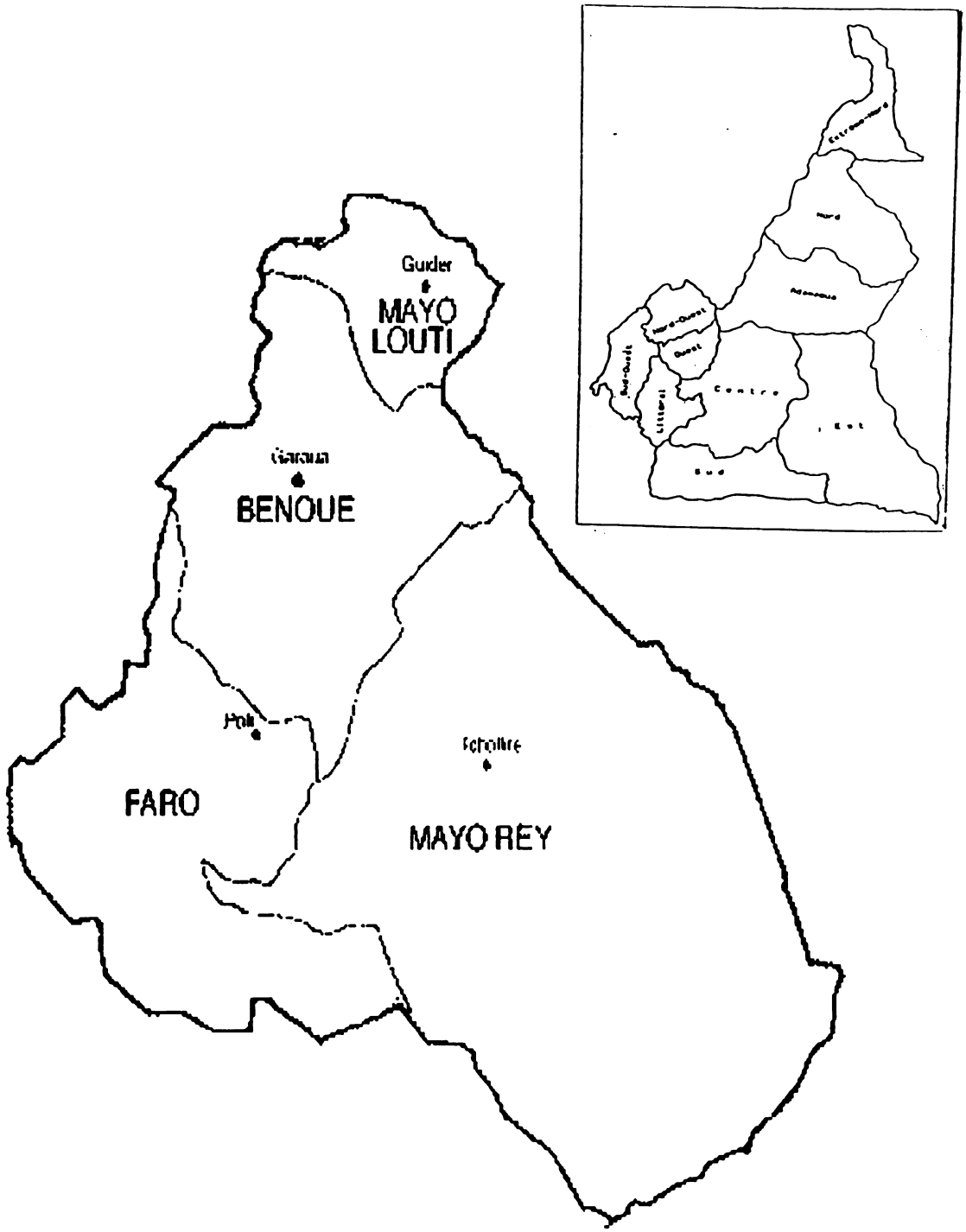

Figure 2.1: North Province Administrative Divisions

The North Province benefits from relatively favorable climatical conditions, which have made both crops and livestock the Province's primary activities. Unfortunately, its isolation from the major consumption and supply centers has hindered agricultural development of this sector. However, agricultural development in the Province has been enhanced by an integrated rural development approach promoted by the government through various projects and institutions, some of which cover the entire country. Those with a national mandate include "*Office Céréalier*", *Fond National de Développement Rural* (FONADER[3]), the *North Cameroon Seed Multiplication Project* (NCSM), SOCOOPED, and the *Institute of Agronomic Research* (IRA). Major projects with a regional coverage include *Société de Développement du Coton* (SODECOTON) and *Projet Nord Est-Bénoué* (NEB).

2.3.2 Climate

The Northern Provinces (Adamaoua, North, and Extreme-North) experience a tropical climate, with a monomodal rainfall distribution which increases from north to south. Based on annual distribution of the rains and predominant vegetation types, the North Province has been divided into three major agro-ecological zones: (1) the Sahelian savannah zone in the north-east region with an annual rainfall ranging from 600 to 800 mm, (2) the Sudan savannah zone in the west region with 800 to 1000 mm of rainfall, and (3) the Guinea savannah zone in the south region with 1000 to 1200 mm of rainfall (figure 2.2).

Unlike the southern regions of Cameroon which have two rainy seasons alternating with two dry seasons, the North Province has only one rainy season (April-May through October-November). The highest rains generally occur in August. The cropping period and calendar across the Province are determined by rainfall patterns, which vary from four to six

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[3] FONADER has been restructured and transformed into a bank called Credit Agricole.

months. This makes planting time the busiest period for farmers, since they must plant their principal crops during a very short time period (mid-May to mid-June). In the north and west regions, the rainy season is shorter (mid-May and mid-June), compared to the south and east regions (April- mid-June). The average monthly temperature varies from 26.5 °C in November-December to 45 °C in March-April.

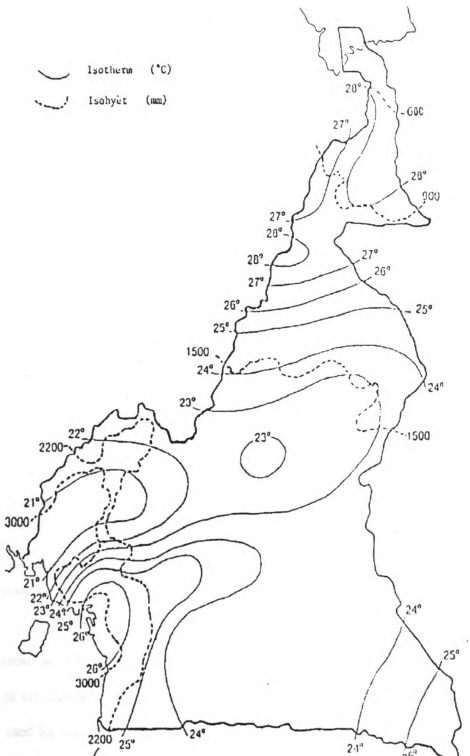

Figure 2.2: **Average Rainfall and Temperature Distribution in Cameroon**

2.3.3 Crop Production

The main traditional food crops in the North Province are cereals (sorghum and millet) and legumes (Groundnut and cowpea) as shown in Table 2.1. In most years, Sorghum has accounted for the largest proportion of cultivated area, followed by cotton, groundnut, and maize. However, recently, maize area has been expanding rapidly (figure 2.3), especially in the south-east Bénoué region which is referred to as the Province's maize belt. In this area, maize is not only grown as a sole crop, but also intercropped, and in rotation with cotton and/or legume crops.

Table 2.1: Area Cultivated (Ha) for the Major Crops in the North Province, Cameroon, 1984-1990.

Year	Cotton	Sorghum /Millet	Peanut	Maize	Beans	Cowpea	Cassava	Rice
1984	35,974	60,956	27,237	10,700	3,980	2,094	761	1,448
1985	61,536	85,043	29,873	24,044	5,372	973	1,052	654
1986	51,534	101,037	36,371	15,849	5,786	1,780	1,294	642
1987	31,464	67,473	20,676	12,554	2,430	366	1,006	12
1988	38,497	102,668	18,909	17,585	5,811	1,178	124	428
1989	34,115	75,978	20,696	23,553	3,981	1,307	1,924	384

Source: Adapted from the 1984-1989 National Agricultural Survey.

Cereals account for 53% of households' caloric intake (IRA, 1986; Ngambeky, 1990). These crops are generally consumed as flour, porridge, grits, and as local beverage; and the stalks are used for fuel, fences and fodder. Maize is also consumed green during the hunger period to fill the food deficit. Cotton has been the dominant cash crop, followed by groundnut which also serves as food crop. However, in the last decade, maize has become an

increasingly important food crop and a new source of family income, particularly in the west and south-east Bénoué regions.

The relative importance of these crops vary across the Province. Dry season sorghum (muskwari) and cowpea are mostly grown in the west and north-east regions. Maize is mostly grown in the south-east region while groundnut and cowpea are popular throughout the Province (IRA, 1986; Ngambeky, 1990).

2.3.4 Farming Systems

In general, North Province farming systems can be grouped into three major categories: the state-supported agro-industrial system, the traditional crop/livestock sedentary system, and the traditional pastoral nomadic system. Cropping period and calendar, as well as land clearing method, are identical in both the state-supported agro-industrial system and the traditional crop/livestock sedentary system. The most common land clearing method is slash and burn, especially for maize, cotton and sorghum. These systems have been extensively described by the IRA-SAFGRAD Farming Systems Research team (IRA, 1986; Ngambeky, 1990).

2.3.4.1 State-Supported Venture Systems

This term refers to the low and high input cropping systems, both of which are being extended by SODECOTON. They are essentially cotton based rotation systems, which vary in terms of management level depending on the crop[4]. SODECOTON provides the inputs used in these systems and technical back-stopping to participant farmers. The distinctive

[4] The main cotton based rotations are cotton-sorghum-sorghum, cotton-sorghum-cotton-maize, and cotton-sorghum-cotton-groundnut, cotton-maize or cotton-groundnut.

features of these systems, compared to the traditional systems, include the use of animal traction for land preparation[5], row planting, and the used of seed treatment, chemical weeding, and herbicides. However, some farmers following the *low systems* also have adopted these recommended practices, especially fertilizer, but at lower application rate.

Sorghum is planted under both management systems. The farmers following *high input sorghum system* generally plant improved sorghum varieties, either in pure stands or in association with maize, after cotton. In contrast, farmers following the *low input system* mostly plant local varieties in pure stands, after either cotton, a cereal or legume. Unlike with sorghum, SODECOTON promotes maize in a high input package, mostly in pure stands but also in association with sorghum.

Generally, farmers plant cowpea and other supplementary crops like millet and vegetables between early May and mid-May, sorghum and groundnut between mid-May and early June, cotton between early June and mid-June, maize in early May to mid-May, and rice in mid-June.

Animal husbandry and agro-forestry are important components of both the state-supported system, as well as of the traditional crop/livestock sedentary system. Animals are used for land preparation (animal traction), transportation, milk and sold to meet emergency cash needs. The most common animal found are cattle, oxen, goats and a small number of sheep, which are fed crop residues, grain husks, tree leaves and hay.

Government's effort to encourage tree planting through SODECOTON, ONAREF and NEB, and CARE have increased farmers' awareness and recognition of the economic importance of trees, including fruit (mango and lime) and non-fruit trees (Ngambeky, 1990).

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[5] Land preparation with animal traction is used mostly for cotton, maize and groundnut, but less so for sorghum, cowpea and muskwari (dry season sorghum).

2.3.4.2 Traditional Crop/livestock Sedentary Systems

In this category, farmers grow sorghum/groundnut as the main crops while raising animals on permanent locations. These farmers adopt very few of the practices recommended by SODECOTON. About 85% of the rural farming population practice the traditional crop/livestock sedentary systems.

Traditional farmers generally grow food crops in rotation with cotton, in pure stands or in association. At the Province level, 85 percent of the farmers grow pure groundnut[6], 75 percent pure maize, and 75 percent pure sorghum, and 45 percent pure cowpea. The most common associations are sorghum/cowpea, sorghum/groundnut, and sorghum/groundnut/maize, but farmers also grow maize/millet, groundnut/cowpea, maize/cowpea, and maize/groundnut in intercrops. The main non-cotton-based rotations are simple rotations of sorghum-groundnut, maize-sorghum, maize-groundnut, and cowpea-maize, or sorghum/groundnut followed by maize/sorghum, maize/groundnut or cowpea/maize.

2.3.4.3 Traditional Pastoral Nomadic System

This system involves 15 percent of the rural farming population, mostly from the ethnic group Foulbé, who graze cattle (transhumance) over a wide-ranging area, with no interaction with crop production. During the dry season, these farmers move further south in the valleys in search of grazing land and water.

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[6] SAFGRAD (1986) reports that 96 percent of the farmers in the NEB, 83 percent in the SEB, and 84 in the WEB grow groundnut in pure stand.

2.4 *Maize Research, Extension and Marketing Institutions*

2.4.1 *Cameroon's Agricultural Research System*

The foundations of scientific research in Cameroon was laid during the colonial period. As in most developing countries, agricultural research is organized and implemented by governmental agencies. Since independence, both the disciplinary as well as qualitative aspects of research have changed profoundly. Similar to the country's general economy, Cameroon's research system evolution during the post-colonial period can be classified into three distinct periods:

1) The 1960s were characterized by increased government recognition of the importance of research. Key policy initiatives included the creation of a coordination council[7] and executive bodies[8] which were dominated by French private interest groups. These structures were solely responsible for promoting and implementing scientific research activities.

2) The 1970s were characterized by increased nationalization of research structures, a rapid expansion of research executive bodies, as well as an expansion in the number of research disciplines and the scope of activities.

3) From the early 1980s to date, government support to agricultural research dramatically declined due to the economic crisis.

Post-colonial agricultural research, which dates to 1963, followed the general pattern describes above, both in terms of budgetary as well as disciplinary evolvements. Originally,

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[7] A *National Council for Technical and Scientific Research, Studies and Surveys* was created in October 20, 1962. It was chaired by the Vice-President of the then Federal Republic of Cameroon, assisted by five specialized committees.

[8] The executive bodies include ONAREST (May 24, 1965), Federal University of Cameroon (July 26, 1962) and associated higher schools, French institutes and Office (IRHO, IFCC, IRCA, IFAC, IRTC, CTFT, ORSTOM), and other technical services located within various ministries.

research was performed by French institutes, which focused -- on export crops namely cotton (IRTC), cocoa and coffee (IFCC), oil palm (IRHO), fruits (IFAC), and wood (CTFT).

Alerted in the early 1960s by potential food shortages in the western and extreme-northern parts of the country, the government urged the research system to expand its mandate to include food crops; As a result, two research stations were created in Dschang and Guétale in 1965. In 1974, in accordance with a nationalization campaign undertaken in the early 1970s, Cameroon government took full control over agricultural research by nationalizing the French ICVT to create the *Institute of Agricultural Research* (IRA).

Initially, IRA's primary mandate was to carry out crop research in order to improve their productivity. Subsequently, this mandate was extended to include:

a) Increased responsibility for multiplication and certification of improved seeds and vegetative planting materials, as well as ensuring that an adequate supply of these materials were available to farmers;

b) Ensure wide diffusion of research results by reinforcing the capacity of the Ministry of Agriculture and relevant government agencies to extend research results; and

c) Support planning and policy making by various governmental development agencies.

Since its creation, IRA has undergone majors changes, both in terms of the Institute's structure as well as the scope of research conducted. These changes reflected a recognition that agricultural research represented the country's main vehicle for reversing declining per capita production that characterized the 1980s, the future threat of food insecurity problems posed by a rapid urbanization and a rapid population growth. The latest structural changes in the agricultural research system are summarized in the five year *Action Plan*, submitted by IRA to Cameroon government and published in May 1991. The current IRA structure is summarized in the following chart:

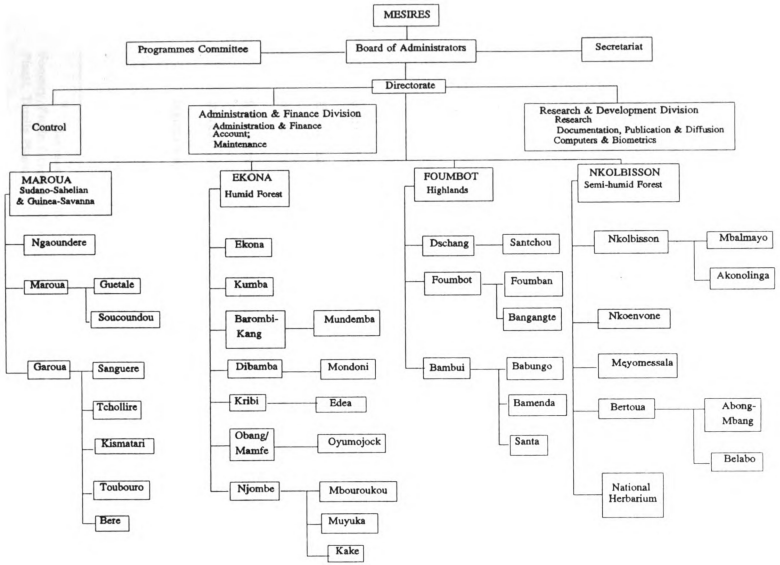

Figure 2.3: Organizational Structure of IRA.

Four key features of IRA's structure are highlighted below:

1) IRA's activities are organized within four research Centers, located to cover the country's major agro-ecological zones, as presented in Figure A.1 in the appendix.

2) IRA's research programs are carried out by 190 researchers whose qualifications range from "Engineer Agronome" to PhD. These researchers are distributed across a total of 16 programs[9], as opposed to 22 before the crisis. IRA supports ten commodity programs, six of which deal with food crops, and two of which are multiple crops oriented (Farming Systems, and Food Technology). The specific commodity program emphasis vary across Centers, depending on the agro-ecological zone in which the Center is located[10]. Cereals and roots and tubers continue to receive top priority. Among industrial crops, cocoa and coffee receive the highest priority, with the objective to reverse the declining trends and reduce unit production costs for these crops (IRA, 1989).

3) During the past two decades, food crops research has gained increased importance in terms of both its budget share and the scope of activities undertaken. Many projects have been implemented to address the various problems facing farmers in an effort to increase their welfare through the use of high yielding cereals, roots and tubers, leguminous crops and improved agronomic practices.

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[9] Bananas and Plantain, Botanic research, Cereals, Farming Systems, Food Technology, Forestry, Fruits, Genetic Resources, Latex Plants, Legumes, Oil Plants, Roots and Tubers, Soils, Stimulant Plants, Textile Plants, and Vegetables.

[10] Maroua: Cereals, Legumes, Textiles, Roots and tubers;
Ekona: Roots and Tubers, Fruits, Bananas and Plantain, oil Plants, Rubber, Soils, Forestry;
Foumbot: Cereals, Stimulant Plants, Roots and Tubers, and
Nkolbisson: stimulant Plants, Soils, Cereals, Roots and Tubers, Botanic research and Forestry.

4) In 1984, IRA initiated an adaptive research program with a farming systems perspective at Bambui, as part of the *National Cereals Research and Extension Project* (NCRE) and carried out mainly by *Testing and Liaison Units* (TLU). There are currently four TLUs located in four different Centers (Bambui, Ekona, Nkolbisson, and Maroua). This focus is expected to expand in the future.

5) In addition, IRA's Research and Development Division has among its various responsibilities, the mandate for economic analysis of the research programs.

IRA's *Action Plan* is based on "a redefinition of the Institute's goals, and the identification of ten strategic objectives directed at restructuring, reprogramming, and rehabilitating the institute. For each strategic objective, the Plan identifies a set of specific actions which will be taken to ensure that the goal of the Plan is accomplished" (IRA, 1989).

2.4.2 Maize Research

2.4.2.1 Introduction

Maize, rice, sorghum/millet and to some extent wheat[11] are the major cereals grown in Cameroon. While the country's total consumption requirements of maize and sorghum/millet are produced domestically, Cameroon import about 20% of its rice requirements and most of the wheat consumed. Maize was introduced in coastal Cameroon some 400 years ago by the Portuguese (Ayuk-Takem, 1991). Cultivated extensively in all ten provinces, maize is an important part of the population's diet. Annual production is estimated to be over 500,000 metric tons, but yields are low and unstable, mostly due to a lack of improved varieties for the various ecologies and limited use of improved agronomic practices.

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[11] The major wheat production areas were Wassandé (400 meters in the Adamaoua Province with the former SODEBLE), and Mbui and Donga/Mantung (more than 1600 meters) in the North-West Province. The annual production was estimated to be below 200 mT.

Research on cereals began in the early 1960s and was concentrated on maize, rice, and sorghum/millet. Ayuk-Takem (1991) identified several important periods in the evolution of maize research in Cameroon. From 1961 to 1965, most research activities were aimed at testing introduced materials in the highlands. The year 1965-66 marked the beginning of applied research, when the former French institute, IRAT, introduced varieties from West and East Africa, France, and Israel at Dschang and Maroua (200 meters). In 1971, a systematic breeding program was started at Bambui (1600 meters) based on new introductions from USA, West, East and Southern Africa (Zimbabwe and Zambia), Zaire, and Central America. However, maize research program did not become a major research activity until 1981 when the NCRE Project was started. Today, maize research in the North Province is primarily conducted by IRA through two projects: the NCRE Project, and the *Semi-Arid Food Grain Research and Development Projects* (SAFGRAD).

2.4.2.2 NCRE Project

2.4.2.2.1 Project Overview

While Cameroon began receiving US foreign assistance after signing a bilateral agreement in 1961, prior to 1978 USAID's assistance to Cameroon was relatively small (Jaeger, 1987). For example, in the 1960s, Cameroon received about 1.5 percent of total US assistance in Africa. This share then fell to 0.2 percent in 1975, but increased to 3-5 percent in the late 1970s and 1980s (Jaeger, 1987). Agriculture became the major focus of USAID in the early 1980s when the share of its assistance going to the agricultural sector grew from 25 percent in 1977 to 80 percent in 1982 (Jaeger, 1987). The NCRE Project (631-0013) is the most important component of this contribution.

The NCRE Project began in August 1979 as a five-year $7.697 million grant to the government of Cameroon. Implemented by IRA, it was designed to develop the institutional capacity of the Cameroon Institute of Agronomic Research to provide high-quality research on maize, rice, sorghum, and millet, as well as develop linkages to facilitate the transmission of research results. The *International Institute of Tropical Agriculture* (IITA) was contracted to provide technical assistance, limited supplies and short-term training, with USAID/Cameroon responsible for long-term training and major infrastructure. The Project is composed of four technical units, namely: Maize Improvement and Agronomy, Rice Improvement and Agronomy, Sorghum Improvement and Agronomy, and Testing and Liaison Units (TLU)[12]. Maize and rice were chosen partly because significant research directly applicable to the Cameroon environment has been done on these crops, while sorghum and millet were chosen because they are the dominant food crops in one of the most deprived part of the country, the northern provinces.

A 1983 evaluation of Phase I of the Project determined that the output and quality of the research were encouraging, and that the farmers (clients) were receptive to the research-generated recommendations. Therefore, a ten-year extension phase (NCRE II) was recommended and approved for $39 million, including a US $3.6 millions loan. The second phase built upon the first phase's accomplishments and continues to develop IRA's institutional capacity and facilitate the transmission of research results to farmers. Over this period, Cameroon government contributed an additional $25.4 million.

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[12] The TLU is a multidisciplinary research unit created to perform a testing function and to increase the likelihood of farmer adoption by fine tuning the technology developed on station through the use of a farming system methodology. This unit therefore completes the research process and enables researchers to develop relevant problem-solving programs and to develop technologies appropriate to farmer circumstances. The first TLU was created at Bambui in 1982. Later, three additional TLUs were created to serve the different agroecological regions of Cameroon: the Nkolbisson TLU (1986), for the subhumid forest and part of the forest-savanna transition zones, the Ekona TLU (1984), and the Maroua TLU (1988).

The project has successfully developed links with other international research institutes such as ICRISAT, CIMMYT and IRRI. In North Cameroon, NCRE researchers collaborate with the Beans/Cowpea CRSP on cowpea research, and with SAFGRAD for on-farm testing of NCRE/IITA varieties. SAFGRAD has also brought varieties from their headquarter in Burkina Fasso to the attention of NCRE team. The NCRE maize Agronomy unit works closely with SODECOTON. To date, NCRE has released about 11 open-pollinated maize varieties, four rice varieties, and five sorghum varieties (see Table A.2). A major component of the NCRE Project is the training program for national scientists. Overall, when the project terminates in 1994, 35 nationals will have been trained in various US universities (23 MSc and 12 PhD) in 12 different disciplines (Table A.3).

2.4.2.2.2 Maize Breeding

The NCRE maize breeding program's main objective is to develop stable, high-yielding maize varieties with good agronomic characteristics that are adapted to the Cameroon environment and satisfy consumers' requirements. The first year of the project was viewed as an observational and testing experience (NCRE, 1982). Maize breeding activities focused on screening introduced materials (Early Variety Trials) from IITA and CIMMYT, and comparing them to IRA and farmers' varieties. A total of 22 trials were implemented, including three maize/fertilizer trials and three evaluation trials. The single maize research unit which covers the three major agro-climatical zones where maize is grown (lowland rain forest, lowland savanna, and mid-altitude subtropics) was initially managed by a team of three researchers[13].

[13] The team was made up of two nationals (Dr. Jacob Ayuk-Takem at Bambui, and Mr. Jean-Bosco Zangue at Nkolbisson) and one expatriate (Dr. Jay Chung at Nkolbisson).

In 1984, an additional IITA breeder (Leslie Everret) joined this team. The unit was then divided into low and mid-altitude units. The low altitude unit (also referred to as the lowland program) covers areas less than 1,000 meters above sea level, which encompasses all of the forest zone, and the Sudanian and Guinea savanna. Administratively, these zones include the Center, South, East, South-West, the North and Extreme North provinces. The mid-altitude area corresponds to locations 2,000 meters above sea level.

Since its beginning, the major constraints that the lowland breeding program has sought to address include diseases (mainly maize streak virus), pests infestation (mainly stem borers), soil acidity in the forest zone, and shortness of the rainy season, and striga in the savanna area. Some of the program's specific objectives have been to develop maize varieties that are: (a) tolerant to drought and shade, (b) early maturing and have a deep root system, (c) suitable to intercropping, (d) streak resistant, and (e) soft endosperm.

The lowland breeding program comprises five major activities: variety screening of introduced material, population improvement, inbred line development, variety breeding, and breeder and foundation seed production. These activities are carried out in eight locations in the forest zone, and nine in the savanna. Since 1988, the intent has been to reduce the amount of germplasm introduced each year and to put more emphasis on population and hybrid development (NCRE, 1990). In general, before any new introduction is released for agronomic and on-farm testing, it is tested for a minimum of three years within the program. The first step is the *Experimental Variety Trial* (EVT) stage, followed by *Elite Experimental Variety Trials* (EEVT), and finally the *National Variety Trials* (NVT).

Experimental variety trials are designed to evaluate newly introduced varieties. These are grown in various ecologies to identify the best genotypes/location combinations. Superior or promising varieties identified at this stage are then advanced to the EEVT level. Each of

the EEVT generally includes 12 entries, six of which are superior varieties selected from the previous year's EVT while the other six are the best selection from the previous year's EEVT. The most promising varieties at the EEVT stage are then advanced to the NVT stage and, ultimately, to an *Advanced Variety Trials* stage, before being released for agronomic trials.

In addition, the unit carries out *Regional Unified Variety Trials* (RUVT), which are cooperative variety screening trials provided by international research institutions. Variety development has basically involved testing families in each of the female gene pool populations which have undergone one generation of random mating with the objective to produce experimental varieties. This generally happens in the first season. In the second season, the effect of random mating on yield, and resistance to disease is evaluated. This effort is complemented by line development, diallel evaluation, and variety evaluation[14].

Most of the maize variety developed by the program are open pollinated varieties. Although a hybrid program was started in 1984, it has expanded slowly mainly because of reluctance to promote the use of hybrids among small farmers. The traditional justification for this perspective has been that: (a) small farmers cannot profitably adopt hybrids under

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[14] Line development is an attempt to develop high-yielding and good combiner inbred line for synthetic and hybrid varieties development, and to identify new trait donor sources for population improvement.

Variety evaluation essentially aims at studying varieties' potentials as new trait donor sources for population improvement.

Diallel evaluation consists of testing (in the second season) direct and reciprocal crosses (and parents) made in a diallel fashion among a number of parents in the first season. The objective is to study the breeding value and heterotic relationships of the lowland maize population found adapted to the Cameroon environment.

Population improvement is designed to restore high-yielding capacity and improve some agronomic characteristics. It is achieved through traditional intra-population breeding methods and mass selection for local adaptability.

risky and low input conditions[15], (b) small farmers will not be willing or cannot afford to replace their seeds each season, and (c) the successful introduction of hybrids requires the existence of a well-established seed industry. The validity of these assumptions are further discussed in Chapter 4.

2.4.2.2.3 Maize Agronomy Research

Maize agronomy research in the North Province is carried out by the NCRE's *Cereal Agronomy Unit* based at Garoua. The unit is responsible for maize, sorghum, and pearl millet agronomic experiments in the semi-arid lowland savanna (Extreme North Province), the subhumid lowland savanna (North Province), and the highland plateau of Adamaoua. The main research objectives are to: (a) better understand the main agronomic constraints to cereal production in this mandate area, and (b) test different agronomic practices in an effort to alleviate these constraints.

When the unit started in 1982, its activities were limited to conducting fertilizer and variety trials, especially on maize and mainly in the western provinces. Since 1985, it has established an extensive production-oriented research program, devoting about 70 percent of its research efforts to maize and 30 percent to sorghum, especially since 1985 (NCRE, 1986 p.190; NCRE, 1988, p.63. Unlike other NCRE's agronomy units, the cereal agronomy program in the North operates to a considerable degree as an extension agronomy unit, due to the nonexistence of a TLU in the Province. It also helps manage maize and sorghum breeding trials in the Province. Due to the wide diversity of agroclimatic conditions in the

[15] It is often argued that hybrid production potential can only be achieved under favorable climatic conditions and with the use of a complementary input package including fertilizer. Therefore, small farmers, who are believed to be operating under risky and low input conditions and rarely adopt the entire package cannot recovers their expenses.

ecologies the unit covers, field research activities are conducted at ten IRA substations and on many farmers' fields. The unit develops its work plan with considerable inputs from SODECOTON.

2.4.2.2.4 On-farm Maize Research

On-farm research started in Cameroon in 1977 when SAFGRAD JP #26 was established at Maroua under the leadership of Alex Bouchette. Following the creation of the first NCRE Project TLU at Bambui in 1981, the program took a completely new dimension. The success of this TLU in the first phase of the NCRE project led to the creation of more TLUs, as discussed in the project overview section. SAFGRAD Projects and the TLU have addressed various research themes, including: date of planting, plant density, fertilizer response, weed control, planting methods, intercropping, and crop rotation trials. SAFGRAD's activities were concentrated in the North Province while the TLU/NCRE operates in the Extreme-North. Since 1982, the NCRE maize agronomy research team based at Garoua has carried out extensive on-farm testing in collaboration with SODECOTON.

2.4.2.3 SAFGRAD Projects

2.4.2.3.1 Introduction

Three SAFGRAD projects have operated in the North Province since 1977, namely: SAFGRAD Joint Project #26[16], SAFGRAD Joint Project #31, and SAFGRAD/Farming Systems Research. All these projects are collaborative projects with the *Scientific, Technical and Research Commission* (CSTR) of the *Organization of African Unity* (AOU). SAFGRAD

[16] This project started in Maroua in 1977 under the management of Alex Bouchette. Virtually no written document about this project is available.

activities are coordinated from its headquarter in Burkina Fasso. Generally speaking, SAFGRAD provides funds to IITA and ICRISAT to (a) support food crop research programs with a regional scope in the semi-arid area of Africa, (b) improve communications among food crop scientists in this region by funding visits, conferences and seminars, (c) test research station results under farmers' circumstances[17], and (d) support long-term training in the US, as well as short-term training at ICRISAT and IITA. The major source of SAFGRAD's financial support has been USAID. Some funding have been provided by FAC, IDRC, IFAD, and national governments.

2.4.2.3.2 SAFGRAD J.P. #31

SAFGRAD J.P. #31 started in 1979 as a continuation and extension of the J.P. #26 with the arrival of Owen Gwathmey, assisted by a national (Martin Fobasso). In 1984, Fobasso went for training in the US and was replaced by Jean Zoning, who unfortunately died on February 1986. During this same period, Jerry Johnson took over from Owen in 1984. Until the early 1980s, SAFGRAD J.P. #31 research activities focused on station varietal trials on sorghum, millet, maize and cowpea. The project progressively shifted to emphasize on-farm testing, as the number of food crop scientists at IRA Maroua increased. By 1983, their entire research program was on-farm oriented.

The variety screening process followed by SAFGRAD J.P. #31 involved a minimum of five steps:

1) *Regional Variety Trials* (RVT) for newly introduced material, which were implemented on research stations.

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17 On-farm research was the focus of SAFGRAD's *Accelerated Crop Production* (ACPO) program which was implemented in four member countries, namely Mali, Togo, Burkina Fasso, and Cameroon.

2) *Advanced Variety Trials* (AVT) which were theme-specific adaptive trials for promising varieties identified in the RVTs.

3) *Pre-extension Trials* (PET), which were on-farm multilocational trials.

4) *Taste Tests* of varieties retained at the PET stage. Varieties selected at this level were called "elite varieties".

5) *Premultiplication plots* of foundation seeds for extension services and specialized seed multiplication companies. The multiplication process followed FAO's recommendations.

The on-farm testing program's objective was to make both research and extension stronger and more effective by establishing a link between station research and SODECOTON. In the framework of this institutional collaboration, IRA had the responsibility to provide an annual work plan with SODECOTON input. In return, SODECOTON made available over 300 field agents to supervise the implementation and inputs to be used, and formulated new extension themes based on on-farm test results. In addition, farmers contributed to the program by providing the "local" variety to be used as a check in the trial, as well as labor.

Each January, an annual planning meeting IRA-SODECOTON is held. The SAFGRAD on-farm research team submit a preliminary report, which summarized last year results and proposed new test themes. The results and theme proposals are discussed by all participants, and a final report of test results and revised proposals are made available for the agronomists research meeting. To implement the agreed upon research, each SODECOTON sector head chooses the field agents best qualified to conduct each test.

At the end of April or early May, the selected agents meet with IRA scientists in groups from three to four *sectors*. During these meetings, the tests implementation process is

explained and discussed, and the necessary inputs distributed. Specifically, these field agents are instructed on how to choose an appropriate farmer and field, when to plant the trial (late May early June), and how to prepare the land and supervise seeding.

The research team visits the selected sites a minimum of two times. The first field tour is made in June-July to check the choice of the fields, the status of land preparation and seeding, and to discuss and solve early season problems. Another field tour is made around the end of July or early September. This tour is the most important one because during this visit researchers gather detailed information regarding plant density, treatments and operations performed for each treatment; check the consistency of what the field supervisors did with the guidelines on the instruction sheet; make agronomic observations; and collect rainfall data. At the end of the visit, instructions for harvest are discussed.

2.4.2.3.3 SAFGRAD/FSR

SAFGRAD/FSR was established in 1986 with the following objectives:

1) To develop agricultural production technologies adapted to the conditions and need of small-scale farmers, with emphasis on soil-water, soil-moisture, soil-fertility and other conservation techniques.

2) To strengthen the national *Farming Systems Research Program* by working together with national researchers and extension agents.

3) To foster the transfer of agricultural research results by conducting on-farm trials and socioeconomic studies in collaboration with farmers , and by providing feedback between station researchers, development agents, and farmers.

SAFGRAD/FSR followed a multidisciplinary approach to research implemented by a team of scientists from three disciplines (agricultural economy, agronomy, and agro-forestry),

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and had a mandate to cover the five northern-most regions of SODECOTON. The team conducted on-farm research with both *SODECOTON and non-SODECOTON farmers*. SAFGRAD/FSR operates in *primary and secondary villages* selected using a multistage random sampling procedure[18].

Research activities carried out can be grouped into four categories: (1) research-managed agronomic trials and (2) on-farm trials conducted in collaboration with SODECOTON and farmers that are implemented in the *primary sites*, (3) on-farm trials conducted in collaboration with farmers only in the *secondary sites*, and (4) socioeconomic studies[19]. In 1986, a large number of *tertiary sites* were used for farmer-managed trials. Both agronomic and economic evaluation of the trials (partial budget analysis) were done.

Researchers' interaction with SODECOTON starts with a planning meeting in early February, during which previous results are discussed and new themes (mostly variety trial) for on-farm testing are identified. After agreement, the SAFGRAD team's responsibility is to prepare the trials' protocols, to provide seed, to visit the trial sites, and analyze the collected data. SODECOTON selects sites and farmers, and assigns monitors to the selected farmers.

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[18] The SAFGRAD team divided its mandated area into three agroecological zones (Sahelian savanna, Sudan savanna, and Guinea savanna), which are further divided into geographical regions, based on cropping patterns, soil types, and farmers' socioeconomic setting. A sample of 2-3 *primary villages* and 2-3 *secondary villages* around each *primary villages* were randomly selected in each region from the list of villages in that region. The *primary villages* are selected based upon soil types, accessibility, relative location and size, and local public support programs. A *field research assistant* was posted in each of the *primary villages*. He compiled a list of farmers in each village, including their affiliation with SODECOTON. From each of these lists, 5-10 farmers were randomly selected, depending on the size of the farming population. A total of 220 farmers were selected from these villages. Non-SODECOTON farmers are selected on a voluntary basis during a meeting with the farmers, presided over by the village chief. During this meeting, the project and proposed research themes objectives are explained and discussed.

[19] Numerous socio-economic surveys were conducted. A sample made up of the 200 farmers selected was used in a baseline survey of the Province. Various subsets of this sample were included as respondents for specific studies, including verification, farm resources use, marketing and storage, transportation facilities, and farmers organizations.

More specifically, a *chief of sector* selects 2-3 *zones*. The selected *zones* chiefs in turn select 1-3 villages. In each village, a farmer is identified for the trial. Each farmer is treated as a replication within a *sector*.

Before planting in each *region*, a series of meetings were held between the SAFGRAD team, *chief of sectors*, *chief of zones*, and *monitors*. The SAFGRAD team visited the trials at least four times: (1) before planting to distribute planting material, (2) between planting and harvest to record observations, (3) close to harvest to distribute harvesting material and provide instructions, and (4) at harvest to weigh and collect harvest samples.

2.4.3 Maize Extension

Maize extension activities in North Cameroon are performed by various institutions, most of which are state owned. Socioeconomic economic surveys conducted by the SAFGRAD/FSR team in 1986 revealed that the most important of these institutions is SODECOTON with a coverage of about 39 percent of the North Province farming population. The other institutions which are marginal include the Ministry of Agriculture's extension service (9 percent) and "*Société de Développement du Blé*[20] (SODEBLE).

2.4.3.1 SODECOTON

2.4.3.1.1 Structure

SODECOTON is a rural development-oriented agro-industrial agency created in 1974 to take over from the French cotton company, CFDT. It is co-founded by the Cameroon government and France, and supervised by the Ministry of Commerce. However,

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[20] Officially created for wheat production, SODEBLE ended up engaging in maize production. It was however terminated in the late 1980s.

SODECOTON agreed to collaborate with the Ministry of Agriculture's extension service. Geographically, SODECOTON's activities cover both the Extreme-North and North provinces, as presented in Figure A.2 in appendix.

SODECOTON's activities are organized in two main Divisions: the Division of Rural Development, and the Division of Industries and Equipments. The Division of Industries and Equipments manages industrial activities of nine physical degraining plants. The Division of Rural Development, headed by a Director and Deputy Director, carries out production extension activities. At the bottom level of the Division of Rural Development structure are *markets*, managed by one field agents (*monitors*) per *market* or two if the *market* is large (i.e. 300 to 350 ha). These *markets* are grouped into *zones* (5-14 per *zone*), which in turn are grouped into *sectors* (3-5 per *sector*). The *sectors* are also grouped into *regions* (3-5 per *region*). Each of these substructures is headed by a Chief, assisted by a training service.

Over time, the size of the Division of Rural Development has undergone various changes in an attempt to ensure effective and close monitoring at reasonable costs. The current *regions* are: Mora-Mokolo-Diamaré, Kaélé, and Mayo Daney in the Extreme-North; Mayo Louti, North-East Bénoué (NEB), West Bénoué, and South-East Bénoué (SEB) in the North Province.

2.4.3.1.2 Activities Overview

SODECOTON extension service follows a modified Training and Visit extension system approach. Over time, these activities have been organized within various rural

development projects[21], either as one of many participants responsible for implementation or as the sole participant. SODECOTON performs numerous activities, including:

1) Extension. Food crops and cotton production extension program serves about 180,000 participant farmers.

2) Inputs supply. Inputs for the packages extended include fertilizer, improved seeds, herbicides, pesticides and animal traction supplies. These inputs are not subsidized, but they are given to farmers as a loan, which must be repaid in cash after farmers sell their cotton to SODECOTON. As a result, only cotton farmers are eligible to receive the loans.

3) Promotion of farmers' cooperatives. This activity, initiated in 1980, is aimed at organizing farmers into producer associations for the commercialization of cotton and cereals. SODECOTON monitors the program and in return the associations pay a management fee to SODECOTON. The first associations were called *Pre-cooperative Farmers' Groups* (GVP), but SODECOTON gradually transfers responsibilities to farmers.

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[21] These include:

a) Project South-East Bénoué phase I, II and III: It was initiated in late 1974 with funding from the government, the *National Product Marketing Board*, and SODECOTON. The second phase (1983/84-1987) was sponsored by CCCE, BIP, and SODECOTON. In 1987, the CCCE gave F.cfa 6.42 billion to continue finance, among others (i) crop diversification in relation with the creation of a research station at Garoua and the growing importance of maize in the North, (ii) *Self-Managed Farmers Associations*, (iii) 120 Km of rural roads and 43 wells, and (iv) the relocation of 6,000 migrants in area suitable to farming.

b) Project North East Bénoué: participated from 1975 to 1979-80 by providing technical support to farmers.

c) Project West Bénoué (1983-): sponsored by FAC, BIP, and SODECOTON.

d) Project Centre-Nord (1981-1988): sponsored by BIRD, USAID, BIP, and SODECOTON.

e) Project Motorization (1981/82-1985/86): sponsored by CCCE, BIP, and SODECOTON.

f) Project FSAR II (1985-): designed by FONADER and sponsored by BIRD, and BIT. SODECOTON participate by implementing the functional alphabetization of farmers, storage and degraining of groundnuts.

In 1987/88, the GVP were replaced by the *Self-managed Farmers' Associations* (AVA), with activities extended to inputs management (acquisition and distribution) and field monitoring. Wherever an AVA is created, SODECOTON field agents are phased out and replaced by farmers selected by the AVA members. However, SODECOTON does not completely abandon the area; It continues to provide training to the AVAs' leaders and supply inputs that are warehoused in some villages. AVAs are responsible to get the inputs from SODECOTON (as loans) and ensure their distribution to its members. In 1990/91, there were 471 AVAs with 93,716 members.

4) Commercialization. Cotton is the main crop commercialized by SODECOTON. Maize commercialization started in 1981-82 through GVP. However, food crops sales or purchases are marginal. The GVP maize price to SODECOTON ranges from 45 to 65 F.cfa/kg. In general, commercialization activities are carried out either directly or through farmers cooperatives.

5) Promotion of animal traction for land preparation. This effort is supported through sales of supplies, veterinary products and training for animal feeding and dairy animal management.

6) Promotion of agricultural mechanization. This is supported through sales or rent of tractors and equipments, including training and maintenance. This activity was initiated in 1978 in the Bénoué area.

7) Collaboration with research (IRA). Collaboration, especially on the on-farm research activities, is implemented through IRA/SODECOTON annual planning meetings and on-farm trials. During annual planning meetings held at the beginning of the cropping season, researchers present and discuss new results (if any) and work plans for the

coming season. SODECOTON gives suggestions to improve the work plans and ensure that the research conducted is appropriate, and also provide feedback on the on-farm performance of previous research results.

Initially, SODECOTON participated in on-farm research activities, at no cost to IRA. But since 1989, SODECOTON has charged 50,000 F.cfa for every CRB trial conducted and 52,250 F.cfa for every RCB trial, which has considerably reduced the number of trials implemented.

8) Infrastructure. These activities include building rural roads, warehouses, schools, hospitals, dispensaries, schools, and wells, and relocating migrants in areas suitable to farming.

SODECOTON involvement in food crop extension began in 1974-75 with rainfed rice and maize extension activities followed a year later. The objective of these food crop extension activities was to progressively encourage farmers to replace sorghum with more productive crops, so that farmers could devote more of their time and larger portions of their land to cotton production (SODECOTON, 1976-77; p.20). Also, SODECOTON expected that these crops would provide farmers with a secure and adequate food supply during the hunger period before sorghum is harvested. Food crop extension was later expended to cowpea, sorghum and groundnut through a World Bank project (*Project Centre-Nord*), which was managed and implemented by SODECOTON in collaboration with IRA. Since 1990, food crop activities have been reduced in an effort to fulfil the *Performance Contract* agreements signed with the government in an attempt to improve the financial results.

2.4.3.1.3 Maize Extension

As reported earlier, SODECOTON initiated its maize extension activities in 1976-77. In that year, two maize varieties imported from Nigeria (Samura 123 or S123 and Upper Volta Early) were tested over about 100 hectares. Since then, numerous varieties have been evaluated under farmers' conditions and extended as summarized in Table 2.2.

Table 2.2: Maize Varieties Extended by SODECOTON, 1975-1991, North Province, Cameroon.

Variety Extended	Year of Introduction	Last Year in Extension	Variety Origin
Samura 123	1975-76	1983-84	Nigeria
Upper Volta Early	1975-76	1975-76	Nigeria
NCA	1977-78	1077-78	IRAF
TZPB 81	1982-83	(a)	IRAF
Mexican 17 Early	1984-85	(a)	IRAF
CMS 8501	1988-89	(a)	NCRE
CMS 8704	1990-91	(a)	NCRE

(a) Still being extended.
Source: Adapted from SODECOTON Annual Reports 1976-77 to 1990-91.

In the North Province, maize is extended under *low input* and *high input systems*. These two systems differ not only in terms of the inputs use but also in terms of SODECOTON monitoring. The *high input system* is characterized by SODECOTON field agents supervision, mechanical land preparation (oxen and tractor), seed treatment, herbicide and fertilizer application, and a specific plant stand (0.80 x 0.25 m, one plant per hill). Farmers participating in the intensive system have little choice but to follow SODECOTON's guidelines. For example, land is prepared with either oxen or tractors. Cotton farmers who

do not use treated seeds are not eligible to receive the fertilizer loan. Herbicide and fertilizer recommendations are monitored closely. Planting is strictly done during the recommended period.

By contrast, the *low input system* is characterized by minimal use of these inputs and no SODECOTON monitoring. The varieties planted in the *low input system* are those extended by SODECOTON, either the same year or in some recent years ago. Row and manual plantings, as well as a cotton/maize crop rotation, are very common in both systems, and in 70-85 percent of the cases, maize follows cotton, a crop sequence recommended to take advantage of the residual effect of the fertilizer applied on cotton.

Originally, the *high input system* was extended for maize grown in a pure stand. Beginning in 1983-84, this system was also extended for maize grown in association with sorghum (the initial pattern which alternate planting within a row, was later replaced by alternate single rows). This association is intended to provide farmers with food (maize) during the August-September hunger period before sorghum harvest. Under this cropping pattern, a different herbicide (sorghoprim) and a lower fertilizer application rate (50 kg/ha of urea for maize and 50 kg/ha of urea for sorghum) are recommended.

Over the last decade, the maize area in the northern part of Cameroon has expanded tremendously. This can be seen using SODECOTON data presented in Table 2.3 and Figure 2.4 below, even though SODECOTON does not deal with all farmers in the Province. However, a comparison of SODECOTON and census data (Table 2.1) shows no significant difference.

Table 2.3: Area (Ha) Planted for Crops Extended by SODECOTON, North Province, Cameroon, 1979-1990.

Year	Maize	Sorghum	Peanut	Rice	Cotton
1979-80	6,160	md	md	747	56,594
1980-81	6,152	md	md	347	65,340
1981-82	6,691	md	23,043	546	63,343
1982-83	6,870	143,529	26,943	826	54,629
1983-84	7,621	120,049	28,772	941	71,092
1984-85	9,319	140,659	34,467	1,078	73,319
1985-86	13,877	149,480	43,447	867	89,232
1986-87	15,592	151,660	42,589	644	94,461
1987-88	13,291	142,017	35,578	414	94,744
1988-89	18,657	158,442	42,786	181	111,604
1989-90	27,232	173,314	45,100	223	89,004
1990-91	24,985	158,504	40,290	161	93,835

"md" stands for missing data.
Source: Adapted from SODECOTON Annual Reports, 1976-77 to 1990-91.

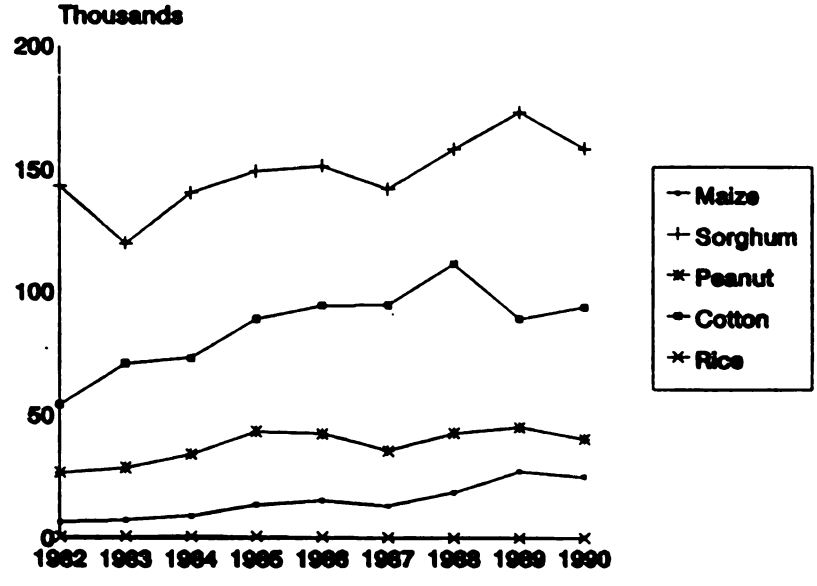

Figure 2.4: Area (ha) Planted for Major Food Crops in the SODECOTON Zone, North Province.

While SODECOTON considers maize area expansion to be a success, it recognizes that it has been taking place at the expense of sorghum and cotton (1978-79, p.15; 1982-83, p.32). This expansion has occurred mainly in the North Province (about 70-96 percent of the area), especially in the Tcholliré subdivision, while the area under sorghum and cotton has been expending in the extreme-north. In 1983-84, SODECOTON decided to stop maize extension activities in the north-most part of its mandated area (i.e., current Extreme-North Province) because of poor yield resulting from unfavorable climatic conditions. In contrast, the southern area proved to have good potential for maize production thanks to favorable rains. Over time, maize yield under the *high input system* in farmers' fields has averaged 2.3 metric tons per hectare, ranging from 2.0 to 3.0 mt/ha.

2.4.3.2 *Ministry of Agriculture*

The Ministry of Agriculture is comprised of eight Directorates, one of which is the Directorate of Agriculture (DIRAGRI). The DIRAGRI has the responsibility for delivering extension services for agricultural production and plant protection through Provincial Delegations in each of the country's ten provinces.

Overall, the extension activities from Agricultural Provincial Delegation (North Province) has been marginal and their liaison with IRA has been weak. The main reasons are partly the weaknesses of the majority of the extension services within the DIRAGRI referred to in the agricultural policy section of this chapter. Thus, most of the effective extension activities in this Province has been carried out by SODECOTON, which delivers extension support primarily to cotton farmers.

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2.4.4 Seed Production

2.4.4.1 Seed Policy

Since the 1970s, various government institutions have carried out seed multiplication, either as full time activities or as a complementary activity, including:

a) NCSM operating in the northern part of the country and sponsored by USAID;

b) MIDEVIV (Mission de Développement et des Semences et des Cultures Vivrières) seed multiplication center at Ntui, operating in the South, with FAO technical assistance;

c) UCCAO (Union Centrale des Cooperatives Agricoles de l'Ouest), operating in the West (Bafole), with World Bank founding;

d) MIDENO (Mission de Développement de la Province du Nord-Ouest) operating in the North-West, with limited donors' support;

e) French technical assistance, which provided contributions for procurement and the training of nationals.

Despite the impressive number of institutions involved in seed production and distribution, Cameroon has no clear seed policy, even though MIDEVIV was given the mandate to promote the development of food crops and seed production. In an attempt to improve seed production policy, the government created a seed council in 1990 and liquidated MIDEVIV. This council is now responsible for establishing the procedures for seed certification and registration, varieties release and publishing a seed catalog.

Among the institutions involved in seed production and distribution, NCSM has performed best based on the amount of seed distributed[22]. But due to the ongoing economic

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[22] A total of 300 mt of maize and groundnut seeds were distributed by NCSM up to 1989, as oppose to a total of only 15 to 40 mt for the other institutions.

crisis faced by the country, the poor financial performance of NCSM, and the increasing demand for seed, the government decided to privatize the seed production and distribution sector. As a result, Pioneer established a subsidiary in Cameroon and initiated operations in 1991.

2.4.4.2 North Cameroon Seed Multiplication Company (NCSM)

The NCSM project was created on June 15, 1975 to serve the northern part of Cameroon through a bilateral agreement between USAID and the government of Cameroon. The objectives assigned to the project were: (1) to improved farmers' productivity through the production and distribution of improved seeds, as well as training, and (2) to reduce market prices of cereals and legumes by increasing market supply. Its parent organization is the Seed and Food Development Authority (MIDEVIV).

The NCSM project lasted 15 years before being terminated in 1989/1990. It went through two phases. Phase I lasted five years (1975-1980), followed by an intermediate phase (1980-1982) which was entirely financed by Cameroon government. The goals in phase I were not achieved in part because "the project tried to undertake too many activities at the same time with limited resources" (Jaeger, 1987).

NCSM did not make a serious effort to address seed production requirement until during its second phase, when it was included as a component of *Project Centre-Nord*. This phase went from 1983 to 1990, including three years extension after the original end of project date. Under *Project Centre-Nord*, NCSM was redesigned to broaden its scope of seed multiplication activities, to institutionalize a functioning seed flow program including linkages with research, and to ensure delivery of improved seed to farmers (Johnson, 1987). The

NCSM carried out seed production in six multiplication fields located in the Extreme-North (Kousseri, Guetale, Gazawa), North (Garoua, Sanguéré) and Adamaoua (Wakwa) provinces.

NCSM initially focused on producing sorghum. It was not until 1978-79 that its expanded its production to maize. The maize varieties grown are open pollinated. Table 2.4 and 2.5 below present crops dealt with by the NCSM project, the area cultivated and production of each of these crops over the years.

Table 2.4: Area Planted (ha) for Seed Production by NCSM Project, 1979-1989, Cameroon.

Year	Sorghum	Maize[a]	Groundnut	Cowpea	Onion	Coton	Sweet P.
1979	53.10	11.40	348.40	0	0	0	0
1980	41.40	68.10	139.10	0	0	87.00	0
1981	31.00	43.00	122.00	0	0	0	0
1982	28.00	59.00	116.00	0	0	0	0
1983	16.70	56.00	137.00	7.00	1.00	0	0
1984	35.00	57.25	235.50	27.00	1.20	0	0.10
1985	41.20	136.00	130.00	15.50	1.70	0	0.50
1986	79.20	128.40	104.70	30.00	7.30	0	0
1987	49.00	84.00	98.50	24.50	6.50	0	0
1988	6.16	59.60	70.64	14.01	0	0	0
1989	45.00	109.00	75.25	3.50	0	0	0

[a] 5.57 hectares of maize were planted in 1978 and none before 1978.
Source: Adapted from the NCSM Annual Reports and Evaluation Documents.

Table 2.5: Seed Production[b] (mt) by NCSM Project, 1979-1989, Cameroon.

Year	Sorghum	Maize	Groundnut	Cowpea	Onion	Cotton	Sweet P.
1979	39.10	11.40	280.94	0	0	0	0
1980	35.44	89.45	121.75	0	0	108.00	0
1981	29.88	60.76	183.08	0	0	0	0
1982	33.60	141.20	167.70	0	0	0	0
1983	17.00	147.00	203.00	11.00	0.35	0	0
1984	50.30	113.50	1,445.66	15.52	0.87	0	0.55
1985	74.30	242.60	163.22	18.20	0.85	0	3.00
1986	164.77	340.40	191.49	32.56	80.56	0	0
1987	md	md	md	md	md	0	0
1988	0.00	62.30	113.36	md	0	0	0
1989	md	md	md	md	0	0	0

[b] Does not include purchases from contractual farmers.
"md" stands for missing data.
Source: Adapted from the NCSM Annual Reports and Evaluation Documents.

The NCSM project seeds were produced either by the project itself[23] or through contract farming. These seeds were mainly sold to SODECOTON for distribution, and less so to NEB and SODEBLE. NCSM did not have a clearly defined seed price policy (NCSM, 1986). While project officials favored differentiating prices from grain prices, SODECOTON staff claimed a high seed price would curtail farmers' demand. Consequently, certified seed prices were subsidized (60% subsidy). Later, during the mid-term evaluation in July 1980, NCSM was advised to carry out a market study and farm survey to estimate farmers reactions to and effective demand for improved seeds (Johnson, 1987).

[23] Maize, sorghum, cowpea and groundnut were produced at Sanguere, Guetale and Gazawa, onion at Kousseri and fruits at Karéwa and Wakwa.

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The NCSM was terminated in 1983 because of poor financial performance, slow implementation of most project activities, poor management and coordination among participant government agencies (IRA, SODECOTON, MIDEVIV), and the project attempt to do too much in such a short time (Jaeger, 1987). In addition, the evaluation team criticized the project design by commenting that "several optimistic assumptions were made and that constraints to the project's long-term objective were not properly considered. These include poor farm size selection, lack of research results, inadequate marketing systems, lack of quality control, and uncertainty about the capacity of the private sector" (Jaeger, 1987). Thus, the project poor performance was in part due to the failure of the project designers to consider that research on breeder seeds required is a long-term effort for which the outcome was difficult to predict.

2.4.4.3 Pioneer Agrogénétique Cameroon (PACSA)

Following the decision to privatize the NCSM project, seed production was taken over by *Pioneer Cameroon* (PACSA) under an agreement signed with the Government in March 1991. This agreement handed over all facilities previously used by the defunct the NCSM project to *Pioneer Cameroon* in exchange of a symbolic franc.

Unlike the NCSM project, *Pioneer Cameroon* operated on a profit-making basis. In order to achieve this goal, the company planed to expand geographically, increase the number of commodities produced, as well as gradually phaseout open-pollinated varieties for hybrids. Soybean, sunflower, and alfalfa will be added to the crops traditionally grown by NCSM (maize, sorghum, cowpea and onion). In addition, suitable hybrids were expected to be developed or identified to replace the open-pollinated maize varieties. PACSA's first target area was the northern part of Cameroon. Its first produced open-pollinated seeds in 1991.

Seed production activities were expected to expend over time in the South, North-west, South-west provinces, and ultimately, in all Central Africa economic union countries[24].

While in its developmental stage, PASCA's managers strongly believed there is a high potential to achieve their goal, given the large market, guaranteed support from the Ministry of Agriculture if needed, and a well-structured research system with which they will be collaborating. Unfortunately, all hopes raised by *Pioneer*'s involvement in seed production in Cameroon ended up as broken promises as the company closed down in July 1993, leaving behind a vacuum that will have to be filled if Cameroon is to expend its production to satisfy the demand.

2.4.5 Maize Marketing

Unlike for export crops, the government intervenes minimally in support of food crops commercialization. Due to high product market prices during the hunger period (resulting from precarious climatical conditions) especially in the northern provinces, the government has attempted to control the cereal market through *Office Céréalier*. Yet, the maize market in the North Province is dominated by individual buyers and sellers and MAISCAM. Although SODECOTON and SODEBLE also purchased grains, their impact on the market has however been marginal.

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[24] This union known as UDEAC (Union Douanière des Etats de l'Afrique Centrale) includes Cameroon, Chad, Congo, Gabon, Guinea Bissau, and RCA.

2.4.5.1 Office Céréalier

Created in 1974, Office Céréalier has a national mandate to intervene (buy and sell) in the market in order to guarantee reasonable prices[25] to both producers and consumers, and to create a food security stock of 6000 mt of cereals. Unfortunately, this project has failed to influence market prices, as the prescribed 10 to 15 percent market coverage at both sales and purchases level was never achieved. Up to 1985, the coverage rates were 6.7 to 9.9 percent of purchases, and 4.7 to 7.5 percent of sales.

2.4.5.2 MAISCAM

MAISCAM, a private agro-industrial enterprise owned by a national, is located 20 kilometers north of Ngaoundéré in the Adamaoua Province. Its activities includes the production and purchased of maize grain, which it processes into flour, grits, and oil for households' consumption, and flour and maize cake for animal feeding.

MAISCAM's opened in 1984 and produced 100 hectares of maize. Since then, the firm has expanded tremendously. In 1985, it cultivated 500 hectares, and in each of the last three years, it planted 3,000 hectares, with two crops annually. These 3,000 hectares are cropped in maize (2,300 ha), soybean (500 ha), and sunflower (200 ha). Sunflower and soybean are planted mainly in rotation with maize in an attempt to maintain good soil fertility. All maize seeds used are hybrids, imported from Zimbabwe and Kenya.

MAISCAM produced a total of 12,500 mt of maize in 1990. With a milling capacity of 40,000 mt, the firm has engaged in a vast campaign to purchase maize from traditional farmers throughout the North, Adamaoua, and West provinces in order to run its plant economically. This campaign started slowly in 1989 with only 3,000 tones of maize grain

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[25] Cereal market prices increase by about 46% during the hunger period.

bought. As farmers became aware of the existence of MAISCAM and their interest in maize production grew, purchases increased to 6,000 mt in 1989. In 1990, the firm intends to buy 10,000 to 12,000 mt of maize from traditional farmers.

The ultimate objective of MAISCAM is to expand its farm to 5,000 hectares, to be complemented by about 20,000 mt of grain purchased from traditional farmers. The firm's management believes that the pace at which this targeted ceiling will be reached largely depends on the experience they acquire over time, particularly their aptitude to maintain soil fertility on the available land, and their financial capacity to make the investments required to expand their enterprise.

MAISCAM's main maize suppliers are small size traditional farmers and retailers. Nevertheless, they occasionally buy maize from cooperatives, Office Céréalier and SODECOTON. The average price of the grain purchased is 50 F.cfa per Kilogram with a ceiling of 75 F.cfa. The firm's products are mainly sold in big cities like Yaoundé, Douala and Bafoussam, but attempts to expand the market area are being considered.

MAISCAM's manager forecast for maize expansion in the region is very optimistic. The arguments given to support this positive perception are the fact that MAISCAM buys in cash large amounts of grain at a relatively attractive price. Furthermore, maize is an easy crop to produce, the climatical environment is favorable, and the possibility of fresh consumption during hungry periods provides incentive for farmers to grow the crop.

CHAPTER 3 THEORETICAL FRAMEWORK and LITERATURE REVIEW

3.1 Theoretical Framework

This section reviews the literature on the economic theory behind the analytical model used in this thesis. Definitions of benefits and costs are discussed, as well as the criterion for their valuation.

3.1.1 Benefit/Cost Analysis

Benefit/Cost analysis is a tool for evaluating changes in public welfare resulting from an investment in a project. This analytical approach was developed during the 1950s and 1960s to evaluate social benefits and costs of investments in large scale projects[26] (Little and Mirrlees, 1979). There has been numerous refinements in Benefit/Cost analysis methodology over time. The most important development led to an expansion in the scope of benefits and costs that are considered in the analysis, including equity, employments, and training impacts.

3.1.1.1 Benefit and Cost Concepts

In general, project successes are measured by quantifying the costs incurred and benefits generated by the project, and weighing them against each other in order to determine

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[26] The benefit/cost analysis approach originated in the United States as an element of the 1933 Flood Control Act, as amended in 1936 (Pearce & Nash, 1981; Krutilla, 1981; Bromley, 1990). This Act basically required that flood control projects be analyzed in terms of their benefits and costs (explicit estimation of expected gains and losses), and should only be implemented if the benefits accrued are in excess of the estimated costs. Early efforts to refine benefit/cost analysis methodology were led by the Organization for Economic Cooperation and Development (OECD,1969) and United Nations (UN, 1972). Applications to project appraisal in developing countries were refined during the 1970s by the World Bank (Gittinger, 1972; Squire and Van Der Tak, 1972).

the returns to the investment made. This section defines what is considered as a cost and what is considered as a benefit.

Benefits and costs are defined with respect to one or more objectives. In a simplistic way, anything that contributes negatively to the objective is considered as a cost, and anything that contributes positively is considered as a benefit. According to Gittinger (1982), "in most developing countries, increased income is probably the single most important objective of individual economic effort, and increased national income is probably the most important objective of national economic policy". Consequently, in this study, costs include all the investments incurred by various institutions involved in maize research and extension in the Northern Province, as well as investments made by farmers (adoption costs). The benefits correspond to the monetary value of all of the maize production in the area originating from the project activities. Consumers' valuation is the basis for attributing values to the benefits items identified. Their valuation is assumed to accurately represent consumers' willingness to pay for the goods and services provided.

The problem with such an approach is that, in actual fact, individuals have multiple objectives and projects generate externalities. For example, an individual may have objectives including securing adequate food supply, particularly during hunger periods, and generating enough money for children's education or household members' medical care expenses. For the country as a whole, project benefits can be judged in terms of increased national income, but also as pointed out by Gittinger (1982), in terms of their impact on income distribution, job opportunities, increased savings, and broader economic consideration such as regional integration.

Indeed, no formal impact study could possibly measure or take into account all the various costs and benefits of an investment. Furthermore, there is a need to express all of

them in a common unit. Thus, as Gittinger (1982) points out, analytical approaches that have been used focus on the projects contribution to national income. To the extent possible, all benefits and costs expressed in a common units are included, and the importance of other potential costs and benefits associated with the investment but which cannot be quantified and/or valued are recognized and discussed qualitatively. Only a few recent studies have included in the analysis externalities generated by and the distributional impact from the project. In fact, it is often assumed that the income distribution or equity objective will be taken care of by various state fiscal policies. But, this assumption has been challenged in the literature on the grounds that virtually all developing countries have been unable to adopt strong macroeconomic policies that could successfully address this issue[27].

3.1.1.2 Benefit and Cost Items Valuation

3.1.1.2.1 Financial and Economic Analysis

Once all benefit and cost items have been identified, the next step in project appraisal is their valuation. The valuation procedure depends on whether one does the analysis from the point of view of individual farmers (financial analysis) or from the point of view of the nation as a whole (economic analysis). Financial analysis is generally done first, followed by economic analysis.

A distinctive feature of economic analysis is that actual benefits and costs are adjusted to better reflect social gain or real resource costs (Little and Mirrlees, 1974). Two key adjustments are made. First, as in financial analysis, all benefits and costs are discounted to

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[27] In fact, Amin (1978) argues that practically all national plans "pay lip service" to these issues, but the rest of the plan rarely has anything to do with addressing those issues. In practice, projects specifically designed to address the income distribution issue are often the first to be dropped when resources are limited.

take into account the time value of money and, thus, to reflect present values. Second, market prices used in financial analysis are adjusted to reflect social accounting or their shadow prices to eliminate the effect of existing distortions in national economy. In addition, economic analysis attempts to account for externalities and indirect effects, both of which are ignored in financial analysis. On the other hand, taxes, subsidies, and other transfer payments are included in financial, but not in economic analysis.

3.1.1.2.2 Shadow Pricing

There is a wide debate in the literature about shadow pricing. Some authors argue against shadow pricing for it requires a lot of effort that is sometimes not proportional to its contribution to the evaluation results. Gittinger (1982) suggests starting with market prices, generally at the point of first sale, unless it is proven that they do not accurately reflect economic values. Thus, adjustments are only required if there are significant distortions arising from direct transfers or policy induced distortions (such as taxes, subsidies, tariff, etc), supply restrictions, existence of monopoly power, and excess capacity. Adjustments are generally done in three successive steps: (1) adjustments for direct transfers, (2) adjustments for price distortions in traded items, and (3) adjustments for price distortions in non-traded items (Gittinger, 1982).

Adjusting market prices for policy-induced distortion implies treating taxes, subsidies, loans, and loan services as direct transfer payments, either from the government to farmers or vice versa, because they do not reflect changes in national income. Taxes such as sale taxes are part of the benefit stream, as opposed to being part of the cost stream, as it is normally the case in financial analysis. Subsidies on fertilizer or seeds sale would be ignored and the full amount of the prices used.

For non-traded items, the valuation procedure starts with determining the domestic market prices. For traded items, the valuation procedure starts with estimating border prices which are equal to the CIF prices for imported items and FOB for exported items. These prices are then adjusted for domestic transport and marketing costs between the point of import (export) and the project site. The rationale behind this approach is that if, for example, the project produces an import substitute, the value of this good to the nation as a whole is equal to the value of the foreign exchange saved that would have otherwise been used to import the good (Gittinger, 1982). In the case of diverted exports, the cost to society is the foreign exchange loss that would have been gained had the good been exported. These adjustments are necessary because in many countries people may be paying a premium on traded goods as a result of currency over valuation, over what they pay on non-traded goods. This distortion is not taken into account when the prices of traded goods are converted to the domestic currency equivalent at the official exchange rate (OER).

Two equivalent ways are often used in the literature to incorporate a premium on foreign exchange during the price adjustment process. One of these is the shadow exchange rate (SER) approach advocated by the World Bank and UNIDO. This approach converts the foreign exchange into domestic currency by making the traded goods relatively more expensive in domestic currency by an amount equal to the premium (FEP). The other method is the standard conversion factor (SCF) approach, which is advocated by OECD. This approach consists in (1) converting foreign exchange prices to their domestic currency equivalent by using the official exchange rate, and (2) reducing all prices of non-traded goods by multiplying them by an appropriate SCF.

$$SER = OER(1+FEP) \tag{3.1}$$

$$SCF = \frac{1}{(1+FEP)} \tag{3.2}$$

More comprehensive valuation methods, which focus on the accuracy of the valuation, have been developed by the World Bank, OECD, UNIDO and environmental economists. These methods include in the valuation various social weighting schemes, but they have not been widely used because of their complexity and the controversial feature of some of their aspects (Little and Mirrlees, 1990; Squire, 1990).

3.1.1.3 Benefit/Cost Analysis

3.1.1.3.1 Efficiency Benefit/Cost Analysis

Ideally, the most desirable state of any society is maximum social well-being. The determination of the maximum social well-being point requires the existence of a social well-being function emerging implicitly from a unanimous agreement among members of the society. The problem is that, as established by Arrow's impossibility theorem, the social well-being function is impossible to find or, if determined, it can only be dictatorial. In the absence of an identifiable social well-being function, economists have proposed a number of criteria by which the social desirability of a project could be measured.

Efficiency benefit/cost analysis is viewed as a specific application of modern welfare economic analysis, which emerged out of positivism as a behavioral norm for scientific objectivity. It is a particular approach to benefit/cost analysis which focuses on net contribution to the national income and uses the potential Pareto improvement criterion. This principle states that an investment is considered welfare improving if and only if those who gain can potentially afford to compensate those who lose and still be better off, provided that

there is a random sorting of losers and gainers over an unending sequence of actions. It therefore considers aggregate benefits and costs expressed in terms of national income, without regard to the distributional effects, and implicitly assumes a social welfare function (utilitarian welfare function) with a unitary weight for all individuals. In order words, it assumes a society in which all individuals have identical preferences.

Various measures have been used to quantify individual welfare change. Conventionally, the equivalent variation (EV)[28] and compensating variation (CV) are used in applied welfare analysis as exact measure of welfare change. One of the problems that the use of CV and EV poses is the fact that a straightforward, manageable procedure of expressing them, in terms of elementary mathematical functions, has not yet been derived (McKenzie, 1983). As a result, information require to obtain them is very demanding. This is so because they are based on the Hicksian demand curve which is not directly observable. It is therefore common to resort to empirical approximation in applied work. The theory of consumer behavior indicates that, in principle, there is a link between the ordinal structure of consumer preferences and the structure of consumer demand functions. The greater the income effects, the greater is the difference between the CV, the EV, and consumer surplus. Willig (1979) argues that, in most cases, consumer surplus is a "close" approximation of CV and EV. Furthermore, he established that for a single price change, provided individual's expenditure on the good and the variation are not very large, the error involved in using consumer surplus as an estimate of the CV or EV is less than five percent.

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[28] The EV and CV are expressed in terms of the difference in expenditure functions between the initial and terminal price, plus the change in individual's money income. The EV represents the amount of money which if added to the individual's initial income, would have an effect on his utility equivalent to that of the policy change if he was to face the original set of prices. By contrast, the CV measures the change in money income that would just compensate the individual for a policy change in order to keep him at the initial level of utility. Unlike the EV, the CV is not a utility indicator, and it is ambiguously defined. In addition, both have different property rights implications.

In this study, even though the conditions referred to by Willig were not empirically validated, they are assumed to be satisfied, on the grounds that the maize technology is relatively new in the studied area and MAISCAM is the major buyer. Consumer surplus is therefore used to measure welfare change. The welfare or utility that consumers are expected to derive from consuming a good is reflected by economic prices which in turn are assumed to accurately reflect consumer willingness to pay.

3.1.1.3.2 Social Surplus and Technological Change

Figure 3.1 represents a partial equilibrium model of the total demand and supply for a good under perfect competition. The equilibrium condition is achieved at price P_0 and quantity Q_0 where quantity demanded equals quantity purchased.

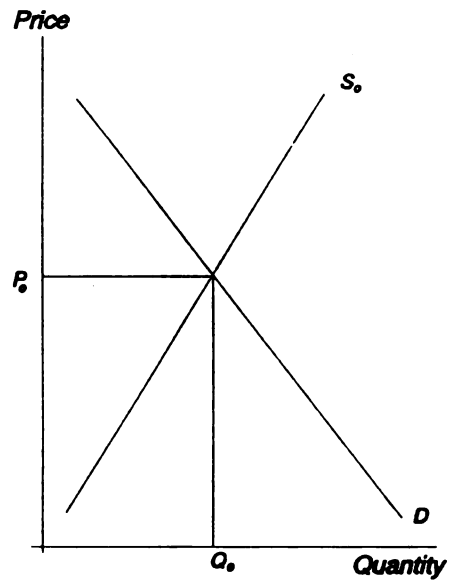

Figure 3.1: Graphical Representation of Individual's Welfare.

The total welfare derived from the quantity Q_0 could be approximated by the area under the demand curve. For all units up to Q_0, the price the consumer is willing to pay exceeds the cost (price) of producing a unit of the good. Therefore, there exists an excess of welfare or utility over cost. However, on the last unit, the price just equals the cost of producing it. Traditionally, consumer surplus is the area under the demand curve (D) and above the equilibrium price (P_0). It is used to approximate the excess of what consumers would be willing to pay over what they actually do pay. Producer surplus is the area above the supply curve (S) and below the equilibrium price.

With changes in technologies, output for a given unit cost increases, or the price for producing a given unit of output falls. This is represented graphically in Figure 3.2 by an outward shift of the supply curve. Therefore, the change in the welfare surplus resulting from technological changes is the total area P_0abP_1 between the demand and supply curves before and after adoption of a technology.

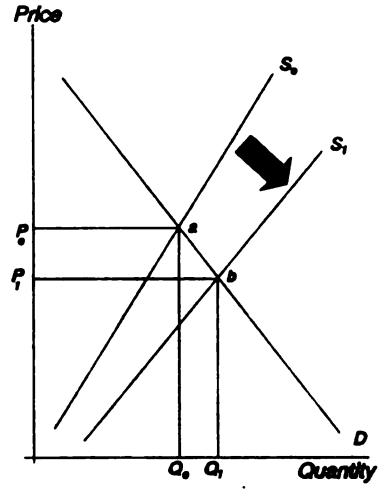

Figure 3.2: Welfare Effect of a Single Price Change.

In this study, simplifying assumptions of a perfectly elastic demand curve and perfectly inelastic supply curve are made in order to measure economic welfare, strictly as a function of the value of additional products generated, as indicated by Figure 3.3.

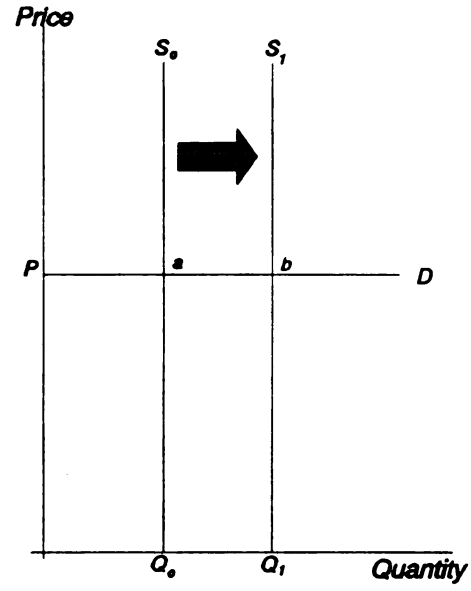

Figure 3.3: Welfare Effect of a Single Price Change under Simplified Assumptions.

Even though the supply and demand elasticity assumptions were not empirically validated, they are assumed to be justified. Social surplus is therefore used to measure welfare change asa net contribution to the national income. The main advantage of the assumptions on demand and supply elasticities is that they preclude analysis of distributional effects, and make it unnecessary to undertake the difficult task of estimating the Hicksian demand curve. Thus, no information needs to be generated about the characteristics of supply and demand in order to analyze welfare changes. While there are methods to incorporate non-efficiency objectives, all require using some type of arbitrary weighting scheme, which requires *a priori* agreement regarding the social welfare function. Moreover, as Contant and

Bottomley (1988) point out, distributional objectives can always be taken into account when setting priorities, and when interpreting the results of efficiency benefit/cost analysis.

3.1.1.3.3 The Measure of Project Worth: The Internal Rate of Return

After benefits and costs are identified and valued, the next step in benefit/cost analysis is to select and compute success criteria. There are basically three distinct quantitative measures of project worth suitable for application to impact studies in agriculture. The measures most often used are the benefit/cost ratio (B/C)[29], net present Value (NPV), and internal rate of return (IRR).

The internal rate of return corresponds to the discount rate i that makes the NPV equal to zero. The net present value is a straightforward discounted measure of project worth, computed as the present value of the incremental net benefit stream.

$$NPV = \sum_{1}^{n} \frac{B_t - C_t}{(1+i)^t} \qquad (3.5)$$

where, B_t = benefit in year t
C_t = cost in year t
i = discount rate

The NPV can also be calculated by subtracting the present value of the cost stream from the present value of the benefit stream:

[29] Historically, the benefit/cost ratio criterion was the first widely used discounted measure of project worth, but it is not commonly used in developing countries. Gittinger (1982) argues that this is so because by the time measures of project worth began to be applied in developing countries, the NPV and IRR were widely known and used.

$$NPV = \sum_{1}^{n} \frac{B_t}{(1+i)^t} - \sum_{1}^{n} \frac{C_t}{(1+i)^t} \qquad (3.6)$$

Two simplifying assumptions are implicit in the formulation of the NPV criterion: the reinvestment rate is equal to the discount rate, and both are assumed to be constant over time[30]. The first assumption is only valid if the capital market is perfect and the opportunity cost of capital (discount rate) does not depend on the size, the length or other characteristics of the investment.

The formular of the IRR is therefore as follow:

$$NPV = \sum_{1}^{n} \frac{B_t - C_t}{(1+i)^t} = 0 \qquad (3.7)$$

When used in economic analysis, the IRR is sometimes referred to as the economic rate of return, as opposed to the financial rate of return terminology used in financial analysis. It is the World Bank's preferred measure of project worth.

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[30] Assuming net returns at each period are reinvested at the rate r and a discount rate i, assuming both r and i are constant over time:

$$NPV = \frac{(B_1 - C_1)(1+r)^{n-1} + (B_2 - C_2)(1+r)^{n-2} + \ldots + (B_n - C_n)}{(1+i)^n}$$

If the reinvestment rate and the discount are equal:

$$NPV = \frac{(B_1 - C_1)(1+i)^{n-1} + (B_2 - C_2)(1+i)^{n-2} + \ldots + (B_n - C_n)}{(1+i)^n}$$

$$NPV = \frac{(B_1 - C_1)}{(1+i)^1} + \frac{(B_2 - C_2)}{(1+i)^2} + \ldots + \frac{(B_n - C_n)}{(1+i)^n}$$

which is the expanded version of equation (3.5).

Numerous problems are encountered in the application of the IRR. First, if compared with the NPV, it could result to a different ordering when ranking different investment alternatives. Secondly, there exists no simple formula for finding it. Thirdly, it could be negative, non-existent or have more than one value, depending on the number of sign changes in the cash flow stream -- which makes the IRR sometimes difficult to interpret.

Concerning the ranking issue, Robinson et al (Forthcoming) showed that this occurs if the homogeneity of measurement principle and consistency in timing principle are violated when the model is constructed in an inconsistent manner. Robinson et al (Forthcoming) identified six consistency principles[31] that should be taken into account in any IRR model, which implies some adjustments. The adjustments do not change the NPV value and its ranking, but do change the value of the IRR so that its ranking becomes identical to the NPV ranking. As a result, these adjustments are not necessary when the NPV is used as evaluation criterion.

In practice, the IRR is determined by a trial and error procedure, based on some key facts: (1) it requires at least one negative value in the net benefit stream, and (2) the relationship between the NPV and the discount rate depends on the pattern of cash flows.

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[31] These principles are:

1) The cash flow principle which requires that physical units of inputs and outputs be converted to their cash equivalent and be measured in a consistent unit (mostly discounting).
2) The consistency in timing principle which requires that returns and costs be entered in the formula in the period they are received or paid for.
3) The homogeneity of measurement principle which requires that the investment under analysis and the rate of return on the alternative to which it is compared be measured in a consistent units, namely with respect to inflation, taxes, size etc.
4) The life of asset principle which requires that the proper length of time for measuring all costs and returns associated with the investment be considered, and,
5) The total costs and returns principle which requires that all costs and returns associated with the investment be considered.
6) The geometric mean principle which states that investments be compared using geometric means (not arithmetic means).

Usually, the IRR is negatively related to the NPV, when an initial negative outlay is followed by positive cash flows in the later periods. But when the initial positive outlay is followed by negative cash flows in the later periods, the NPV and the discount rate are positively related. This is for example the case when loans are evaluated from a borrower's perspective.

One of the common practical way used to determine the IRR is to find, by trial and error, two discount rates that are positive and negative, respectively, and make an interpolation between them to identify the rate at which the NPV is equal to zero. Gittinger (1982) advises never to interpolate between discount rates that are more than five percent points apart.

3.1.1.4 Limitations of Benefit/Cost Analysis

The theoretical justification of efficiency benefit/cost analysis has been criticized by various authors. They all recognize the importance of efficiency (which dominates benefit/cost analysis) and they all identify efficiency as one necessary condition in determining the social desirability of a project. Yet, they argue that the society may have other legitimate goals. Some authors require that a movement toward efficiency be achieved for any improvement to be considered as having taken place. When applied alone, most of the criteria used are vulnerable on ethical, philosophical and pragmatic grounds. The debate hinges on whether or not the improvement injures someone in the economy and how legitimate that could be (Randall, 1987).

One major criticism is targeted at the traditional assumptions that it does not matter whether benefits generated by the investment accrue in consumption or in investment, or whether these benefits accrue to the poor or the rich, as long as the compensation principle applies. This criticism can be summarized by the claim that, in a competitive market setting,

it is a tradition to assume that everybody places the same private (relative) value to a product which is reflected by its price, but this does not mean that one additional unit of that good is socially valued in the same way by the poor and the rich. Squire and Van Der Tak (1972) argue that the distribution of benefits among consumer groups (poor and rich) affects social output due to differences in consumption and investment propensities. Furthermore, in a situation where the nation's level of investment is not enough to sustain a desired growth, investment would be preferred to consumption.

Additional criticisms against efficiency benefit/cost analysis as stated by Baram (1980) include (i) the tendency to omit intangible effects of improvements or their arbitrary valuation, and (ii) the theoretical fact that consumer surplus does not have any willingness to pay or to accept compensation interpretation, especially under large price changes. It is only under no income effect (i.e., under constant marginal utility of money) and relatively small changes that it could approximate consumer willingness to pay. Furthermore, its value is path dependent under a multiple price change situation (Boadway and Bruce, 1991).

Smith (1986) argues that the criticism about the tendency to omit intangible effects of investments is incorrect, as omissions simply result from error in specific benefit/cost analysis, and are not the fault of the methodology. A significant amount of research has been directed toward non-market valuation techniques such as the contingent valuation approach to value the intangible effects.

Despite these criticisms, efficiency benefit/cost analysis based on consumer surplus concept continues to be the most frequent used approach. This is so mainly because it is the easiest approach to apply and understand. In addition, the United States' Flood Control Act of 1936 provided a legal sanction to its fundamental principle (potential compensation) in the United States. Also, the development in the 1950s in the United States of programs where the

government set targeted benefits made cost effectiveness a desirable objective. Another reason is the fact that various second order efficiency effects identified by Squire and Van Der Tak and various authors have proven, in actual application, to have relatively small impact on the configuration of relative prices and measurements, and on other errors inevitable in benefit/cost analysis. Citing the World Bank's project planning experience, Little and Mirrlees, Krutilla (1981) argue that this is particularly true in the somewhat special circumstances in developing countries.

3.1.1.5 Sensitivity Analysis

The reliability and validity of all measures of project worth depend on the quality of the data collected, and on the assumptions made. Typically, the data and assumptions used are imperfect. Some benefits (costs) are difficult to measure and there is always some degree of uncertainty associated with the projections that are made. Consequently, it is advisable to use conservative values or best estimate values in the estimation process. Unfortunately, as Pouliquen (1970) argues, the use of conservative values implies looking at a project with conservative eyes. Therefore, the final result is likely to be conservative. In practice, a straightforward way to handle data quality, uncertainty and conservative estimation problems is through sensitivity analysis. This technique measures how sensitive the measures of project worth used are to reasonable changes in the assumptions made. It is performed by relaxing the assumptions made. If the measure of project worth does not change significantly, one can therefore feel reasonably confident about the accuracy of the project worth measures. Also, by introducing alternative values, one could determine which variables are critical to the overall performance of the project.

Unfortunately, although sensitivity analysis does permit one to identify variables that are critical to the project's performance, it does not by itself provides information about the sources of uncertainty, nor does it completely take into account risk and uncertainty. Also, it poses serious problem when variables are related, since one typically vary one variable at a time.

Various other alternative approaches for assessing the sensitivity of assumptions and data values are found in the literature. For example, the simplest method is to use the switching value technique. The switching value of a variable corresponds to a value of that variable at which the NPV becomes zero or the IRR equals to the economic opportunity cost of capital. More sophisticated tool of risk analysis include the use of probability theory.

3.1.2 Institutional Analysis

This section builds on the subsector analysis approach. The subsector concept refers to a "vertical set of activities in the production and distribution of a closely related set of commodities" (Shaffer, 1968). Marion et al. (1986) defines it as " an interdependent array of organizations, resources, laws, and institutions involved in producing, processing and distributing and agricultural commodity". These definitions emphasize the vertical orientation of subsector analysis, the institutional framework, and how its affects the various stages.

Two key aspects are recognized in the subsector concept: (1) there is a chain of dynamic relationships among the different steps which require some kind of coordination for the subsector to perform efficiently, and (2) because these steps mutually affect each other, any analysis at any given level of the various activities is insufficient. What is needed is a global assessment to identify the weaknesses and strengths of the subsector. In this respect,

this approach follow a kind of system approach. More so, it "iteratively combines a global, systematic approach with an analytical one" (Bino and Duncan, 1992).

3.2 Review of ROR Studies in Africa

3.2.1 Geographical Distribution of ROR Studies

There is a substantial literature on *ex-post* impact assessment of agricultural research investments throughout the world, but most of this literature assess investments made in developed countries, Latin America, and Asia. Oehmke et al. (1992) reports that up to 1992, less than a dozen of rate of return studies were conducted in Africa (Table A.4), compared to 79 in developed countries, 66 in Latin America, and 25 Asia.

3.2.2 Nature of ROR Studies

Schultz made the first attempt to quantify the returns to agricultural research investments in 1953 (Norton and Davis, 1981). Basically, using a consumer surplus approach, he assumed that research benefits could be estimated by the value of the input saved. He compared the costs of 1950 output, using 1910 techniques, with the actual costs of producing 1950 output. A review of the research impact evaluation literature reveals that the methods used have been steadily improved over the last three decades. Norton and Davis (1981) report that over this period, two basic methodologies have been dominant: the index number and the production function approaches. The key distinguishing feature of the index number approach is that it generates an average rate of return which allows for assessing the entire research investment, as opposed to the production function approach which estimates a marginal rate of return.

In addition, numerous non-rate of return or descriptive approaches to assess research impact have often been used, particularly in Africa. Most of these studies were carried out as part of a project assessment activity, either in a national research institute or in an international institution. Typically, the assessment criterion used is the adoption rates, both in terms of number of farmers and total land under cultivation. For example, in 1984, 75 percent of the total irrigated rice area of 15,000 hectares in Tanzania were planted to two IRRI varieties, while 60,000 hectares in Nigeria in the same year and 70,000 hectares in Senegal in 1983 were planted to improved varieties (Daniels et al., 1990 citing Anderson, Herdt, and Scobie, 1988). This literature reveals a wide array of collaborative germplasm and varieties exchange efforts between IRRI, ISNAR, CIMMYT, IITA and various national research institutes.

Two studies evaluated USAID experience in agricultural research. In 1982 Dai (1982) examined 131 evaluations of 48 agricultural research and in 1983 Murphy (1983) analyzed numerous project evaluation studies. Dai highlighted the problems of national research limited technical capacity, procurement delay, and unavailability of good data to facilitate project performance comparisons. Also, this study revealed that while 21 of the projects were explicitly focused on small farmers, only 8 attempted to analyze farmers' constraints.

3.2.3 Magnitude of ROR Values

Most non-African studies indicate high rates of returns in excess of 30 percent as could be seen in Table A.4. Theses results indicates that agricultural research has generally performed well, and justifies investment in this sector. However, some authors argue that this literature presents a biased picture of research investment impact because research failures

are rarely included in the evaluation portfolio. Daniels et al. (1990) argue that nonetheless, if this argument is true for some specific commodity research, "many aggregate studies from Asia and Latin America measuring the impact of a country's total level of investment in agricultural research....indicates high returns".

As in developed countries, Latin America, and Asia, agricultural research evaluations in Africa indicate high rates of return. A World Bank study (World Bank, 1988) estimated the returns to cotton development projects in Burkina-fasso, Côte-d'Ivoire, and Togo to be 31, 37, 11 and 41 percent, respectively. Yet, Evenson (1985) argues that, generally, the impact of national agricultural research efforts is lower in West African countries than in developed countries.

3.2.4 Key Determinants of the ROR Values

Griliches (1958), Bredahl and Peterson (1976) indicate that a key determinant of research benefits is the total value of the crop. However, this does not mean that "low value" commodities do not yield high returns. Also, in almost all of the studies, the importance of the institutional support emerges. Ayer and Schuh (1972), Evenson and Jha (1973), Akino and Hayami (1975), and Flores-Moya et al. (1978) indicated that the structure of research institutions was critical to the success of research programs in Brazil, India, Japan, and the Philippines. Also, Evenson and Jha attribute high returns to agricultural research in the USA to the linkage between research, extension, and farmers, while Hertford et al. (1977) attribute the negligible returns to cotton research in Columbia to the poor organization of the research efforts.

An equally important determinant of research success is the infrastructural support. Daniels et al. (1990) report that the contribution of research in Asia, Latin America, and

North America was substantially increased because it was complemented by efforts to develop irrigation, drainage and other physical infrastructures".

The high returns on cotton in the World Bank study in Burkina-fasso, Côte-d'Ivoire, and Togowere were attributed to a cotton package which included new technology, a strong input supply networks, timely cash payment to farmers, and support from autonomous institutions. Daniels et al. (1990) citing Lele et al. (1989) report that institutional factors such as extension, input availability, marketing, processing and capitalization of cotton sector were fundamental in explaining the sustainable development of cotton in African French-speaking countries.

Research design and implementation were cited as a problem in 15 of 39 projects by Dai (1982) from an examination of 131 evaluations of 48 USAID-sponsored agricultural research projects. Murphy's (1983) study documented USAID's success in training researchers and establishing or expanding research facilities. She also stated that the effectiveness of USAID assistance was hindered by managerial weaknesses, unfavorable government policies, and inadequate awareness of household farming circumstances.

In 1985, an evaluation of the 128 World Bank-supported projects in 10 countries highlighted the Bank's lack of consideration for the sustainability of research beyond the investment period, the need to improve research management, and inadequacy of the institutional structures. In 1988, an impact assessment of 13 CGIAR centers found that high-yielding wheat varieties, mostly from CIMMYT and its predecessors, were being widely grown in developing countries in 1982-83, including Zimbabwe, Ethiopia and Kenya. Also, Zimbabwe, Kenya, Malawi and Tanzania, using germplasm from CGIAR Centers in their variety development program. IITA has released two maize varieties with a good resistance to tropical rust, and lowland blight.

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*3.2.5 **ROR Studies in Cameroon***

In Cameroon, even though agricultural research has been conducted for more than three decades now, only two non-published pilot ROR impact studies have been conducted within the national Institute of Agricultural Research (IRA). In 1989, Pham et al. applied the ISNAR approach to agricultural research impact assessment, developed by Contant and Bottomley, in a priority setting exercise for the Fruits and Pineapples, as well as Cereals programs. Two year later, Ngo Nlend (1991) applied the same methodology to assess the impact of the Nkolbisson TLU recommendation for three maize and three cassava varieties, as well as a maize fertilizer recommendations in the Center Province. Her study indicated high internal rate of returns to the investment made, ranging from 60 to 108 percent. She also reports that these rates were not sensitive to reasonable variations of adoption factors, unless these factors are reduced by 90 percent.

*3.2.6 **Conclusion***

The consistently high returns to research in Latin America, Asia, and in the few African countries' studies suggest a bright future for African agricultural research. However, Africa differs from developed countries, Latin America, and Asia in many ways, including more complex environmental constraints, weak physical infrastructural, and the lack of a long research tradition (Oehmke et al., 1992). Furthermore, many environmentally sensitive area of Africa have experienced a loss in their productive capacity to a point where, in some cases, maintaining the current level of productivity is crucial.

Daniels et al. (1990) argue that while it is too early to expect a rapid and large-scale transformation of African agricultural research, this does not mean that research projects with low RORs should be considered acceptable in Africa, merely because they are from Africa.

It simply means that research impact assessment in Africa should be based on a realistic perspective that takes into account its ecological and socioeconomic environments. In addition, impact analysis must pay particular attention to providing insights as to the key factors that have contributed to the success or failure of prior investments. Only with this information will it be possible to increase the impact of agricultural research in Africa.

CHAPTER 4 ANALYSIS and RESULTS

4.1 Research Activities

Data needed to carry out the ROR analysis were collected in Cameroon from June 8 to August 31, 1991. Data collection proceeded in three phases. This section briefly presents research activities during these phases.

4.1.1 Identification of Research Focus

From June 8 to June 15, the researcher met with IRA, NCRE, and USAID administrators in Yaoundé, as well as with other key informants in Maroua and Garoua, to identify potential crops and location for the research evaluation study. Two concerns were emphasized during these discussions: data availability, interests and the needs of primary users of the results. By the end of this period, it was agreed that the study should focus on maize in the North Province.

4.1.2 Preliminary Data Collection

From June 16 to July 14, the researcher undertook the first round of data collection. This effort concentrated on (a) identifying the institutions that have been involved in maize research and extension in the North Province, (b) determining specific data to be obtained from the identified institutions, and (c) contacting key informants within each of the institutions. During this phase, the researcher met with key informants at IRA-Maroua, IRA-Garoua, SODECOTON, MINAGRI, NCSM, and "Office Céréalier" and reviewed available reports.

4.1.3 Supplemental Data Collection

From July 20 to August 31, after reviewing the documents obtained to identify additional data needs and their possible sources, the researcher conducted a second round of data collection, concomitantly with visiting with farmers in various villages. During this period, the researcher interviewed several new and previously contacted key informants, reviewed more documents, and visited farmers and extension agents. The goal of these visits was to visually assess the impact of maize research and extension, as well as to check the validity of some assertions made by key informants. In addition, the researcher attempted to design and implement a complementary formal survey, but this effort was abandoned due to the relatively high fee requested by the Ministry of Agriculture's Division of Statistics to implement the survey.

During data collection, the researcher interviewed a total of forty-nine key informants, some two or three times, collected numerous reports, and held four group meetings with farmers and extension agents. Key informants interviewed included 15 IRA and NCRE researchers, 8 SODECOTON staff members, 2 NCSM staff members, and 20 others from various institutions such as World Bank, USAID, MINAGRI, "Office Céréalier", MAISCAM, Pioneer Seed, NEB, and EEC.

4.2 Time Frame

In general, a new agricultural technology generated through research and extension has a long gestation period. During the development phase, net benefits are negative, but become positive once the new technology is widely adopted by farmers. Thus, an appropriate choice of the time period over which costs and benefits are to be included is critical to achieving an unbiased ROR result.

This study includes costs incurred and benefits generated over the period 1979 to 2000. While research on maize in the North Province began 1976 with SAFGRAD Project #26, no information is available on research activities and costs prior to 1979. The year 2000 was selected as the ending year, based on the assumption that the varieties released up to 1990 will still be used by farmers for the next ten years, given Cameroon's financial crisis which has led to a substantial reduction in research funding.

4.3 Costs Determination

The costs attributed to research, extension and adoption of maize in the North Province are partitioned into two main categories: research costs and extension-adoption costs. The procedure used to estimate the various costs was mainly determined by data availability. For example, seed multiplication costs were not directly included because data were not available, but are accounted for indirectly by including the cost of seeds to the farmers. The implicit assumption here is that seed prices reflects actual production costs. In addition, numerous simplifying assumptions were made because the data collected were not organized to serve a ROR study. For example, long-term training costs were excluded due to the long-run nature of the associated benefits and the difficulty in estimating the share of these costs that should have to be attributed to a single crop. These assumptions are then relaxed in the sensitivity analysis section to assess their impact on the ROR estimates.

For the years 1979 to 1990, research and extension costs as well as benefit estimates are based on actual data collected during field work. For the period 1991-2000, only extension costs and benefits are considered[32]. To estimate these costs and benefits through

[32] Although under ordinary circumstances some maintenance research costs should have been included, no provision is made for it in this study because of the financial crisis IRA faces.

the year 2000, the study introduces two scenarios. First, the base run analysis incorporates constant costs and production levels (equivalent to the 1990 levels), based on the assumption that given the financial crisis, there is no reason to expect any increase in extension expenditures or maize production in the North Province. Then, a more realistic scenario, which assumes a minimum 50 percent decline in expenses and production over the same period, is introduced.

4.3.1 Research Costs

Research costs include breeding, on-station agronomy, and on-farm research costs incurred by all research units (mainly NCRE and SAFGRAD's Projects) involved in maize research in the North Province. These expenditures are subdivided into four costs categories: equipment and supplies, salaries and benefits, direct research expenses, and administrative and short-term training costs. See Table A.5 for the specific components in each of these costs categories.

4.3.1.1 NCRE Costs (ATC^{NCRE})

NCRE provides financial support to maize breeding and agronomy activities. Maize breeding in the North Province is conducted by a research team of three researchers based at Nkolbisson (Dr. C. Thé, J.B. Zangue, and C. Zonkeng) and at Garoua (B. Mongmong). The breeding unit's mandated area covers the lowland altitude zone of Cameroon, which encompasses the North Province, as well as the South, the Center, the East and the South-West provinces. However, the maize breeding unit has focused its research in all these provinces with the exception of the South Province. Most of the maize varieties developed by

this unit are tested in its mandated area. The agronomy unit is based at Garoua and works on a variety of crops including maize, sorghum, millet, groundnut, and cowpea.

Breeding and Agronomy Costs

Since actual expenditures for these two research units were not directly available for the historic period 1981-1990, yearly summaries of total NCRE actual expenditures (Table A.5) are used to estimate each unit's costs, based on the following procedure. First, as the data obtained from NCRE administration did not include salaries and benefits for national researchers (Table A.5), these costs were estimated by first determining each scientist's current civil servant status (*class*, and *echelon)* and then using the public service *salary schedule* to estimate his salary, including research allowances.

Second, since data are not available to estimate trial costs for each year, actual work plan budgets for the years available (i.e.; 1987-91) were used to estimate the proportion of NCRE's total expenditures that supported these units; and then this proportion was used to compute the annual costs for the trials implemented by each research unit as summarized by following formula:

$$\textit{Breed.:} \quad ATC_b = \mu_b * TC^{NCRE} * OER \quad \textit{with} \quad \mu_b = \frac{ATC_b^{Bgt}}{ATC^{Bgt}} \quad (4.1)$$

$$\textit{Agro.:} \quad ATC_a = \mu_a * TC^{NCRE} * OER \quad \textit{with} \quad \mu_a = \frac{ATC_a^{Bgt}}{ATC^{Bgt}} \quad (4.2)$$

where:
ATC_b = Estimated annual total trial costs for the maize breeding unit.
ATC_a = Estimated annual total trial costs for the cereal agronomy unit.
μ_b = Proportion of TC^{NCRE} attributed to the Nkolbisson maize breeding unit.
μ_a = Proportion of TC^{NCRE} attributed to the Garoua cereal agronomy unit.
TC^{NCRE} = NCRE's actual annual expenditures.

ATC_b^{Bgt} = Annual budget estimates for the breeding unit.
ATC_a^{Bgt} = Annual budget estimates for the cereal agronomy unit.
ATC_{Bgt} = NCRE's annual budget estimates.
OER = Official Exchange rate (US dollars into F. cfa).

As mentioned above, the coefficients of proportionality μ_b and μ_a are computed from the available five years (1987-1991) of work plan budget estimates (Table A.6). NCRE's work plans provide rough budget estimates of trial costs (less salaries and benefits) for each research unit. Budget estimates represent a reliable source of data for partitioning total project costs because NCRE uses an incremental budget approach which does not allow a research unit to spend more than 10 percent in excess of its budget estimates. Even though key informants observed that these two units regularly overspent their budgets, NCRE administrators argued that the pattern of spending was somewhat similar over the years. The values of μ_b and μ_a estimated to be 1.15 and 1.11 percent, respectively (Table A.6), are therefore assumed to closely reflect the proportion of the each unit's actual share of NCRE's total expenditures.

North Province's Share of Maize Breeding and Agronomy Costs

Because only part of the breeding unit's costs are spent on research in the North Province, it was necessary to estimate the share of this unit's total expenditures to be assigned to maize research. Also, because the agronomy unit works on several crops, it was necessary to estimate the share of this unit's total expenditures to be assigned to maize. The procedure used to estimate the breeding unit's expenses attributed to the North Province assumes that the team expenses in each province within its mandated area are directly proportional to relative maize area in that province. For the North Province, the coefficient of proportionality is estimated to be 28.37 percent (Table A.7). Similarly, for the agronomy unit, the unit's expenses attributed to maize research in the North Province are assumed to be directly

proportional to this unit's annual "research efforts"[33] on maize. The following equations summarize these assumptions:

$$ATC_{bm} = \lambda_b * ATC_b \qquad with \qquad \lambda_b = \frac{AREA_b^{North}}{AREA_b^{Total}} \tag{4.3}$$

$$ATC_{am} = \lambda_a * ATC_a \qquad with \qquad \lambda_a = 0.70 \tag{4.4}$$

where:
ATC_{bm} = Estimated annual total costs for maize breeding in the North Province.
ATC_{am} = Estimated annual total costs for maize agronomy in the North Province.
$AREA_b^{North}$ = Maize area in the North Province.
$AREA_b^{Total}$ = Total maize area from Provinces covered by the breeding unit.
λ_b = Proportion of the North Province maize area in $AREA_b^{Total}$.
λ_a = Proportion of estimated annual costs for agronomy attributed to maize.

The estimation procedures for the share of each research unit's total expenses attributed to maize in the North Province are different because of data problems. The preferred estimation approach for this study is the use of "research effort" data which are assumed to better reflect the actual share value. The value 0.70 (estimate of λ_a) was obtained from direct interviews with the research team, and from NCRE annual reports and work plans. The proportion of the North Province maize area from the total maize area in the breeding unit's mandated zone is used as a second best proxy because the unit's "research effort" data by province was not available. On the basis of the equations (4.3) and (4.4), Table 4.1 and Table 4.2 below summarizes NCRE's maize breeding and agronomy costs in the North Province.

[33] The concept "research effort" refers to the proportion of the research unit's time allocated to a particular operation or trial. This concept is used by the NCRE project under the assumption that researchers' time allocation is directly proportional to the relative financial cost of the operation or trial under consideration within the team's research program.

Table 4.1: Estimated NCRE Maize Breeding Expenses (Nominal F.cfa), North Province, Cameroon, 1981-90.

Year	Equipments and Supplies	Salaries & Benefits		Direct Research Costs	Adminis. Conference & Training	Total Annual Costs
		Expatriates	Nationals			
1981	96,870	223,561	673,120	17,044	76,126	1,086,721
1982	183,789	792,872	2,799,790	45,068	150,163	3,971,682
1983	112,330	868,402	3,011,180	136,473	200,897	4,329,282
1984	179,633	1,040,651	3,298,492	172,835	235,166	4,926,777
1985	107,792	1,143,273	3,344,695	182,755	211,765	4,990,280
1986	142,666	1,234,270	4,090,509	127,156	193,891	5,788,492
1987	360,272	1,328,063	4,229,789	239,337	286,308	6,443,769
1988	95,188	1,352,526	4,393,819	226,333	315,441	6,383,307
1989	237,501	1,659,685	4,545,272	271,916	227,279	6,941,653
1990	220,077	1,852,407	4,787,155	433,903	533,454	7,826,996
Total	1,736,118	11,495,710	35,173,821	1,852,820	2,430,490	52,688,959

Table 4.2: Estimated NCRE Maize Agronomy Expenses (Nominal F.cfa), North Province, Cameroon, 1981-90.

Year	Equipments and Supplies	Salaries & Benefits		Direct Research Costs	Administration Conferences & Training	Total Costs
		Expatriates	Nationals			
1981	230,702	532,426	0	40,592	181,306	985,026
1982	437,729	1,888,281	34,274	107,332	357,625	2,825,241
1983	267,522	2,068,163	115,873	325,021	478,450	3,255,029
1984	427,808	2,478,385	134,662	411,618	560,066	4,012,539
1985	256,715	2,722,787	610,109	435,245	504,333	4,529,189
1986	339,769	2,939,503	2,231,756	302,831	461,765	6,275,624
1987	858,014	3,162,880	2,525,520	569,999	681,863	7,798,276
1988	226,698	3,221,140	2,504,030	539,029	751,247	7,242,144
1989	565,626	3,952,661	2,760,997	647,587	541,281	8,468,152
1990	524,129	4,411,643	3,048,685	1,033,372	1,270,459	10,288,288
Total	4,134,712	27,377,869	13,965,906	4,412,626	5,788,395	55,679,508

One major observation that can be made from these two tables is that over the historic period, salaries and benefits averaged 88.6 and 74.3 percent of the NCRE maize breeding and agronomy units' expenses, respectively. By contrast, direct research expenses accounted for only an average of 3.5 and 7.9 percent of the breeding and agronomy units' expenses, respectively.

4.3.1.2 SAFGRAD Projects' Costs

SAFGRAD's costs included in this study are those incurred by SAFGRAD JP #31 and the SAFGRAD/FSR[34]. Therefore, total SAFGRAD costs on maize research are equal to:

$$ATC^{SAF} = ATC^{JP} + ATC^{FSR} \qquad (4.5)$$

where:
ATC^{SAF} = Estimated annual SAFGRAD projects' costs attributed to maize.
ATC^{JP} = Estimated annual costs for SAFGRAD JP #31 attributed to maize.
ATC^{FSR} = Estimated annual costs for SAFGRAD/FSR attributed to maize.

Unfortunately, available SAFGRAD data provides only estimates of these costs aggregated for all research activities. But, given the multiple crop involvement of these projects (i.e., maize, groundnut, cowpea, and sorghum), only a portion of their costs should be charged against the maize research program. The assumptions used to determine these shares are discussed below.

SAFGRAD JP #31

SAFGRAD JP #31 cost data were obtained from two different sources (Table A.8). For the first five years (1979-1983), data on total costs by main expenditure categories (i.e.,

[34] Another SAFGRAD project (SAFGRAD JP #26) operated in the North Province from 1977 to 1979, but it is not considered in the analysis because virtually no written documents are available.

travel and per diem, shipping and storage, housing, other direct costs, equipment-supplies-materials, salaries and benefits) were obtained from a final report submitted by Owen Gwathmey, the first of the two expatriate researchers assigned to the project. During a phone call, he also provided the assumptions that made it possible to break down each category total into annual expenditures. First, for travel and per diem, shipping and storage, he reported that the first and the last years accounted for 35% of the total costs for each category, while each of the middle years accounted for 10%, respectively. Second, for housing and other direct costs, he proposed using an annual 4% "institutionalized" increase assumption. Finally, annual shares for equipment, supplies and materials are assumed to equal 35%, 30%, 15%, 15%, and 5%, respectively for the years 1979 to 1983.

For the remaining years (1984-1987), the second expatriate, Jerry Johnson, provided (via phone interview) estimates of annual project costs broken down into salaries and benefits and non-salary expenses, based on his personal files (past contracts and canceled voucher reports). Because no reasonable assumption was provided to breakdown this second set of data into expenditure categories, it was is not further partitioned.

In addition, these scientists estimate that maize accounted for 35% (for 1980-1984) and 7% (for 1986) of annual Project expenditures. These estimates were then used to estimate Project costs attributed to maize research under SAFGRAD JP #31, as summarized in Table 4.3 below.

Table 4.3: SAFGRAD JP #31 Expenses (Nominal F.cfa) on Maize, North Province, Cameroon, 1979-1987.

Year	Travel & Per Diem	Shipping & Storage	Housing	Other Direct Expenses	Equipments Supplies & Materials	Subtotal Non-Salary Expenses	Salaries and Benefits[a]	Total Expenses
1979[b]	0	0	0	0	0	0	0	0
1980	202,873	47,657	862,416	39,012	1,542,405	2,694,363	2,422,174	5,116,537
1981	260,865	61,279	1,164,384	52,671	991,651	2,530,850	3,244,641	5,775,491
1982	315,495	74,112	1,478,644	66,887	1,199,324	3,134,462	4,081,015	7,215,478
1983	1,280,656	300,837	1,800,629	81,452	463,646	3,927,220	4,914,970	8,842,190
1984	na	na	na	na	na	6,214,053	15,148,168	21,362,221
1985[b]	0	0	0	0	0	0	0	0
1986	na	na	na	na	na	656,543	2,508,168	3,164,711
1987[b]	0	0	0	0	0	0	0	0
Total	2,059,889	483,885	5,306,073	240,022	4,197,026	19,157,491	32,319,136	51,476,628

"na" stands for data "not available" by expenditure category.
[a] Includes both nationals and expatriates salaries.
[b] The value zeros indicate that no maize trials were implemented in that year.

These results indicate that, as with NCRE data, salaries and benefits were the dominant costs component (62.8 percent) of SAFGRAD JP #31's total expenditures attributed to maize. Also, it appears that the total expenditures in support of maize research were very high. This suggests that either the weights used to partition total project costs are not realistic or that the project was a high cost investment. In the sensitivity analysis, these weights are adjusted to check the importance of the likely estimation error on the ROR.

SAFGRAD/FSR

Total SAFGRAD/FSR annual costs (1986-1988), excluding researchers' salaries and benefits, broken down into specific categories, were available from the documents collected (Table A.9). A further search traced the salaries and benefits for the national (G. Ngono)

and expatriates (D. S. Ngambeki and L. Singh). To estimate the share attributed to maize, these costs are partitioned between the various crops dealt with by the research team, based on the assumption that 55%, 79%, and 62% of the team's effort was directed at maize in 1986, 1987, and 1988, respectively[35]. The estimated costs incurred for maize research under SAFGRAD/FSR are summarized in Table 4.4.

Table 4.4: Estimated SAFGRAD/FSR Expenses (Nominal F.cfa) on Maize, North Province, Cameroon, 1986-1988.

COST ITEMS	1986	1987	1988	Total
Total Equipment and Supplies	7,075,215	10,003,135	202,215	17,280,565
Total Salaries and Benefits for Expatriates	10,757,578	29,126,445	24,488,071	64,372,094
Total Salaries and Benefits for Nationals	4,009,068	19,516,849	13,205,599	36,731,516
Total Direct Research Expenses	2,424,185	2,548,867	1,588,442	6,561,494
Admin., Conf. & Short-Term Training	828,430	4,094,610	1,226,337	6,149,377
Total Expenses	25,094,476	65,289,906	40,710,664	131,095,046

4.3.2 Extension and Production Costs

Extension Costs

Extension costs include costs incurred primarily by SODECOTON. The Ministry of Agriculture's extension service and other "minor" projects' costs were excluded in this study because their maize activities are marginal and, most importantly, these data are either unreliable or simply non-existent. SODECOTON extension costs (EXC^{SOD}) attributed to maize include only salaries and benefits since the primary focus of SODECOTON is cotton.

[35] These estimates, computed using SAFGRAD/FSR's annual reports data, were calculated by dividing the trial area under maize by the total area for all trials the research project implemented in each of the corresponding years.

Total staff costs were available from SODECOTON, by personnel category (Table A.10). To estimate maize's share of total extension costs, the study relied on SODECOTON's Director of the Production Division's rough estimate (personal interview) that one-twelfth of all extension time is spend on food crops. This estimate was validated through a rapid field interviews with several extension agents. This study assumes this proportion has varied over time, given that the crop area serviced by SODECOTON and the relative importance of food crop versus cotton has changed over the study period. An analysis of SODECOTON food crop and cotton areas (Table 2.3) identifies three distinct periods. Prior to 1982, SODECOTON focused on cotton, but in the second (1982 to 1984) and third (1985 to 1990) periods, it expanded its support to food crop production. Therefore, the study assumes that, based on each period's relative average area, 0.5 percent, 5.0 percent, and 8.0 percent (i.e., one-twelfth) of extension time was spent on food crops during the periods 1979-1981, 1982-1984, 1985-1990, respectively. Total salaries and benefits attributed to maize are then computed by assuming that maize extension costs are proportional to maize's share of the food crops area. These two assumptions are reflected in the following equation.

$$EXC^{SOD} = (\alpha * TPC) * \frac{Area_{Maize}}{Area_{Food}} \qquad (4.6)$$

Where:
α = Proportion of extension time spend on food crops extension activities.
TPC = Total SODECOTON's Extension Personnel Benefits and Salaries.
$Area_{Maize}$ = SODECOTON extension area under maize in each year.
$Area_{Food}$ = Total SODECOTON extension area in each year.

As stated earlier, this equation is used to estimate salaries and benefits over the historic period 1979-90 (Table 4.5a-c). For the period 1991 to 2000, it is assumed extension costs allocation to food crop will remain unchanged and equivalent to the 1990 level. This

rather optimistic assumption, given the ongoing financial crisis, is relaxed in the sensitivity analysis.

Production Costs

This cost category refers to expenses incurred by farmers. Maize in the North Province is cultivated under two distinct production systems, the *low input system* and the *high input system*. Because farmers following each system apply different inputs, the costs associated with each system are different. Thus, to estimate the total annual costs to farmers adopting the maize package, it is necessary to first estimate the unit costs (per hectare) associated with each system and then multiply these costs times the area planted in each of these systems. Annual production system costs (APC), defined as the costs associated with both systems, are computed as:

$$APC = APC_{Trad} + APC_{Imp} \quad with \quad APC_i = INP_i * AREA_i \tag{4.7}$$

Where:
APC_i = Estimated annual costs for system i, i=traditional or intensive system.
APC_{Trad} = Estimated annual costs for the traditional system.
APC_{Imp} = Estimated annual costs for the intensive system.
INP_i = Estimated annual unit input costs per hectare in system i.
$AREA_i$ = Estimated area cultivated each year under system i.

The *low input system* is implemented by both SODECOTON and non-SODECOTON farmers; but the *high input system* is only followed by SODECOTON farmers, who plant either monocrop maize or intercrop maize with sorghum.

Total Extension and Production Costs

Using equations (4.6) and (4.7), the base run estimates of annual maize extension and production costs in the North Province were computed, as summarized in Table 4.5 below.

Table 4.5(a): Estimated Maize Extension and Production Costs (Nominal F.cfa), North Province, Cameroon, 1979-2000.

COST ITEMS	1979	1980	1981	1982
I. EXTENSION COSTS				
Salaries and Benefits: - Senior Staff	133,691,888	274,664,066	351,161,203	392,209,511
- Others	212,351,618	265,318,256	342,440,879	416,619,197
Ratio Area Maize vs Other Crops (weights)	0.69	0.83	0.76	0.08
Total Extension Costs for Maize	955,080	1,792,741	2,108,550	3,235,315
II. PRODUCTION SYSTEM COSTS				
• Low Input System				
Land Clearing area (ha)	4,500	4,500	4,500	4,500
Land Clear. Costs (8 days-hour/ha at 4,400 fcfa)	19,800,000	19,800,000	19,800,000	19,800,000
Land Prep. (21 days-hour/ha at 11,550 fcfa)	51,975,000	51,975,000	51,975,000	51,975,000
Total Seed Cost	4,500,000	4,500,000	5,062,500	6,187,500
Planting Cost (15 days-hour/ha at 8,250 fcfa)	37,125,000	37,125,000	37,125,000	37,125,000
Weeding Cost (49 days-hour/ha at 26,950 fcfa)	121,275,000	121,275,000	121,275,000	121,275,000
Total Costs for the Low Input System	234,675,000	234,675,000	235,237,500	236,362,500
• High Input System				
Land Clearing Area (ha) -- pure maize	1,660	1,652	2,191	2,370
Land Clearing Area (ha) -- mixed	0	0	0	0
Land Clear. Cost (8 days-hour/ha at 4,400 fcfa)	7,304,000	7,268,800	9,640,400	10,428,000
Land Prep. Cost (21 days-hour/ha at 11,550 fcfa)	19,173,000	19,080,600	25,306,050	27,373,500
Total Seed Cost (30 kg/ha)	3,304,000	3,304,000	4,382,000	4,740,000
Planting Cost (6 days-hour/ha at 3,300 fcfa)	5,478,000	5,451,600	7,230,300	7,821,000
Weeding:				
Area (ha): Pre-emergence Chemicals	1,632	1,632	1,632	1,671
Contact Chemicals	0	0	0	0
Manual Weeding	28	20	559	699
Market Price of Chemical (Fcfa/ha)	2,000	2,000	2,000	2,000
Cost/Chemical (2 days-hour/ha at 1,100 fcfa)	5,059,200	5,059,200	5,059,200	5,180,100
Cost/Manual (49 days-hour/ha at 26,950 fcfa)	754,600	539,000	15,065,050	18,838,050
Fertilizer (N-P-K):				
Area (ha): 0-50-0	0	0	0	0
200-50-0	1,660	1,652	2,153	2,350
150-50-50	0	0	0	0
150-50-100	0	0	0	0
100-50-50	0	0	0	0
100-50-100	0	0	0	0
NPKSB Market Price (50 kg bag)	5,000	5,000	5,000	5,000
Urea Market Price (50 kg bag)	2,000	2,000	2,000	2,000
Cost of Fertilizer	36,520,000	36,344,000	47,366,000	51,700,000
Cost of Fertil. Application (2 hrs/ha at 300 Fcfa)	498,000	495,600	645,900	705,000
Total Costs for the High Input System	78,090,800	77,542,800	114,694,900	126,785,650
Total Production System Costs	312,765,800	312,217,800	349,932,400	363,148,150

Table 4.5(b): Estimated Maize Extension and Production Costs (Nominal F.cfa), North Province, Cameroon, 1979-2000 (Cont'ed).

COST ITEMS	1983	1984	1985	1986
I. EXTENSION COSTS				
Salaries and Benefits: - Senior Staff	137,892,322	249,427,626	255,245,710	210,392,283
- Others	563,019,678	562,475,392	885,918,576	657,819,779
Ratio Area Maize vs Other Crops (weights)	0.10	0.11	0.14	0.12
Total Extension Costs for Maize	3,504,560	4,465,467	13,313,583	8,682,121
II. PRODUCTION SYSTEM COSTS				
• **Low Input System**				
Area Cleared (ha)	5,150	5,857	7,760	9,350
Land Clear. Costs (8 days-hour/ha at 4,400 fcfa)	22,660,000	25,770,800	34,144,000	41,140,000
Land Prep. (21 days-hour/ha & 11,550 fcfa)	59,482,500	67,648,350	89,628,000	107,992,500
Total Seed Cost	7,081,250	8,419,438	11,640,000	14,025,000
Planting Cost (15 days-hour/ha at 8,250 fcfa)	42,487,500	48,320,250	64,020,000	77,137,500
Weeding Cost (49 days-hour/ha at 26,950 fcfa)	138,792,500	157,846,150	209,132,000	251,982,500
Total Costs for the Traditional System	270,503,750	308,004,988	408,564,000	492,277,500
• **Intensive System**				
Land Clearing Area (ha) -- pure maize	2,379	3,296	5,544	5,303
Land Clearing Area (ha) -- mixed	92	168	573	932
Land Clear. Cost (8 days-hour/ha at 4,400 fcfa)	10,872,400	15,241,600	26,914,800	27,464,800
Land Prep. (21 days-hour/ha at 11,550 fcfa)	28,540,050	40,009,200	70,651,350	72,095,100
Total Seed Cost (30 kg/ha)	6,120,000	8,555,000	21,505,500	24,029,000
Planting Costs (6 days-hour/ha at 3,300 fcfa)	8,154,300	11,431,200	20,186,100	20,598,600
Weeding:				
Area (ha): Pre-emergence Chemicals	1,977	2,624	3,860	3,221
Contact Chemicals	0	0	0	0
Manual Weeding	494	840	2,257	3,021
Market Price of Chemical (Fcfa/ha)	2,000	2,000	3,000	5,000
Cost/Chemical (2 days-hour/ha at 1,100 fcfa)	6,128,700	8,134,400	15,826,000	19,648,100
Cost/Manual (49 days-hour/ha at 26,950 fcfa)	13,313,300	22,638,000	60,826,150	81,415,950
Fertilizer (N-P-K):				
Area (ha): 0-50-0	92	167	573	939
200-50-0	0	0	0	0
150-50-50	803	1,146	0	0
150-50-100	1,553	2,150	0	0
100-50-50	0	0	2,104	2,162
100-50-100	0	0	3,440	3,141
NPKSB Market Price (50 kg bag)	5,500	6,000	6,500	8,500
Urea Market Price (50 kg bag)	3,000	4,000	4,000	5,000
Cost of Fertilizer	57,945,000	94,964,000	132,476,000	163,581,000
Cost Fert. Applic. (2 hrs/ha at 300 Fcfa)	1,441,200	2,027,700	3,498,300	3,463,500
Total Costs for the High Input System	132,514,950	203,001,100	351,884,200	412,296,050
Total Production System Costs	403,018,700	511,006,088	760,448,200	904,573,550

Table 4.5(c): Estimated Maize Extension and Production Costs (Nominal F.cfa), North Province, Cameroon, 1979-2000 (Cont'ed).

COST ITEMS	1987	1988	1989	1990
I. EXTENSION COSTS				
Salaries and Benefits: - Senior Staff	139,089,000	112,271,120	103,504,697	98,316,000
- Others	646,606,000	557,322,988	532,705,465	494,999,000
Ratio Area Maize vs Other Crops	0.08	0.12	0.13	0.11
Total Extension Costs for Maize	5,237,967	6,695,941	6,892,277	5,438,721
II. PRODUCTION SYSTEM COSTS				
• **Low Input System**				
Land Clearing Area (ha)	8,750	12,736	20,030	19,990
Land Clear. Cost (8 days-hour/ha at 4,400 fcfa)	38,500,000	56,038,400	88,132,000	87,956,000
Land Prep. Cost (21 days-hour/ha at 11,550 fcfa)	101,062,500	147,100,800	231,346,500	230,884,500
Total Seed Cost	11,484,375	16,716,000	22,533,750	22,488,750
Planting Cost (15 days-hour/ha at 8,250 fcfa)	72,187,500	105,072,000	165,247,500	164,917,500
Weeding Cost (49 days-hour/ha at 26,950 fcfa)	235,812,500	343,235,200	539,808,500	538,730,500
Total Costs for the Low Input System	459,046,875	668,162,400	1,047,068,250	1,044,977,250
• **High Input System**				
Land Clearing Area (ha) – pure maize	3,833	5,444	6,420	4,746
Land Clearing Area (ha) – mixed	706	477	782	249
Land Clear. Cost (8 days-hour/ha at 4,400 fcfa)	19,971,600	26,052,400	31,688,800	21,978,000
Land Prep. (21 days-hour/ha at 11,550 fcfa)	52,425,450	68,387,550	83,183,100	57,692,250
Total Seed Cost (30 kg/ha)	17,450,000	23,207,000	29,427,300	20,717,550
Planting Cost (6 days-hour/ha at 3,300 fcfa)	14,978,700	19,539,300	23,766,600	16,483,500
Weeding:				
Area (ha): Pre-emergence Chemicals	2,971	3,144	2,501	1,782
Contact Chemicals	805	1,890	2,950	1,436
Manual Weeding	763	887	1,751	1,777
Market Price of Chemical (Fcfa/ha)	8,000	10,000	10,000	10,000
Cost/Chemical (2 days-hour/ha at 1,100 fcfa)	27,921,600	36,977,400	31,006,100	21,359,800
Cost/Manual (49 days-hour/ha at 26,950 fcfa)	20,562,850	23,904,650	47,189,450	47,890,150
Fertilizer (N-P-K):				
Area (ha): 0-50-0	565	477	782	249
200-50-0	0	0	0	0
150-50-50	0	0	0	0
150-50-100	0	0	0	0
100-50-50	642	950	2,117	1,202
100-50-100	3,188	4,494	4,269	3,528
NPKSB Market Price (50 kg bag)	8,500	8,500	6,000	6,000
Urea Market Price (50 kg bag)	5,000	5,200	5,500	5,500
Cost of Fertilizer	122,175,000	175,014,800	174,658,500	129,563,500
Cost Fert. Application (2 hrs/ha at 300 Fcfa)	2,467,500	3,409,500	4,066,200	2,912,700
Total Costs for the High Input System	277,952,700	376,492,600	424,986,050	318,597,450
Total Production System Costs	736,999,575	1,044,655,000	1,472,054,300	1,363,574,700

To estimate production costs reported in Table 4.5a to Table 4.5c, the following data and assumptions were used. The labor requirement (mandays) and labor opportunity costs[36] for cultural practices were obtained from research data collected under farmers' conditions. Estimates of input consumption (area, type and application rate) and their unit costs are based on data reported by SODECOTON. However, to value seed used in the *low input production system*, the market purchase price of maize grain is used, under the assumption that farmers following this system get their seeds from either the previous year's crop or from the market. In contrast, farmers following the *high input production system* use treated seeds obtained from SODECOTON. The area under each production system was obtained from SODECOTON's annual reports.

Although land is actually prepared manually, with animal traction, or with tractors, this study assumes all land was prepared manually. This simplification was necessary since no data are available to estimate animal traction and tractor use costs. This introduces minimal bias since SODECOTON reports indicate that about 90 percent of the total maize area is cultivated manually. In addition, this analysis assumes only one weeding, which reflects the usual practice. The costs of tools and harvesting are not included because data were not available. Finally, social costs such as those related to infrastructure development and literacy program, as well as numerous administrative costs are not included in this study because they are primarily incurred for cotton production.

One general comment that Table 4.5a-c highlights is that, over the historic period, the *low input production system* averaged 66 percent of the total production costs. The most important cost component in this production system is weeding cost which represents about 50

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[36] Since an estimate of the opportunity costs of labor was only available for 1990, this is used to value labor costs throughout the estimation period. This opportunity cost was obtained from the Maroua TLU (TLU Maroua, 1991).

percent of the system's total costs. The most important cost component in the *high input production system* is fertilizer cost.

*4.2.3 **Benefits Determination***

The estimation of benefits associated with maize research and extension in the North Province is based on two key assumptions. First, many key informants interviewed during the field work claimed that all of the maize varieties grown in the North Province are improved varieties. However, the North Province is contiguous to the Adamaoua Province, which has a long tradition of maize production. Thus, some farmers following the *low input production system* in the area adjacent to the Adamaoua plateau, could be growing traditional varieties. In fact, the 1978-79 SODECOTON annual report (p.15) notes that "local traditional varieties" are being replaced by improved varieties in these areas[37]. Consequently, although some traditional maize could have been introduced from the Adamaoua Province, the base run analysis assumes all of the Province's maize area has been planted to improved varieties.

Second, key informants and various reports reviewed suggested that some of the maize area replaced land previously planted to sorghum. Unfortunately, data on the maize area previously (or intended to be) cropped to sorghum were not available. Therefore, in the base run analysis, it is assumed that all of the maize area has been planted in newly opened fields, but subsequent scenarios relax this assumption in the sensitivity analysis.

The annual benefit stream is computed as the value of the Province's total maize production netted out by the foregone sorghum net revenues (SNR) or opportunity cost (OPC) of maize production as summarized in the following general equation:

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[37] One objective of the survey that the researcher unsuccessfully attempted to carry out was to resolve this issue.

$$BENEFIT = [YLD*(AREA*ADOP)]*PRI - OPC \quad (4.8)$$

$$with \qquad OPC = [(AREA*ADOP)*AAF]*SNR \quad (4.9)$$

Where:
YLD = Maize yield.
AREA = Maize area in the North Province
ADOP = Adoption rate.
PRI = Unit price of Maize.
AAF = Area adjustment factor i.e., maize area previously planted with sorghum.
This equation is used to compute the base run net revenue estimates, as summarized in the Table 4.6.

Table 4.6: Estimated Maize Revenues (Nominal F.cfa), North Province, Cameroon, 1979-2000.

Year	Improved Sorghum Adoption Rate (%)	High Input System Maize Area (ha)	Low Input System Maize Area (ha)	High Input System Maize Yield (t/ha)	Maize Grain Market Price (F.cfa/kg)	Sorghum Weighted Average Net Revenues (F.cfa/ha)	Gross Revenues[a]
1979	0	1,660	0	2.00	40	83,350	132,800,000
1980	0	1,652	0	2.00	40	83,350	132,160,000
1981	0	2,191	0	2.00	45	83,350	197,190,000
1982	0	2,370	4,500	2.00	55	83,350	592,350,000
1983	0	2,471	5,150	2.50	55	83,350	814,206,250
1984	0.004	3,464	5,857	2.50	58	83,351	1,062,052,313
1985	0.012	6,117	7,760	2.30	60	83,352	1,379,586,000
1986	1.030	6,242	9,350	3.00	60	83,546	2,251,170,000
1987	1.849	4,541	8,750	2.10	53	83,701	1,146,985,875
1988	2.613	5,921	12,736	2.30	53	83,846	1,745,334,990
1989	3.081	7,202	20,030	2.00	45	83,935	1,549,530,000
1990	3.299	4,995	19,990	2.35	45	83,977	1,944,562,725

[a] Computed under the assumption that maize did not replace sorghum (i.e., with zero opportunity cost).

Maize area and yield data in the historical period were obtained from SODECOTON annual reports. Even though the area under SODECOTON supervision includes only about 70 to 80 percent of the Province's farming population, using SODECOTON data does not seem to create a major problem for estimating the maize area since these data are fairly similar to the Province 1984-89 data from the national agricultural census. However, SODECOTON reports provide separate yield estimates neither for sole versus intercropping, nor for *low* versus *high input production systems*, partly because of the extreme variability in plant density across farms. To address this issue, the study assumes that the maize yield in *low input production system* is two-thirds the yield in the *high input production system*. The margin of error associated with this assumption is likely to be fairly small.

Similarly, to estimate the opportunity cost of the sorghum area replaced by maize, the net revenue per hectare of sorghum should be computed for each system under which sorghum is produced. However, since the necessary time series data were not available, to estimate this value, the study uses a one year (1990) estimate of net revenues for the *low and the high input sorghum production systems* that were calculated by the Maroua TLU (1991). These two values are weighted by the sorghum annual adoption rate --time series estimated by Sterns (1993)-- to compute annual weighted average net revenues.

Finally, the value of total production (maize and sorghum) is estimated using market prices reported by the Provincial Delegation of Agriculture in the North. Assuming that maize is a new crop in the Province, the benefits generated by maize research and extension in the North Province are estimated using maize area, yield and market prices, as well as the opportunity cost associated with maize production (i.e., the value of the foregone sorghum production, which is initially assumed to be zero).

4.5 ***Benefit/Cost Analysis***

The ROR analysis was carried out in three stages. First, in the base run the financial rate of return (FROR) is computed using equation (3.6). This result incorporates the initial assumptions that reflect the best estimates for all the costs and benefits items, as described above. Due to the non-availability of data necessary to determine the economic values of the costs and benefits identified, only financial analysis is carried out. Hence, no adjustment is made for inflation, the real exchange rate, or shadow prices. Most importantly, the use of a financial maize price is justified by the fact that maize grown in the North Province is produced mostly for local consumption; and while some maize is being imported (especially by MAISCAM and for livestock), the amount imported is minimal.

Second, to assess the sensitivity of the base run results, these initial assumptions are progressively relaxed using alternative values within reasonable bounds. Fifteen variables are considered in this sensitivity analysis: North Cameroon's maize share in the NCRE's breeding and agronomy expenses, maize's share in SAFGRAD JP #31's and SAFGRAD/FSR's total expenses, maize extension/adoption expenses, seed costs, *low and high input systems'* costs, maize area and maize yield in the historic period, the area adjustment factor for foregone sorghum production; and projected extension expenses; and projected maize area. Based on these varying assumptions, ranges of FRORs are computed to determine the sensitivity of this investment evaluation criterion to changes in the value of these variables. Finally, critical variables are identified and their values are changed individually and in combinations. During this sensitivity analysis, the assumption regarding the percent of the maize area planted in newly opened field is relaxed by assuming successively that 10 to 100 percent of the maize area was previously planted to sorghum.

Finally, the third section discusses of the institutional factors that explain the NPV and FROR values computed.

4.5.1 Base Run Analysis

In this analysis, the annual total costs (TC) stream is computed as the sum of NCRE (ATC^{NCRE}), SAFGRAD (ATC^{SAF}),nd extension costs (EXC^{SOD}), and production costs (APC). Using the cost and benefit values presented earlier, annual net revenues from maize research and extension in the North Province are computed, as summarized in Table 4.7 below.

Table 4.7: Estimated Net Revenues (Nominal F.cfa) for Maize Research, Extension and Production, North Province, Cameroon, 1979-2000.

ITEMS	NCRE Expenses	SAFGRAD FSR	SAFGRAD JP #31	Total Research Costs	SODECOTON Personnel Costs	Low Input System Costs	High Input System Costs	Total Extension & Production Costs	Gross Revenues	Net Revenues
1979	na	na	0	0	955,080	234,675,000	78,090,800	313,720,880	132,800,000	(180,920,880)
1980	na	na	5,116,537	5,116,537	1,792,741	234,675,000	77,542,800	314,010,541	132,160,000	(186,967,079)
1981	2,071,750	na	5,775,491	7,847,241	2,108,550	235,237,500	114,694,900	352,040,950	197,190,000	(162,698,191)
1982	6,796,933	na	7,215,478	14,012,411	3,235,315	236,362,500	126,785,650	366,383,465	592,350,000	211,954,124
1983	7,584,311	na	8,842,190	16,426,501	3,504,560	270,503,750	132,514,950	406,523,260	814,206,250	391,256,489
1984	8,939,315	na	21,362,221	30,301,536	4,465,467	308,004,988	203,001,100	515,471,555	1,062,052,313	516,279,223
1985	9,519,467	na	0	9,519,467	13,313,583	408,564,000	351,884,200	773,761,783	1,379,586,000	596,304,749
1986	12,064,115	25,094,476	3,164,711	40,323,302	8,682,121	492,277,500	412,296,050	913,255,671	2,251,170,000	1,297,591,027
1987	14,242,046	65,289,906	0	79,531,952	5,237,967	459,046,875	277,952,700	742,237,542	1,146,985,875	325,216,381
1988	13,625,452	40,710,664	na	54,336,116	6,695,941	668,162,400	376,492,600	1,051,350,941	1,745,334,990	639,647,933
1989	15,409,804	na	na	15,409,804	6,892,277	1,047,068,250	424,986,050	1,478,946,577	1,549,530,000	55,173,620
1990	18,115,285	na	na	18,115,285	5,438,721	1,044,977,250	318,597,450	1,369,013,421	1,944,562,725	557,434,019
1991-2000	0	na	na	0	5,438,721	1,044,977,250	318,597,450	1,369,013,421	1,944,562,725	604,649,304

"na" stands for "Not Applicable" because the project did not exit at that time. Zero indicates no expenditure in that year. Numbers in the parenthesis are negative.

One general comment that this table highlights is that, over the historic period, research costs averaged 82 percent of the total cost of maize research and extension in the North Province. The relative contribution of each of the three research projects involved are 45 percent from SAFGRAD/FSR, 37 percent from NCRE, and 18 percent from SAFGRAD JP #31, the bulk of which is made up of salaries and benefits. If one considers total research, extension and production costs, over the historical period, research costs account only for about three percent while extension costs represent less than one percent.

For the period 1979-2000, maize research and extension generated an internal rate of return of 11.7 percent, computed using the net revenues data stream in Table 4.7. This ROR represents a conservative estimate of impact since it only includes the direct and quantifiable impact of the maize research and extension program. For example, an additional benefit not accounted for in the base run data analysis includes the contribution of these research projects to institutional building at IRA. Although impossible to estimate, these projects made a major contribution to the development of more productive human capital, some of whom are now or are likely to be in positions which give them the opportunity to continue to contribute to agricultural and rural development.

Before assessing the significance to this ROR value, one has to keep in mind two key assumptions upon which this value is based. First, that virtually all of the maize area in the Province is planted to improved varieties from research and extension and, second, that all area planted to maize is grown on newly opened fields. Also, as discussed in the theoretical section, the computational procedure used assumes that all farmers trade cash flows between time periods at the same price or discount rate. The significance of these underlying assumptions are discussed in the sensitivity analysis section.

Given these assumptions, the estimated rate of return is close to the market rate of capital borrowed at the bank, which this study assumes is the approximate opportunity cost of capital (the market interest rate varies between 12 and 15 percent). While there exists an informal credit market, very little information is available on its importance and the discount rates that apply. In addition, these rates vary from one location to another, as well as from one time period to another. A major weakness of this opportunity cost assumption is that it implicitly assumes unlimited savings and borrowing opportunities at the same interest rate. This is not likely to be true because farmers have limited and different credit or borrowing capacity[38], and some farmers tend to use the informal market. Consequently, using the bank interest rate as the defendant underestimates the true opportunity cost of borrowing.

Three of the factors that explain the successful expansion of maize in the North Province are the inherent characteristics of maize production, the characteristics of the physical environment, and the food demand status of the Province. As mentioned in the background section, the North Province benefits from relatively favorable climatic conditions for maize production with annual rainfall ranging from 700 millimeters to 1,100 millimeters, which in addition to favorable temperatures, provides sufficient moisture for plant germination and growth and leads to less post-harvest fungic infestation and damages from weevils. As one moves to the north where there is less rainfall, maize production progressively becomes marginal, while further south, in the Adamaoua Province where the climatic condition are more favorable, maize production is more developed.

In addition, sorghum, which is the Province's major traditional food crop, is less productive than improved maize. As a result, farmers are increasingly relying on maize as an

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[38] The borrowing capacity represents each farmers' reserve available for credit use. When a farmers borrows, he reduces his reserve. The cost of the loan is therefore the interest rate to be paid plus the value of the credit reserve that is sacrificed.

important source of family food, especially in the hunger period before sorghum is harvested. Many key informants believe that, as with sorghum, the compatibility of maize with the existing farming system and the ease of the cultural practices involved in maize production (relative to cotton production) are some key reasons that explain why farmers have adopted the maize technology. In fact, it is a common view that both of these circumstances and a strong market demand are the driving forces of maize research and extension in the North Province. Other factors that have contributed to success of maize research and extension are discussed in the institutional analysis section.

4.5.2 Sensitivity Analysis

This section tests the responsiveness of the estimated base run IRR to reasonable changes in selected assumptions and/or variables' level used in the initial analysis. The choice of variables/levels to modify in the sensitivity analysis is based on educated assessment of critical variables and assumptions believed to potentially affect the ultimate result. More than 50 runs were made, but only the most interesting ones are reported in Table 4.8 below.

Table 4.8(a): IRR for Maize Research and Extension from Alternative Values for Key Variables, North Province, Cameroon.

Key Variables	Run 1	Run 2	Run 3	Run 4	Run 5	Run 6	Run 7	Run 8-9
Research Costs:								
NCRE Expenses	+25%	b	b	+25%	b	b	b	+5-10%
SAFGRAD JP #31 Expenses	b	+25%	b	+25%	b	b	b	+5-10%
SAFGRAD/FSR Expenses	b	b	+25%	+25%	b	b	b	+5-10%
Extension Costs:								
SODECOTON Expenses	b	b	b	b	+25%	b	+25%	+5-10%
Seed Costs	b	b	b	b	b	+150%	+150%	b
Low Input System Costs	b	b	b	b	b	b	b	b
High Input System Costs	b	b	b	b	b	b	b	b
Benefits:								
Maize Area	b	b	b	b	b	b	b	b
Maize Yield	b	b	b	b	b	b	b	b
Sorghum Area	b	b	b	b	b	b	b	b
Future Expectations:								
Future Extension Effort	b	b	b	b	b	b	b	b
Future Maize Area	b	b	b	b	b	b	b	b
Internal Rate of Return (%)	11.7%	11.6%	11.7%	11.6%	11.6%	10.9%	11.0%	10.7-9.8%

"b" implies the base run data is kept unchanged.

Table 3.8(g): IRR for Maize Research and Extension from Alternative Values for Key Variables, North Province, Cameroon (Continued)

Table 4.8(b): IRR for Maize Research and Extension from Alternative Values for Key Variables, North Province, Cameroon (Continued).

Key Variables	Run 10-11	Run 12	Run 13-14	Run 15-16	Run 17	Run 18	Run 19	Run 20
Research Costs:								
NCRE Expenses	+15-25%	b	b	b	b	b	b	b
SAFGRAD JP #31 Expenses	+15-25%	b	b	b	b	b	b	b
SAFGRAD/FSR Expenses	+15-25%	b	b	b	b	b	b	b
Extension Costs:								
SODECOTON Expenses	+15-25%	b	b	b	b	b	b	b
Seed Costs	b	b	b	b	b	b	b	b
Low Input System Costs	b	b	b	b	b	b	+20-30%	+35-40%
High Input System Costs	b	b	b	b	b	+20%	+20-30%	+35-40%
Benefits:								
Maize Area	b	+25%	b	b	b	b	b	b
Maize Yield	b	b	5-10%	+20-30%	+50%	+50%	+50%	+50%
Sorghum Area	b	b	b	b	b	b	b	b
Future Expectations:								
Future Extension Effort	b	b	b	b	b	b	b	b
Future Maize Area	b	b	b	b	b	b	b	b
Internal Rate of Return (%)	8.9-7.0%	13.5%	12.7-13.6%	15.5-17.4%	21.5%	19.8%	16.6-14.8%	14.0-13.3%

"b" implies the base run data is kept unchanged.

Table 4.8(c): IRR for Maize Research and Extension from Alternative Values for Key Variables, North Province, Cameroon (Continued).

Key Variables	Run 21	Run 22	Run 23	Run 24-25	Run 26-27	Run 28-29
Research Costs:						
NCRE Expenses	b	b	b	b	b	b
SAFGRAD JP #31 Expenses	b	b	b	b	b	b
SAFGRAD/FSR Expenses	b	b	b	b	b	b
Extension Costs:						
SODECOTON Expenses	b	b	b	b	b	b
Seed Costs	b	b	b	b	b	b
Low Input System Costs	+20-30%	+35-40%	b	b	b	b
High Input System Costs	+20-30%	+35-40%	b	b	b	b
Benefits:						
Maize Area	b	b	b	b	b	b
Maize Yield	+100%	+100%	b	b	b	b
Sorghum Area	b	b	+9%	+27-28%	b	b
Future Expectations:						
Future Extension Effort	b	b	b	b	-50-(100)%	-50%
Future Maize Area	b	b	b	b	b	-25-(75)%
Internal Rate of Return (%)	25.5-22.5%	21.2-20.2%	10.0%	5.3-(4.3)%	11.9-12.1%	11.8-11.6%

"b" implies the base run data is kept unchanged. Numbers in the parenthesis are negative.

Runs 1-4: Research Expenses

The IRR was recalculated using as much as a 25 percent increase in NCRE, SAFGRAD JP #31, and SAFGRAD/FSR expenses attributed to maize research in the North Province (Table 4.8). These adjustments were run separately (runs 1-3) and simultaneously (run 4). The results obtained show an IRR not less than 11.6 percent, which indicates that as much as a 25 percent error in the estimation of research costs has almost no impact on the ROR. Consequently, the estimated IRR value is close to its true value, if these cost items accounted for the only estimation error in the computation process.

Runs 5-7: SODECOTON Expenses

Three scenarios are considered in an attempt to account for possible underestimation of extension/production expenses. In one case (run 5), both estimated extension and production expenses were adjusted upward by up to 25 percent, and this yielded an IRR of 11.56 percent. In the second case (run 6), it was assumed that the only estimation error is the costs of seeds. This scenario was run to test the impact of the assertion made by many key informants that maize seed price was subsidized by the government at about 60 percent. Adjusting the seed price upward to account for the subsidy reduced the IRR to 10.9 percent. In a third scenario (run 7), both the estimated seed costs and SODECOTON's extension/adoption expenses were increased by 150 (i.e. 60 percent subsidy) and 25 percent, respectively, which yielded a 11.0 percent IRR. Thus, if one considers only potential errors in estimating these extension/production expenses, an upward adjustment of up to 25 percent still gives an IRR of no less than these 11.0 percent.

Runs 8-11: Research, Extension and Production Costs

After having adjusted research and extension/production expenses separately, these three cost items were then increased simultaneously by 5-10 (runs 8-9) and 15-25 (runs 10-11) percents. The results indicate an IRR in the range 10.72-9.79 and 8.88-7.03 percents, respectively. These results show that a 10 percent estimation error on total research, extension and production costs would have a significant negative impact on the IRR. Realistically, given that these costs estimates are based on actual data, estimation errors of this magnitude are highly unlikely.

Run 12: Maize Area over the Historic Period

The base run IRR was computed using SODECOTON data which do not include the entire Province's maize production area, since key informants and available statistics indicated the maize area outside the SODECOTON zone is relatively insignificant. However, this assumption was relaxed upward by 25 percent, *ceteris paribus*. The run generated an IRR of 13.5 percent, representing a 1.8 percentage points increase over the base run IRR.

Runs 13-22: Maize Yield over the Historic Period

In the base run, gross revenues from maize production in the North Province was computed using estimates of the *high input system*'s yield and assuming that the yield in the *low input system* is two-thirds the yield in the *high input system*. In runs 13-14, when these yield estimates were increased to up to 10 percent, the IRR increased by as much as 1.7 percentage points over the base run value. To further test the effect of yield on the IRR, in runs 15-17, maize yield was adjusted upward to as much as 50 percent, which gave an IRR of 21.5 percent. Even when yields are increased by 50 percent simultaneously with 20-40

percent higher input costs (run 18-20), the IRR is still greater than the base run. Finally, when maize yields are increased by 100 percent and input costs by 20-40 percent, the IRR exceeds 20 percent.

Runs 23-25: Maize Area Previously Cropped to Sorghum

A major assumption in the base run analysis is that maize did not replace sorghum, but rather all maize was planted on newly opened land. However, common sense and SODECOTON report suggest the contrary. Run 23, in which it was assumed that only 9 percent of the maize area replaced sorghum, generated a ROR of 10.0 percent. Increasing this percentage to 28 percent further reduces the ROR to -4.3 percent, which shows that the assumption about the proportion of sorghum area replaced by maize is extremely critical. Overall, these results raise some concerns about the profitability of this investment.

Runs 26-29: Extension Effort and Maize Area over the Forecast Period

Given the reduction in government budget allocated to development agencies due to the economic crisis Cameroon is facing, it is realistic to expect a substantial reduction in the level of support SODECOTON is able to provide to farmers in the future. The base run analysis assumed a constant level of investment to the year 2000 equal to the magnitude of the 1990 investment. While there is no way to predict what this level could be, runs 26-27 attempt to take into account a more than likely reduction of extension effort by reducing SODECOTON's expenditures on benefits and salaries for its personnel by 50 to 100 percent. Interestingly, the results indicate that a substantial decline in SODECOTON's support with no reduction in maize area planted reduces the base run rate of return by no more that 0.3 percentage points. This implies that regardless of what would happen from the year 1991 to

2000 in terms of public support to maize extension, the base run rate of return will remain unchanged, *ceteris paribus*.

Yet, to assume that reduced maize extension expenditures would have no effect on maize area is somewhat unrealistic. Thus, to take into account the link between maize extension effort and maize area, both variables were adjusted simultaneously in runs 28-29, by reducing maize extension costs by 50 percent and maize area by 25 to 75 percent. Unexpectedly, the results obtained show that the IRR ranges between 11.6 to 11.8 percent, which is not significantly different from the base run result.

Summary

The sensitivity analysis revealed that the most important determinant of the ROR obtained were the assumption about the maize area previously cropped to sorghum. These results also showed the significant impact of maize yield on investment profitability, supporting the hypothesis that the IRR would have been even more attractive had the varieties extended been hybrids, *ceteris paribus*.

In contrast, adjusting historic research and extension/adoption expenses upward by as much as 10 percent did not prove to have a major impact on the rate of return. But beyond this range, the IRR is reduced by at least 20 percent, if all cost estimates are adjusted simultaneously.

Finally, the sensitivity analysis showed that, regardless of what would happen from the year 1991 to 2000, in terms of the level of maize extension support and maize area, the base run rate of return remains unchanged, *ceteris paribus*. This is explained by the fact that these costs are small (relative to the one of the early periods) and the distant time periods during which they are incurred lead to corresponding present values with only marginal

effects on the IRR. The major drawback in this sensitivity analysis is that fact that in most cases, adjustment are considered separately.

4.6 Institutional Analysis

The previous sections of this chapter present the quantitative part of this ROR study. In general, ROR studies show that there exists considerable variability across locations within a country and between countries with respect to the magnitude of the ROR for the same technology. A major reason for this variability is the difference in the physical and institutional contexts within which the technology is developed and used. These institutional and physical factors establish constraints and opportunities for economic agents, through their effects on the incentive structure, which in turn generate outcomes or payoffs. Consequently, within the same physical environment, alternative institutional arrangements generate differing patterns of interactions and thus differing payoffs. It is only when the quantitative analysis is integrated with an analysis of the institutional setting that one begins to understand factors underlying the performance of a new technology.

While this section incorporates the institutional dimension, it does not attempt to provide a comprehensive analysis of the institutional setting of maize research and extension in the North Province. Rather, it is based on the author's personal experiences, interviews with key informants, and a review of appropriate literature. The analysis proposes key factors that have contributed to the estimated ROR to research and extension, in addition to the characteristics of the physical environment and the technology discussed earlier. It also highlights potential constraints to future expansion of maize production in the North Province.

4.6.1 Research and Extension

Maize expansion in the North Province is partially due to both the unique and long standing complementary organization of research, extension, and seed supply, and the strength of these institutions. In most parts of Cameroon, a large number of institutions, mostly governmental, support the agricultural sector. Their mandates are broad and, in many cases, overlap. For example, in the Center Province, extension activities were undertaken by SODECAO, NETP, MINAGRI, SOCOOPED, MIDEVIV, NGOs, and to some extent by the TLU. Coordination and cooperation between these institutions has been a major issue of concern in the policy debate, and has often been cited as one of the reasons why the implementation of development policies has fallen short of government's expectation.

In contrast, agricultural institutions in the North Province are much better organized. While IRA is responsible for all agricultural research, as is the case in the rest of the country, agricultural extension is dominated by SODECOTON with the support from NCSM for seeds provision prior to its privatization. Although numerous other institutions are also present in the Province, their activities are either marginal (e.g., SODEBLE, MINAGRI and Project Céréalier) or very specific (e.g., SEMRY for irrigated rice and MAISCAM for maize processing). This set up is unique in the country in the sense that fewer different institutions are involved in agricultural research and extension, which facilitates better coordination. For example, SODECOTON deals with both food crops and cash crops, provides inputs to and buy production surpluses from farmers. In addition, SODECOTON follows a modified Training and Visit extension system, which not only seeks to increase production but also to promote commercialization, farmer organization, and education. Specific efforts to support these goals include programs to diffuse improved varieties and production techniques (e.g., mechanization), supply necessary inputs, empower farmers through self-managed

cooperatives, market production surpluses, expand the development of infrastructure (e.g., roads), and promote farmers' literacy. Thus, the success of the maize research and extension in the North Province is partially due to SODECOTON's broad mandate.

Furthermore, the significant impact of IRA and SODECOTON on maize production in the North is partly due to the unique approach to research and extension that they have adopted. In contrast to the classic situation, where research and extension have generated numerous scientific reports and findings with little applicability to small farmers' conditions, these institutions rely on joint annual planning meetings, on-farm testing, field demonstration, joint monitoring and evaluation, and prototype extension bulletins to ensure that the new technology generated is appropriate to farmers' needs and is extended to them.

These joint planning meetings have reinforced the holistic and interdisciplinary characteristics of the farming system methodology, and contributed to building and strengthening proactive and mutually beneficial relationships between research, extension and farmers. This collaboration has resulted in significant management innovations that have (a) improved the identification of farmers' problems, (b) improved research implementation which has produced higher quality research results, (c) provided greater incentives to researchers and extension staff, (d) improved the coordination and use of scarce resources, and (e) generated a greater flow of information that is useful to farmers. As a result, farmers benefit from greater access to high-yielding varieties and cultural practices adapted to their circumstances, and lower transaction costs, all of which translate into more farm income. In addition, farmers' active participation in the identification of research issues and the evaluation of results has increased their interest in new technologies. Finally, a major incentive to researchers is provided by the guarantee that if they develop appropriate

technologies, an effective extension system is in place which has proven its ability to widely diffuse new technologies.

Unfortunately, the close proactive link between research and SODECOTON has been informal, in the sense that there exits no formal institutional arrangements to insure continued cooperation between researchers and extension agents. This deficiency raises some doubts about the sustainability[39] of the system. Also related to the sustainability issue is the high level of donor funding that has been required to support the joint research program (NCRE and SAFGRADs) and the extension system. It is doubtful that the government will be able to maintain a reasonable level of investment after the mid-1994 when the NCRE Project is to be terminated. Already, the current economic crisis has drastically reduced the government capacity to provide recurrent costs for research, credit, input supply, marketing, and processing. Unless the economic crisis is resolved, further reductions are likely in the future.

In an effort to adjust their budgets to the country's reduced finances starting from 1990, SODECOTON and IRA signed *performance contracts* with the government. To comply with its contract, SODECOTON attempted to reduce its expenses for social programs and narrow its focus to a limited number of operations by, for example, decreasing subsidies (e.g., cotton since 1989) and reducing or stopping its purchase of food crops such as maize. While these reforms will reduce operating costs, SODECOTON (1979-80, p.2; 1985-86, p.3) fears that if it no longer buys food crops (which are rotated with cotton), farmers will dramatically reduce their cotton area.

On the other hand, an expansion of the food crop area could also threaten cotton production which is SODECOTON's primary focus. For example, in 1979 when world price of cotton dropped and SODECOTON's groundnut oil (*Diamaor*) faced increased competition

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[39] The concept sustainability is used here to mean sustained institutional performance.

with less expensive imported oil, SODECOTON reduced its guaranteed price for cotton. This prompted many farmers to look for better alternatives, such as maize for which a market was guaranteed by MAISCAM. In addition, after SODECOTON signed its *performance contract*, it started charging IRA for implementing research trials. Because IRA also faced a financial crisis, it immediately decreased the number of on-farm trials it contracted out to SODECOTON.

These policy changes are indicative of the new environment under which both research and extension have to be conducted in the future. Clearly, SODECOTON can no longer afford to ignore the high costs of its activities, given its need to improve its financial performance.

4.6.2 Inputs Availability and Delivery

As indicated by the sensitivity analysis, returns to research and extension are highly sensitive to maize yield. Among various determinants of yield, two are critical; the maize type and cultural practices[40]. While Cameroon has benefited from the existence of a reliable source of open-pollinated maize seeds, little effort has been directed at developing hybrids with greater yield potential.

4.6.2.1 Maize Seeds Production and Provision

A major determinant of maize expansion in the North Province has been the existence of a reliable support system for producing and distributing quality seed. Anecdotal evidence supported by SODECOTON reports (SODECOTON, 1985-86 p.61) suggest farmers are

[40] As discussed previously, collaborative applied research carried out by IRA and SODECOTON has successfully identified cultural practices that have been widely adopted by maize farmers.

reluctant to keep seeds from the previous production (SODECOTON, 1985-86 p.61); Therefore, they either purchased seeds on local markets or through SODECOTON. Historically, SODECOTON's main source of seeds has been the NCSM although IRA has provided limited amounts of seeds. But, due to poor financial performance, NCSM was privatized in 1991 and (symbolically) bought by Pioneer.

While Pioneer's involvement in seed production initially raised hopes for a brighter future for maize production in the country as a whole and in the North Province in particular, these hopes were shattered when Pioneer pulled out in July 1993. This set back constitutes a serious handicap to the expansion of maize in the North Province.

4.6.2.2 Open-Pollinated Versus Hybrid Maize Varieties

With regard to the inherent yield potential, research results indicate that the yield for most improved varieties extended in the North Province are quite encouraging. In the North, under farmers' conditions, the available improved varieties yield two to three times as much as traditional varieties.

To date, maize breeding and extension in North Cameroon in particular, and in the country in general, has been focused exclusively on identifying and developing open-pollinated varieties, despite evidence of some yield advantage obtained by the lowland breeding unit. For example, available research results indicate that hybrids outyielded open-pollinated varieties by 50 to 100 percent, under good management and adequate rainfall (1990 NCRE lowland breeding unit results). But, as Cameroon's economy restructures to overcome the current financial crisis, the traditional debate of hybrid/open pollinated maize types takes greater significance. The study's sensitivity analysis showed that a 50 percent increase in maize yield increases the base run returns to research and extension by 3.08 to 4.86 percent,

assuming a 20 to 30 percent increase in adoption costs. Similarly, the IRR increases by 10.8 to 13.8 percentage points under a 100 percent increase in yield and a 20 to 30 percent increase in adoption costs.

Key informants reported that IRA's focus on open-pollinated varieties has often been justified by the claims that (a) farmers cannot profitably adopt hybrids under risky and low input conditions[41], (b) small farmers will not be willing or cannot afford to replace their seeds each season, as required with hybrids, and (c) that success in hybrid maize production requires the existence of a well-established hybrid seeds industry which does not exist in Cameroon.

Recent evidence from other developing countries suggests that these claims (a and b) are not based on facts. Byerlee et al (1993) report that hybrids have been successfully adopted and were profitable under low input conditions in India and El Salvador, as well as Eastern and Southern Africa (Malawi, Zimbabwe, Kenya, Swaziland, Lesotho, Zambia, and South Africa)[42]. Although these results were obtained from studies that compared hybrids to an unimproved local open-pollinated variety, and where a well-established hybrid seed

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[41] It is often argued that hybrid's higher production potential can only be achieved under favorable climatic conditions when a complementary package of inputs such as fertilizer are applied.

[42] Byerlee et al (1993) reports that:

a) In Swaziland, hybrid maize varieties are extensively adopted by small-scale farmers. Around the late 1980s, hybrid seeds were planted on about 80 to 90 percent of the maize area.

b) In Kenya, there has been a rapid and widespread adoption of hybrid varieties and a complementary package of improved practices even though this seem to have occurred mainly in the commercial maize producing areas. Maize area with hybrids rose from 35 percent in 1970-74 to 64 percent in 1986-88, much of which occurred in areas dominated by very small farmers. This expansion in hybrid maize production has been accompanied by a very low fertilizer use on hybrid.

c) In Malawi, an analysis of the *zero fertilizer plot* of data from 212 on-farm demonstrations (hybrid versus local maize with and without fertilizer) conducted over the past three years (1990-92) in the Lilingwe area shows that hybrids outyielded local varieties by 56 percent (380 kg) over all three years including 1992, one of the driest year in Malawi's history. Simple economic budgets indicated a marginal return to farmers above 100 percent even under no subsidy alternative.

d) In Zimbabwe, the performance of hybrid varieties under the low input conditions has been similar to the results at obtained in Malawi.

industry existed, the results question the conventional wisdom that has guided maize development in Cameroon. Thus, there is a need for Cameroon researchers to reevaluate the potential benefits of expanding research to hybrid maize.

4.6.2.3 Improved Maize Seeds Release

Seed release policies play an important role in insuring that new varieties are available to farmers. Currently, the procedures for seed production and release are determined informally by breeders with the assistance of agronomists and parastatals. As a result, there exists no informed criteria for releasing new varieties. Thus, there is a need to develop a uniform policy that defines the characteristics (yield advantage threshold, stability, color, endosperm type. etc...) to ensure the timely release of high quality seeds.

An attempt to address this issue has already been made with the extension of IRA's mandate to "ensuring an adequate supply of seed and other planting materials through seed multiplication and certification, and provision of foundation seeds to developmental agencies and private sector organization" (IRA, 1989). While IRA now has a mandate for seed production, it is important to ask the question how effective will the research system be in producing and supplying quality seeds, at reasonable costs and in a timely manner?

4.6.2.4 Fertilizer Supply System

Because maize is highly responsive to fertilizer, greater use of fertilizer in maize production could potentially increased yields. Yet, on the average, between 1979 and 1990, farmers applied chemical fertilizer on only 31.5 percent of maize area in the North Province (ranging between 15 and 44 percent), the bulk of which was imported.

Prior to 1987, fertilizer importation was coordinated by government through administrative processes that imposed legal constraints on private transactions (i.e., import authorization and license, special clearance to use ships other than *Cameroon Shipping lines Company* (the national shipping company), and custom inspections. On the other hand, the private sector agents related directly to government agencies and they only indirectly related to one another.

Fertilizer was imported through a joint operation between the MINAGRI and FONADER. An interministerial tender board had authority to accept bids from fertilizer importers and award contracts, with funds provided by FONADER and the Ministry of Finance. Imported fertilizers was then allocated to provincial cooperatives or Delegations of Agriculture on the basis of their needs as determined by MINAGRI -- SODECOTON was the largest consumer of the imported fertilizer. A uniform pricing policy has been applied, regardless of the type of fertilizer and the location. This has corresponded to a government price support to farmers amounting to about 65 percent on the average (Oakerson and Truong, 1990).

The public monopoly on the importation and distribution of subsidized fertilizer created opportunities for rent-seeking behavior and corruption through selective use of discriminatory power entrusted to bureaucrats. This behavior has translated into the offering of large number of small contracts with high freight costs, and failed to generate sufficient information to ensure timely distribution, at low costs. As a result of the institutional setting and the fertilizer subsector's poor performance, an unspecified but seemingly important amount of fertilizer is smuggled from Nigeria[43].

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[43] Up to the late 1970s maize import was marginal, but since 1980, the amount imported has become significant because of: the uncertainty associated with seasonal price fluctuations, security inventory keeping as a strategy to guarantee the supply to potential buyers, the credit structure which makes it easier to get

Triggered by the financial crisis prevailing in the country, in 1988 the government initiated a fertilizer subsector reform program with the support from USAID. This program was aimed at liberalizing and privatizing fertilizer procurement, introducing free market pricing, and reducing fertilizer subsidy to zero by 1991 (Oakerson and Truong, 1990). If successful, these reforms will solve many of the problems plaguing the subsector. Yet, the effectiveness of this major restructuring effort will depend on the sustained commitment of government bureaucrats to liberalization, the entrepreneurial and innovative initiatives of private economic agents, the market structures, their competitiveness and profitability, as well as the introduction of new institutional arrangements relating to issues such as property rights and dispute settlement.

An equally important constraint to increasing the performance of the subsector is related to the intrinsic nature of the fertilizers themselves: chemical fertilizers are bulky products that can be damaged by exposure to water, import and distribution require large amounts of dry storage space, and the chemical compounds in fertilizer decompose and can be depleted over a period of two years under poor storage conditions. Consequently, the actual nutrient content of the fertilizer may not be consistent with its labelling, given delays in transportation, distribution and the seasonality of its use. Until recently, SODECOTON carried out all the necessary functions. Yet, SODECOTON only sells fertilizer to cotton farmers and if mandated again to distribute fertilizer, SODECOTON alone could not possibly satisfy the fertilizer demand of an expanding maize subsector.

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a loan for maize importation than for buying local maize (Conte et al, 1993).

*4.6.3 **Rural Financing***

Another major contributor to the success of maize production and extension in the North Province has been the input credit program sets up by SODECOTON. To some extent, this program contributed to relaxing the capital constraint that farmers faced. Although maize production in the North Province is not capital intensive, farmers need access to working capital, at least to purchase fertilizer. However, as this subsector expends, the demand for capital will grow beyond SODECOTON capability to provide it. Yet, although the country's rural financial sector has expanded rapidly in recent years, its performance has not been encouraging.

In the North Province, a parastatal organization with a national mandate, FONADER, was established principally to distribute credit for rural development. Unfortunately, its organizational philosophy failed to consider the socioeconomic characteristics of the environment in which it operated. For example, farmers were required to provide collateral and go through a lengthy administrative process (negotiation time) in order to be eligible for a loan. In addition, high transaction costs (costs of maintaining and collecting loans), low loan recovery problems, and the scale bias of the loan program against small farmers made it impossible for FONADER to be successful. While the informal sector has limited access to capital,it is more flexible, scale neutral, and sensitive to farmers' circumstances. The challenge for decision makers is to redesign existing credit institutions so they can better support sustained growth and development for the maize subsector in particular and agriculture in general.

4.6.4 Marketing Potential and Post-Harvest Opportunities

Although the area under intensive commercial maize production in the North Province is significant, much of the area is under low input subsistence farming. However, in the last decade, subsistence farming has been gradually transformed into a higher value commercial production system as more and more farmers look at maize as a major source of income. This attitude has been driven by not only the inherent characteristics of the technology itself (relative to cotton), the existence of strong research and extension support institutions, and occasional drops in cotton prices, but also by a stable and attractive guaranteed market provided by MAISCAM.

Because MAISCAM is still operating below capacity, there is still some additional marketing potential to be exploited. However, if maize production in the region expands greatly, MAISCAM alone will not be able to absorb the Province's total production. Thus, in the long-run, an efficient market structure will have to be developed and alternative uses for maize (including the feed industry) will have to be promoted to sustain the growth of the maize subsector over time. In addition, although this study did not include an extensive market analysis, discussions with various key informants indicated that seasonal market price variability is a major constraint to the expansion of maize production in the North Province. For example, these informants cited maize price variability as a major factor for increased importation of maize. A better understanding of the marketing aspect of the maize subsector may therefore be necessary to identify the problem and suggest possible solutions.

4.6.5 Information System and Coordinations

A major constraint to the expansion of maize production in the North Province is the lack of timely and accurate production and market information, which is needed by both the

public sector as well as the private sector. The collection of basic information on agriculture is intrusted to DEP (farm level data on crop planting, production, marketing, prices and input use) and the Direction of Statistics and National Accounts in the Ministry of Plan and Regional Development (for wholesale and food retail prices, population statistics, and imports and exports). Both institutions have historically had problems collecting and disseminating data or information on a timely basis.

With the economic crisis, their performance has worsened. In 1989, the AMP and CAP projects, sponsored by USAID, were established in an attempt to improve data collection and information provision. However, these data are still not available at the intermediate farm and village market levels, except for the West Province. The need for appropriate and timely data has become increasingly critical as the country attempts to restructure its economy to support the private sector, and to detect and adjust to emergencies. Moreover, access to these data is extremely important for the expansion of maize research in the North Province.

CHAPTER 5 SUMMARY and CONCLUSIONS

5.1 Summary

5.1.1 Institutional Setting

The agricultural sector has always been the main contributor to GDP, foreign exchange, and employment in Cameroon's economy. In 1990, it employed 75 percent of the working population, accounted for 47 percent of export earnings, and contributed 24.8 percent of the value of the country's total production (World Bank, 1990).

Facing declining output per capita, the Cameroon government invested heavily in agricultural research in order to increase productivity and thereby meet the expanding demand for food, based on population growth. Agricultural research in northern Cameroon began in the colonial period (1948) with the establishment of a research station at Guétale, which focused on export crops -- mainly cotton. Cotton production rapidly became a way of life for two generations of farmers (Sterns, 1993), as the cotton-based agricultural system, driven by a massive government intervention, literally transformed the agricultural sector in the Province. In the mid to late-1970s, IRA initiated research on food crops, but it was not until 1984 that farming systems research became a full-fledged program. Over the last two decades, the food crop research budget and related activities increased in importance as a result of donors' support to NCRE and two SAFGRAD projects (J.P. # 31 and FSR).

In contrast to the institutional setting of agricultural extension in the southern part of the country, extension activities in the north are dominated by SODECOTON, a parastatal organization created in 1974 to take over from the French cotton company, CFDT. Co-founded by the Cameroon government and France, supervised by the Ministry of Commerce, and collaborating with the Ministry of Agriculture's extension service, SODECOTON covers

both the Extreme-North and North provinces. SODECOTON's extension service, which follows a modified Training and Visit extension system approach, became involved in food crop extension in 1974-75 with rainfed rice, and, then maize a year later. The objective of these food crop extension activities was to encourage farmers to replace sorghum progressively with more productive crops, so farmers could devote more of their time and larger portions of their land to cotton production (SODECOTON, 1976-77; p.20).

*5.1.2 **Maize Production***

The main traditional food crops in the North Province are cereals (sorghum and millet) and legumes (groundnut and cowpea). The relative importance of these crops varies across the Province, with maize being grown mostly in the south-east region. Although maize was introduced in coastal Cameroon some 400 years ago by the Portuguese (Ayuk-Takem, 1991), is cultivated extensively in all ten provinces, and is an important part of the population's diet, key informants argue that it was not until the early 1970s that maize production was introduced in the North Province. But, over the last decades, the maize area in the northern part of Cameroon has expanded tremendously. During the period 1976 to 1990, seven new maize varieties were extended in the North Province, two of which were introductions from Nigeria. These varieties have performed quite well, with the yield under the ***high input production system*** in farmers' fields averaging 2.3 metric tons per hectare, ranging from 2.0 to 3.0 mt/ha.

In the North Province, maize is extended under *low input and high input production systems*. These two systems differ not only in terms of the input use, but also in terms of the level of SODECOTON monitoring. Farmers participating in the ***high input production system*** are supervised by SODECOTON field agents, and must grow crops using mechanical land

preparation (oxen and tractor), seed treatment, herbicide and fertilizer, and a specific plant density (0.80 x 0.25 m, one plant per hill). Farmers participating in the intensive system have little choice but to follow SODECOTON's guidelines. In contrast, most non-SODECOTON farmers grow crops with minimal input (*low input production system*). SODECOTON food crops efforts have been supported by the existence of a public seed company (NCSM) from 1975 to 1990 and, since 1984, MAISCAM has provided a major private market outlet.

5.1.3 Profitability and Success Factors

The base run analysis of estimated benefits and costs yielded an 11.7 percent internal rate of return, which is close to the bank interest rate, considered as the defending alternative. Over the historic period (1979-1990), research expenses accounted for 82 percent of total research and extension costs, the bulk of which was made up of salaries and benefits. In contrast, research and extension represents respectively only about three and less than one percent of total costs including production costs. Over this same period, about 66 percent of total production costs were incurred in the *low input production system*, the main cost component being weeding cost. The interpretation of this result has to be made within the context of two key assumptions upon which the IRR is based: first, that virtually all of the maize area in the Province is planted to improved varieties from research and extension and, second, that all area planted to maize is grown on newly opened fields. This last assumption turned out to be very critical in the sensitivity analysis for the value of the IRR obtained. When the maize area previously under sorghum is assumed to be 28 percent, the IRR becomes negative. This result raises some legitimate concerns about the profitability of maize research and extension in the North Province. In addition, the sensitivity analysis on the base

run data set indicated that (a) upward adjustments of research, extension and adoption expenses within a reasonable range (i.e., as much as 10 percent) have limited impact on the IRR value, while (b) both maize area and maize yield adjustments significantly impact the IRR value. The importance of the latter variable to the profitability of maize research and extension in the North Province, suggests the need to develop and promote hybrids as part of the strategy to increase productivity.

The study indicates that the following key factors have contributed to the expansion of maize in the North Province:

a) Relatively favorable climatic conditions for maize production, coupled with the need for more productive technologies to reduce food insecurity, especially during annual hunger periods.

b) The simplicity of maize production management relative to management requirements for other crops (such as cotton) and the compatibility of maize with the existing farming systems and consumption pattern.

c) The early maturity of maize, relative to other traditional cereals, which enabled farmers to harvest the crop during the hunger period and earn an early income.

d) A unique institutional set-up under SODECOTON, whose mandate extends over a wide range of complementary activities including food and cash crop extension, providing inputs to and buying production surpluses from farmers, contributing to the development of infrastructure, and promoting farmers' literacy.

e) The existence of appropriate research results that were generated through scientific exchanges and collaborative linkages (genes, technical knowhow, institutional build-up, and training) within national programs and between IRA and IARS.

f) The high quality of human capital both in research and extension, which developed effective research and extension methodologies and recommendations consistent with farmers' problems[44]. For example, SODECOTON has a corps of 1,000 relatively well-trained and closely supervised monitors (agents) for about 170,000 farmers (IBRD, 1989; World Bank, 1990).

g) Strong institutional linkages between research and extension, which took advantage of the institutions' complementarities and were effective in identifying and taking into account farmers' constraints and setting research agenda. Furthermore, these linkages provided incentives for both project researchers and extension agents.

h) The emergence in the mid-1980s of a major input supply source (SODECOTON) and a major market outlet (MAISCAM) for farmers' maize production surpluses, almost concurrently with the introduction of maize, that guaranteed access to inputs through the extension service and access to a private sector market for maize.

i) The decline in the cotton price, which gave maize a market price advantage over cotton.

5.2 ***Policy Implications***

The study revealed a positive impact of investment on maize research and extension in the North Province. Field visits and SODECOTON reports indicate a rapid expansion of maize in this Province. But, for maize production in North Cameroon to further expand and be sustainable, there is a need to find ways to develop the marketing and processing side now that the production potential has been developed.

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[44] Although the quality of human capital both in IRA and SODECOTON was not explicitly discussed in the results section, it was often cited by key informants as a major contributor to the expansion of maize research and extension in the North Province.

This study has clearly indicated that research, extension and marketing are complementary. For example, research will have limited impact unless the results obtained are adapted to the target environment and are extended to farmers, and farmers cannot increase their production unless there market opportunities for the surpluses. As a result, none of these functions can, by itself, be effective in achieving its objective; A minimal level of investment in research, extension, and marketing is therefore necessary to achieve an acceptable return on the investments made in the agricultural sector.

On the research side, in order to adjust to the new environment, IRA needs to expand its program of economic analysis, which has been limited to simple partial budgeting. For example, high priority must be given to conducting studies on the economics of production, returns to research, and resource allocation, as well as subsector analysis, if IRA is to play a more effective role in the national policy deliberation. This will require both the systematic collection of research results and related data and the presentation of these data in an appropriate format.

The demonstrated importance of maize yield on the IRR, as well as evidence from various other countries, suggest the need to reevaluate the role of hybrid corn in Cameroon maize future. The conventional wisdom that hybrids must be promoted as part of a rigid package and as a separate and distinct crop with special requirements needs to be reevaluated with the objective of coming up with the best strategy for the farmers. While the agronomic risk seems to be small, the timeliness in the availability of cash, quality seeds and fertilizer, and the timely anticipation of institutional problems related to seed production will be critical for successful adoption of hybrid varieties in Cameroon. The end of direct government involvement in seed production and the emergence of a private sector requires that issues such as intellectual property rights on germplasm (public good by nature) and the associated ethical

problems, as well as potential monopoly profit be regulated to insure that farmers are not exploited. Historically, the role of the public sector in research and development and in extension has been essential and will remain important in the future.

Success stories in hybrid development and adoption in developing countries have depended on strong public sector research and extension. Byerlee et al (1993) notes that in Africa, research and extension on hybrid maize has been stagnating. Most of the varieties are about 40 years old, while in countries like Brazil the turnover rate is about 3 to 4 years. Therefore, active support of public sector research and extension is needed, in addition to incentive provision, training, seed release policy, and for developing and organizing markets. It is interesting to note that, in most of the developing countries that have promoted the adoption of hybrids, all maize breeders are from the public sector, and the seed industry has often been monopolized by multinationals who did not develop the market, but took advantage of an existing market (Byerlee et al, 1993).

A key factor contributing to higher maize yield is fertilizer application. Given the performance of previous public agencies on the importation and distribution of fertilizer, as well as the amount of fertilizer that would be needed to support a major increase in maize production, greater private sector involvement and a reduction of public investment are imperative. This calls for a rationalization of the public investment portfolio to create an attractive environment for the private sector. Already, the reform of fertilizer subsector is underway in an effort to liberalize the economy and expand the private sector. The success of this reform depends on sound microeconomic incentives and reduced administrative control. For example, potential incentives could include policies that would make it possible for entrepreneurs to take advantage of the significant economies of scale in shipping. This would ultimately contribute to reducing fertilizer costs to farmers. Fortunately for the

country, the main port of entrance (Douala) has an excess capacity that could accommodate larger amounts of imports (Oakerson and Truong, 1990), but the reliability of suppliers and transporters, and the availability of dry storage facilities remain a major concern.

Finally, a major constraint to maize expansion in the North Province is the inadequacy of the region's financial support systems. This has been the missing piece in the agricultural development institutional setting's puzzle which SODECOTON was able to partially fill. Yet, SODECOTON's ability to provide financial support to farmers is far too limited to meet public expectations that maize expansion should be a vehicle for poverty alleviation. Thus, there is a need to create new financial support systems which better fit farmers' conditions and development expectations. For example, consideration should be given to developing or strengthening financial intermediaries, as informal financial lenders provide some financial services more efficiently than the formal credit service. In any event, the government needs to realize that the performance of a financial market depends on the economic vitality of the clients it serves. If these clients are poor or financially unstable, their ability to use the financial market is diminished and they will be less willing to borrow and less able to repay the loans. A major implication of this is that maize expansion should be viewed in the more global context of rural poverty alleviation and economic development. This perspective is needed in order to develop rural micro enterprises and production and consumption linkages necessary for an expansion beyond the subsistence level.

5.3 Limitations

The quality of this research is constrained by numerous factors, the most important of which is the availability and quality of data. In Cameroon, inadequate attention has been given to data requirements for this type of analysis. As a result, this constraint required

numerous assumptions, some of which are almost arbitrary, and which turned out to be the basis for most of the difficulties encountered including:

a. inability to compute economic values for the benefits and costs items identified, whenever necessary;

b. inability to estimate research and extension externalities generated by maize production. For example, this is the case for maize research and extension's contribution to household food security and institution building;

c. Maize yield by production system and proportion of maize area previously cropped to sorghum;

d. Inability to account for changes in production that would have occurred without the project;

e. inability to be more specific in predicting future policy, institutional and financial environments under which crop research, extension and adoption will be performed;

f. inability to estimate more realistic supply and demand parameters which made it impossible to do distributional analysis;

g. minimal treatment of risk and uncertainty. This was done using conservative values, best estimates available, and sensitivity analysis. Unfortunately, sensitivity analysis does not constitute a comprehensive analysis of risk. A combination of sources of uncertainty would have been more realistic, but yet difficult to interpret. However, sensitivity analysis is simple and requires less data than more sophisticated methods of risk analysis.

Though attempts made to minimize these weaknesses were not entirely successful, the assumptions that are made are reasonable and, as shown by the sensitivity analysis many of these weaknesses are likely to have little significant impact on the IRR estimate.

5.4 Future Research Needs

Despite the limitations imposed by data availability, reasonable ROR studies can still be done. The methodology that would have to be used may be different from one study to another as specific assumptions are made to accommodate the data available. The importance of an ROR studies for any research institute in general and for IRA in particular stems from the fact that it provides a quantified and documented basis for allocating the constrained research budget. In addition, the inclusion of an institutional analysis highlights the strengths and weaknesses (constraints) in the research and development process. Success stories would be powerful leverages upon which the administration can rely in stressing the importance of research for the national economy and in the negotiation for public support to research.

Yet, as much as ROR studies need to be encouraged, additional effort is required to improve data collection and record keeping in a cost efficient way. The basic data needed for ROR includes yields, area in production, adoption rate, input consumption, input and output prices with information on taxes or subsidy level, salaries and benefits for research staff as well as their time allocation to various crops they work on. Institutional analysis should extend to input and output market studies and to the exploration of forward and backward linkages and coordination processes between various interrelated stages of a particular subsector. Such studies will not only increase the effectiveness of research but also will constitute a major contribution to the national policy deliberation process.

APPENDICES

Table A.1: Macroeconomic Indicators for Cameroon, 1980 to 1989.

Macroeconomic Indicators	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
GDP,market prices[a],FCFA bn	1,410	1,796	2,173	2,618	3,195	3,992	4,166	4,022	3,768	3,560[b]
Real GDP growth[a], %	12.60	13.30	6.10	6.90	7.60	7.40	9.20	-2.80	-8.60	-6.00[b]
Consumer Price Inflation[b]	7.70	9.90	13.10	16.70	11.30	11.50	12.40	11.20	5.00	4.00[b]
Exports FOB[a], US$ bn	1.40	1.53	1.46	1.72	1.99	2.34	2.00	1.71	1.64	1.70[b]
Imports CIF[a], US$ bn	1.44	1.40	1.16	1.22	1.11	1.09	1.48	1.73	1.48	1.25[b]
Current account[a], US$ mn	-250.20	-447.50	-351.90	-372.00	-382.00	337.00	-601.00	-1,171.00	-880.00	-320.00[b]
External debt service ratio%	na	na	na	na	na	22.70	25.90	30.60	30.90	19.40
Crude oil prod., mn tons	na	na	na	5.75	7.00	9.16	8.86	8.35	8.30	8.00[b]
Coffee prod.[c], mn tons	na	na	na	64.00	114.50	101.00	133.70	116.00	153.00	na
Cocoa prod.[c], mn tons	na	na	na	108.90	120.50	119.00	127.00	130.00	123.00	115.00[b]
Cotton prod.[d], mn tons	80.30	84.50	79.80	72.40	94.60	97.40	115.50	122.80	113.70	165.00
Exchange rate(ave) FCFA/US$	211.30	271.70	328.60	381.10	437.00	449.30	346.30	300.50	297.80	319.00

[a] Years ending June 30. [b] Estimates. [c] Crop years begin October 1. [d] Crop years begin April 1.
"na" indicates that data not available; "bn" and "mn" indicate billion and million, respectively.
Source: Sterns (1993) citing Economic Intelligence Unit, World Bank, IMF, & SODECOTON documents.

Table A.2: Varieties Developed and Released by NCRE Project, Cameroon, 1981-90.

Variety	Year Released	Ecology	Description (Cycle, Color, Type[a])
Lowland Maize			
CMS 8501	1985	North, South East	Medium, White, OP
CMS 85-3	1985	Center & North	Medium, White, OP
CMS 8602	1986	North	Early, Yellow, OP
CMS 8704	1987	Center & North	Medium, Yellow, OP
DMR-ESR-Y	1988	Center	Early, Yellow, OP
CMS 8710		North	Late, White, OP
Ndock 8701		Center	Late, White, OP
Highland Maize			
Shaba	1986	Adamaoua	Late, White, OP
Kasai	1985	West & North West	Short, White, OP
Coca SR	md	West & North West	Late, White, OP
Bacoa SR	md	West & North West	Early, Yellow, OP
Rice			
IR 71 67	1986	Ndop Plain	Irrigated
Cica 8	1984	Mbo Plain	Irrigated
BKN 3033	1987	Agrilagdo	Irrigated
ITA 222	md	Agrilagdo	Irrigated
Sorghum			
S35	1985	Extreme North	Early, White
CS54	1988	Extreme North	Early, White
CS95	1988	North	Medium, White
CS61	1988	North	Medium, White
S34	1986	North	Medium, White

[a]"OP" stands for "Open pollinated".
"md" stands for missing data.
Source: Adapted from NCRE Annual Reports, 1992-90.

Table A.3: National NCRE Scientists Trained/in Training[a] from 1982 to 1994, IRA-Cameroon.

Disciplines	Degree			
	MSc		PhD	
	Trained	On Training	Trained	In Training
Agronomy	0	4	0	1
Soil Science	1	0	1	0
Rice Agronomy	1	1	0	0
Rice Breeding	1	0	0	0
Maize Breeding	3	0	1	1
Maize Pathology	1	0	0	0
Cereal Pathology	0	0	1	0
Extension Agronomy	2	1	2	1
Education/Extension	0	0	0	1
Agricultural Economics	1	2	1	1
Sorghum/Millet Breeding	3	1	0	1
Grain Storage Entomology	1	0	0	0

[a] Only the highest diploma acquired is included.
Source: Adapted from various NCRE Documents.

Table A.4: Summary of Published ROR to Agricultural Research Studies for Africa up to 1992.

Author(s)	Year	Country	Crop	Period studied	Rate of Return (%)
Abidogun	1982	Nigeria	Cocoa	-	42
Evenson	1987	Africa	Maize & Staple Crops	1962-1980	30-40
Norgaard	1988	Africa	Cassava	1977-2003	149:1[a]
Schwartz et al	1989	Senegal	Cowpea	1981-2015	63
Karanja	1990	Kenya	Maize	1955-1988	40-60
Mazzucato	1991	Kenya	Maize		58-60
Mazzucato & Ly	1992	Niger	Cowpea & Millet/Sorghum	1975-1991 1975-2006	<0 2-21
Boughton & Henry de Frahan	1992	Mali	Maize	1969-1991 1962-1991	135 54
Schwartz, Sterns & Oehmke	1992	Senegal	Cowpeas	1981-1986	31-92
Sterns & Bernsten	1992	Cameroon	Cowpea	1979-1992 1979-1998	3 15
			Sorghum	1979-1998	1
Harward et al	1993	Zambia	Maize	1978-1991 1978-1991 1978-2001	<0 90-103 96-106
Laker-Ojok	1993	Uganda	Sunflower	1985-1996 1985-2006	31 38
			Maize	1985-1996 1985-2006	<0 33
			Soybean	1985-1996 1985-2006	<0 6
Makau		Kenya	Wheat	1928-1982	30-40
Mcmillan et al		Zimbabwe	Maize		
Ahmed & Sanders		Sudan	Sorghum	1983-2005	22-39

[a] Benefit/Cost ratio of the casaava mealybug control at IITA.

Source: Adapted from Crawford (1993), Oehmke et al (1992), and Salinger and Stryker (1991).

Table A.5: Total NCRE Expenses (Nominal $US), Cameroon, 1981-1990.

COST ITEMS	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Office Supplies	4,941	24,554	32,898	24,516	32,894	74,628	337,832	55,090	32,378	115,110
Office Equipment	15,238	1,222	7,214	1,251	754	12,774	67	1	680	39,532
Vehicle Purchased by IITA	0	29,470	0	34,813	0	0	0	0	0	0
Spare Parst Purch. by IITA	0	15,874	10,611	16,689	0	0	0	0	0	0
Equipment Purchased by IITA	51,127	94,015	19,257	31,611	20,745	22,684	(3,418)	0	3,869	36,348
General Services/Supplies	37,974	6,307	20,364	17,113	19,142	16,187	32,995	42,881	191,274	56,735
1. Total Equipment and Supplies	109,280	171,442	90,344	125,993	73,535	126,273	367,476	97,972	228,201	247,725
Salaries for Expatriates	182,203	593,803	469,853	542,277	625,991	847,303	1,033,183	1,185,896	1,326,527	1,684,353
Rental Housing/Maintenance	38,037	78,278	65,764	73,700	62,937	141,147	185,211	139,676	161,155	213,350
In-country Travel	10,570	38,641	121,003	65,356	69,785	77,909	92,441	49,611	45,646	59,234
International Travel	21,392	28,846	41,813	48,572	21,218	26,088	43,784	16,896	61,368	128,186
2. Total Salaries & Benefits Expatriates	252,202	739,568	698,433	729,905	779,931	1,092,447	1,354,619	1,392,079	1,594,696	2,085,123
Local Staff Costs	0	11,375	31,877	31,005	18,128	44,199	94,069	102,280	112,530	257,619
In-country Travel	0	2,049	7,254	8,654	7,213	9,759	16,497	1	21,321	35,161
3. Total Salaries & Benefits Nationals	0	13,424	39,131	39,659	25,341	53,958	110,566	102,281	133,851	292,780
Gazoline	11,360	25,158	40,097	29,295	23,361	32,694	48,883	47,267	31,948	(4,997)
Vehicle Maintainance	596	7,109	29,835	45,677	30,265	40,482	67,735	67,048	88,788	209,102
Casual Labor	3,957	0	12,015	18,066	5,937	11,087	30,414	39,035	31,618	100,005
Research Supplies	3,315	9,771	27,815	28,187	65,111	28,282	97,091	79,602	108,914	184,304
4. Total Direct Research Expenses	19,228	42,038	109,762	121,225	124,674	112,545	244,123	232,952	261,268	488,414
In-service Training IITA	7,796	9,530	13,790	10,575	15,937	18,004	13,309	386	3,796	28,628
In-service Training Other	908	0	0	10,919	0	20	4,969	0	3,318	(2,552)
Conferences and Workshops	2,878	6,311	14,711	5,828	653	0	0	0	0	0
Short-term Advisors	4,036	8,316	11,131	8,572	1,754	10,347	24,150	34,685	16,342	21,205
Central Service Costs	70,264	115,911	121,944	129,050	126,120	143,241	249,605	289,595	194,923	425,107
Unallocated Costs	0	0	0	0	0	0	0	0	0	128,083
5. Admin., Conf. & S.T. Training	85,882	140,068	161,576	164,944	144,464	171,612	292,033	324,666	218,379	600,471

Source: NCRE Administration.

Table A.6: NCRE Work Plans' Budget Allocation (in Nominal value), Cameroon, 1987-1990.

Year	Breeding Unit (F.cfa)	Agronomy Unit (F.cfa)	NCRE Project ($US)	Official Exchange Rate (F.cfa/$US)	Ratio Breeding Unit (%)[a]	Ratio Agronomy Unit (%)[b]
1987	7,650,000	8,870,000	2,078,157	300.5	0.0123	0.0142
1988	7,400,000	6,900,000	2,442,582	297.8	0.0102	0.0095
1989	9,500,000	11,300,000	2,434,819	319.0	0.0122	0.0145
1990	14,000,000	7,300,000	4,490,334	272.3	0.0114	0.0060
Average					0.0115	0.0111

[a] Computed as: breeding research unit cost/(NCRE cost * official exchange rate).
[b] Computed as: agronomy research unit cost/(NCRE cost * official exchange rate).
Source: NCRE Work Plans 1987-1990 and

Table A.7: Maize Area (hectares) in the NCRE Lowland Breeding Unit's Mandated Zone, Cameroon, 1984-1987.

Year	South Province	Center Province	Adamaoua Province	North Province	Ratio (%)[a]
1984	8,204	12,391	25,174	10,700	0.1895
1985	8,480	13,037	18,988	24,044	0.3725
1986	6,873	21,275	15,815	15,849	0.2650
1987	6,760	20,013	19,608	12,554	0.2130
1988	6,535	15,731	20,310	17,585	0.2923
1989	5,803	11,951	22,326	23,553	0.3701
Average					0.2837

[a] Computed as: North Province area divided by the sum of the area in all three provinces.
Source: National Agricultural Census.

Table A.8: SAFGRAD JP #31 Total Expenditures (in Nominal $US), North Province, Cameroon, 1979-1988[a].

COST ITEM	1979 to 1983[b]	4/4/1984 to 6/30/1986[c]	7/1/1986 to 8/15/1988[d]	7/1/1988 to 8/15/1988[e]
Travel and Per Diem	27,433			
Shipping and Storage	6,444			
Housing	61,308			
Other Direct Costs	2,770			
Equipment, Supplies and Materials	69,518			
Subtotal Non-Salary Expenses		121,881	229,280	
Salaries and Benefits	170,593	222,835		4,099
Office Supplies				3,771
Research Equipment				8,460
Research Supplies				9,137
Vehicle Maintenance/Repairs				3,987
Fuel				14,073
Vehicle Insurance				1,444
Temporary Labor				27,686
Temporary Driver/Secretary				6,873
Training by TLU				1,918

[a]Any blank in the table simply means the data was not provided under that particular form by the source.
[b]"Other Direct Costs" includes health insurance, passport, visas, professional journals, communications, vaccines, bank charges.
[c]"Equipment, Supplies and Materials" includes office supplies, equipment repairs, laboratory equipments, field trials, supplies, labor, secretary, translation, training workshops.
[d]Paid for by SAFGRAD JP #31.
[e]Paid for by NCRE Project.
Source: SAFGRAD J.P. #31 (1984) for 1979 to 1983, and phone interview with Jerry Johnson for 1984-1988.

Table A.9: SAFGRAD/FSR Expenses (Nominal F.cfa), North Province, Cameroon, 1986-1988.

COST ITEMS	1986	1987	1988
Office Maintenance	0	0	31,471
Typing Table	0	422,910	0
Photocopy Machine	0	1,875,193	0
Office supplies	1,426,565	0	0
Office Stationaries	2,813,462	877,817	294,682
Calculator	10,000	6,000	0
Vehicle	8,614,000	6,320,276	0
Motocycle	0	3,160,000	0
1. Total Equipment and Supplies	12,864,027	12,662,196	326,153
Rent and Furniture	8,536,483	4,800,000	9,094,589
Local Transport	1,422,750	3,268,918	1,602,300
2. Total Salaries and Benefits Expatriates	9,959,233	8,068,918	10,696,889
Local Personel Salaries	4,511,724	19,207,876	17,585,344
Overtime	0	10,000	0
Per Diem	702,700	896,910	229,000
Transport	832,785	1,605,275	245,920
Medical Care	0	4,000	0
3. Total Salaries and Benefits Nationals	6,047,209	21,724,061	18,060,264
Experimental Materials	1,215,995	202,965	0
Laboratory Chemicals	191,232	160,600	114,167
Sample Analysis	11,400	0	0
Meetings & Field Days	117,240	49,904	0
Vehicle Maintenance	2,167,697	1,607,125	762,201
Fuel	704,045	1,143,620	1,674,235
Sign Printing	0	62,200	0
4. Total Direct Research Expenses	4,407,609	3,226,414	2,550,603
Insurance, Licence	733,322	3,716,822	992,475
Water, Gaz, & Electricity	108,787	190,345	0
Mail, Cables, Telex	439,569	742,939	521,191
Bank Charges	18,743	60,499	50,657
Documentation	51,558	72,705	0
Miscellaneous	154,258	399,740	413,640
5. Admin., Conf. & Short-Term Training	1,506,237	5,183,050	1,977,963

Source: IRA Maroua

Table A.10: SODECOTON Personel Costs (in Nominal F.cfa), Cameroon, 1979-1990.

Year	Senior Staff	Others
1979	133,691,888	212,351,618
1980	274,664,066	265,318,256
1981	351,161,203	342,440,879
1982	392,209,511	416,619,197
1983	137,892,322	563,019,678
1984	249,427,626	562,475,392
1985	255,245,710	885,918,576
1986	210,392,283	657,819,779
1987	139,089,000	646,606,000
1988	112,271,120	557,322,988
1989	103,504,697	532,705,465
1990	98,316,000	494,999,000

Source: SODECOTON

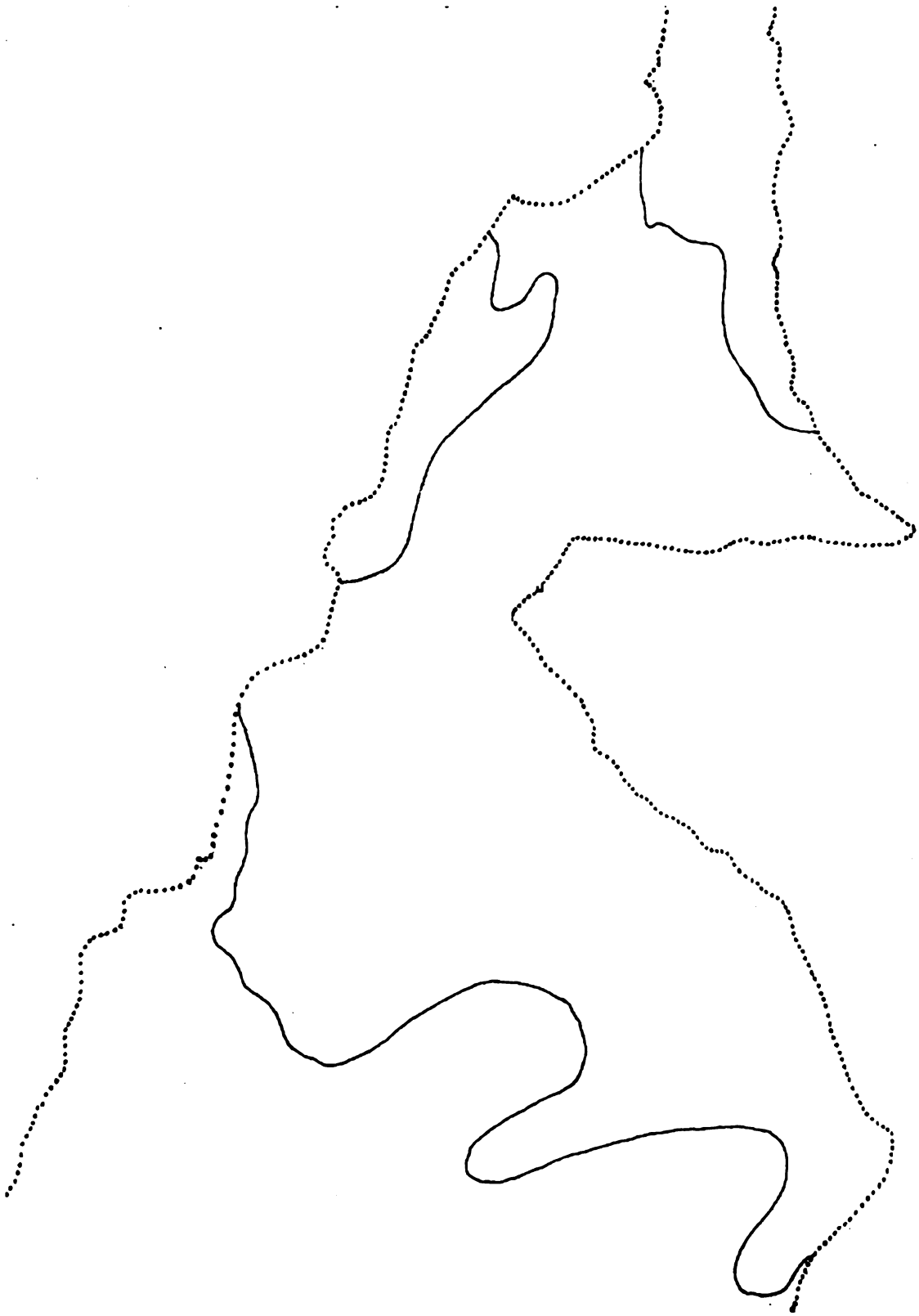

Figure A.2: SODECOTON Geographical Coverage

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