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# **Market Assessment of Photovoltaic Power Systems for Agricultural Applications in Nigeria**

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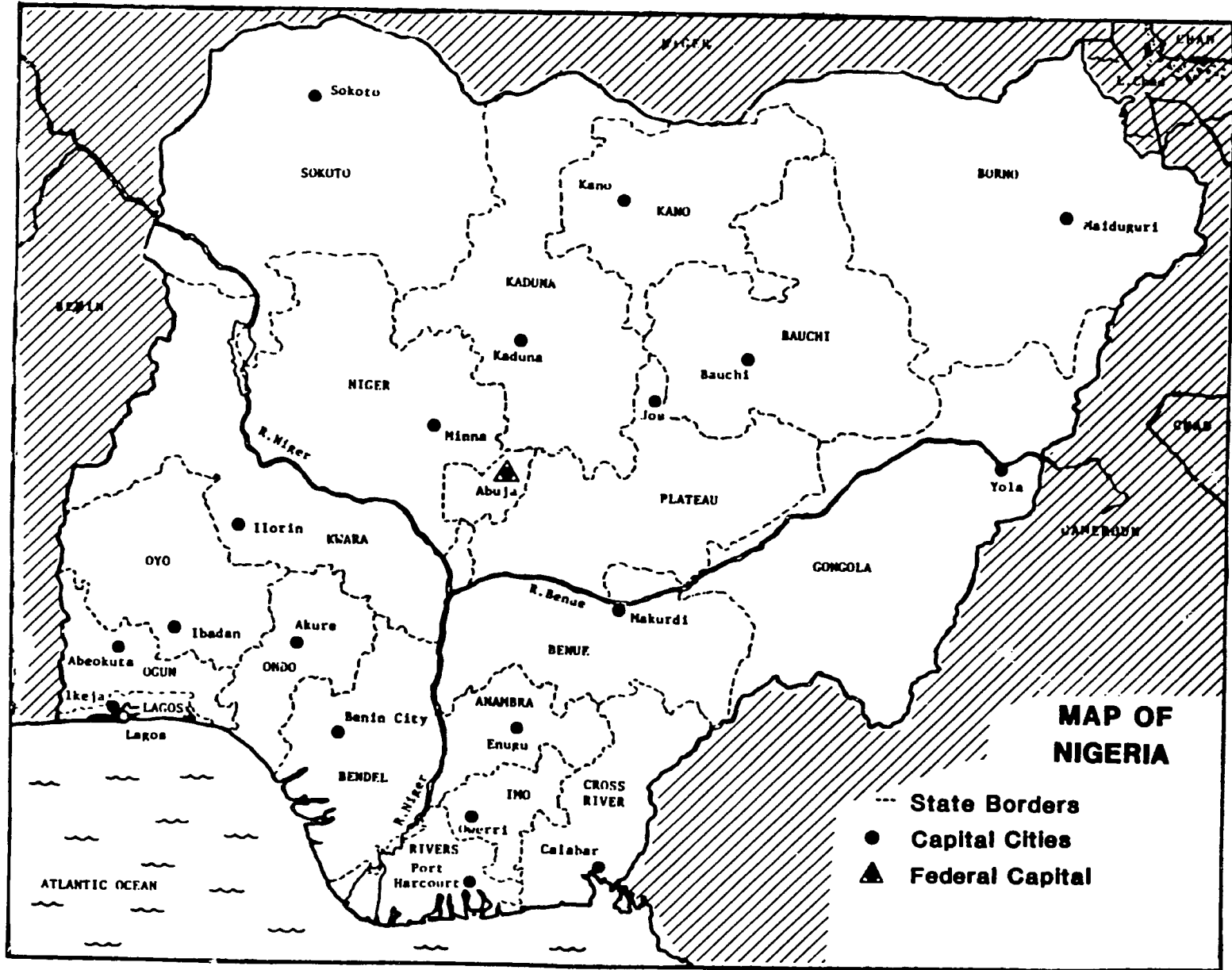
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MARKET ASSESSMENT OF PHOTOVOLTAIC POWER SYSTEMS FOR  
AGRICULTURAL APPLICATIONS IN NIGERIA

Executive Summary

Objectives

The Photovoltaic Stand-Alone Applications Project Office of NASA/Lewis Research Center, Cleveland, Ohio, is conducting an assessment of the market for remote photovoltaic (PV) power systems in worldwide agriculture for the U.S. Department of Energy. The study is to identify PV applications and countries with a high sales potential so that industry may develop appropriate market strategies. The applications considered are those requiring less than 15KW of power and operating in a stand-alone configuration without back-up power. In such applications, cost-competitiveness is based on a comparison with conventional gasoline and diesel power sources. This specific study assessed the market for PV in the Nigerian agricultural sector and in rural services.

The objective of the study was to determine for a number of applications the first year of cost-competitiveness, to estimate the market potential thereafter, and to discuss the environment in which PV systems would be marketed and employed. Emphasis is placed on stand-alone applications that are competitive prior to 1986.

The following market elements specific to Nigeria are addressed in the report:

- Level of interest, awareness and experience with PV power systems.
- Estimates of potential market size for PV power applications in the agriculture sector.
- Operating and cost characteristics of gasoline and diesel power systems that will compete with PV.
- National energy, agriculture and development goals, programs and policies which will influence PV sales.
- Appropriate financing mechanisms and capital available for PV system purchases.
- Investment climate for U.S. companies and appropriate methods for conducting business in the country.

Study Approach

The market study for PV in worldwide agriculture was conducted by DHR, Incorporated, with Associates in Rural Development, Inc., as subcontractor. This report on Nigeria is the fourth in the case study series on PV applications in agriculture. The scope of these studies include livestock, forestry, fisheries, crop production, and rural services.

Representatives from DHR, Incorporated, Associates in Rural Development, Inc., and NASA/Lewis Research Center conducted a month-long study in Nigeria during February 1981. The major activities of the team were a series of meetings with Nigerian energy, agriculture, economic, financial, business and policy experts to obtain current development and policy data and an evaluation of factors important to introducing PV power systems into the agriculture sector. Over 50 people were interviewed and appropriate sources of printed information were utilized. Site visits were made to obtain power requirements and energy use profile data for several agricultural applications. In addition to data collection, the team members gave presentations on PV systems, and distributed sets of brochures consisting of advertising material obtained from U.S. PV companies and from U.S. government sources.

The information gathered served as a data base to characterize the environment in which PV systems would be marketed and used. Data on applications was used to identify cost-competitive end-uses. The potential market size estimate was based on development plans, availability of finance, business environment, cost comparisons and other factors. The market potential for the following five years was estimated.

#### Nigeria Overview and Development Plans

Nigeria has a population greater than 80 million which makes it the most populous country in Africa, as well as the most economically and politically important Black African nation. Nigeria's financial resources are derived mainly from petroleum exports with oil revenues exceeding \$16 billion last year. Agriculture is the second largest element of the Nigerian economy (18% of GDP). Given the Nigerian petroleum revenues, the U.S. balance of trade-deficit (\$9.6 billion in 1980) and the desire by both the private and public sector in Nigeria for more U.S. technology and trade, the atmosphere for development and investment opportunities clearly exists.

The major thrust of the Nigerian government's 5-year development plan (1981-85) is the agricultural/rural sector. Formerly a net food producer, now a net importer, Nigeria has embarked on a "Green Revolution Plan" to dramatically increase agricultural productivity, to provide amenities to improve the quality of life in rural areas, and in general to support small land holders through numerous programs focused on integrated rural development. Present plans of the Federal Government commit \$14 billion to the agricultural sector between 1981 and 1985. Additional funding is available from Nigerian commercial and merchants banks, which must annually commit 8 and 5 percent, respectively, of their loan portfolios to agricultural investments at preferred interest rates. Limited World Bank funds are also available. Table 1 summarizes the anticipated funding levels to the agricultural sector.

In general, emphasis will be placed upon further development of Nigerian infrastructure, through provision of water supply systems, rural electrification, roads, etc. Nigeria has formulated ambitious development plans which are highly dependent upon expected oil revenues. The present reduction in world oil demand may dampen development expectations due to reduced oil revenues. Development efforts, and hence business opportunities are directly related to oil revenues.



Table 1  
Agriculture Development Funding Levels  
1981-1985

<u>Program</u>	<u>(\$ Million)</u>
Crop Production*	5,400
Food crop	117
Tree crop	446
Agriculture inputs	1,749
Agriculture crops	117
Rural development	1,044
Agricultural Mechanization*	
Tractor purchases	142
Agro-service centers	189
Implement development	45
Crop Storage*	180
Institutional Agriculture Development	1,348
Water Resources Program*	1,663
Boreholes*	187
Livestock Development	432
Fishery Production	156

\*Indicates that additional state funds will be made available.

SOURCE: Outline of the Fourth National Development Plan, Federal Ministry of Planning, Lagos, Nigeria, 1980.

Although Nigeria is a major oil producer, energy in the rural areas is often scarce and 2 to 3 times more expensive than the government posted prices of \$1.15/gallon for gasoline and \$0.90/gallon for diesel. Plans are underway to increase oil supply into rural areas, but it is expected that shortages and high prices will continue for many years. Electricity is available in major urban centers from the National Electric Power Authority, although service is often unreliable.

Rural electrification is occurring slowly with only 60% of the country expected to be grid-connected by the year 2000. Rural areas are served by diesel and gasoline generators, which have severe maintenance and reliability problems in addition to frequent unavailability of fuel and spare parts.

### Potential PV Agricultural Applications

In Nigeria, a number of agricultural/rural development applications that could use PV power systems were identified. The factors used in the search were:

- Relevance to Green Revolution Plan and other national development plans.
- Level of production and importance of the product or service supplied.
- Type of operation and its adaptability to a PV power sources.
- Extent of use and mechanization of the operation.
- Size of conventional power unit required for a typical operation.

The feasibility analysis of individual applications included life-cycle cost comparisons. PV systems costs were based on the PV cost projections of the Jet Propulsion Laboratory's "1980 Photovoltaic Systems Development Program Summary Documents," which were the most complete and up-to-date projections of stand-alone PV costs available. Actual conventional (gas or diesel) system data for Nigeria in 1981 were the basis for conventional system costs in the life-cycle comparisons. The parameters used in the economic analysis of PV and conventional power systems in Nigeria are listed below in Table 2.

The applications identified cover a wide range of power requirements (100 w to 10 kw) with diverse load profiles and varying operating environments. The applications cover micro-irrigation and village water supply, crop milling, grinding and storage, veterinary and health centers, agriculture extension services, and small ice plants. It is very likely that most other agricultural related applications will fall within the operating and cost characteristics of the selected applications.

Table 3 indicates the estimated power rating and the probable demand for several applications judged to have high potential for utilization of PV power systems.

Table 2

Cost Analysis Assumptions

	<u>Current Business</u>
Discount Rate	12%
Life of Diesel/gasoline sets	5,000 hrs.
Fuel cost (diesel/gasoline)	\$0.90, 1.15/gal.
Fuel Escalation rate	3%
PV system lifetime	20 yrs.
Labor cost	
PV	\$2.00/hr.
Conventional	\$4.00/hr.

1. <u>Diesel Engine</u>	<u>1KW</u>	<u>2KW</u>	<u>3KW</u>	<u>4KW</u>	<u>5KW</u>	<u>8KW</u>
Cost (\$1980)	2,200	3,600	4,840	5,670	6,840	8,500
Fuel Consumption gal/hr. at full load	0.26	0.33	0.37	0.43	0.52	0.64
2. PV System Costs * \$/Wp (in \$1980) inclusive of batteries	<u>1980</u> 20.85	<u>1982</u> 11.73	<u>1984</u> 9.14	<u>1986</u> 6.55	<u>1988</u> 5.28	<u>1990</u> 4.40
3. Average daily insolation = 390 langleys.						
4. O&M for PV systems = 0.02 hours/KWp/Operating day						
5. O&M for diesel systems = 0.15 hours/hour of operation.						

\*Source: JPL, 1980 Photovoltaic Program Summary Document

Table 3

Agriculture/Rural Development Applications

<u>Application</u>	<u>Estimated Levelized Power Rating (KW)</u>	<u>Expected Number Required 1982-1986</u>
Micro-Irrigation	1.0 - 1.2	5,000
Veterinary Units	.8 - 1.0	200
Grinding	1.5	3,000 - 4,000
Dryer Fans	1.0 - 1.5	500
Produce Coolers	1.5	2,000 - 4,000
Ice Makers	5.0	200
Water/Boreholes	1.5 - 3.0	5,000 - 10,000
Health Centers <sup>1</sup>	1.0	100 - 200
Education Centers <sup>2</sup>	1.0 - 1.5	500 - 1,000
Agricultural Extension Centers <sup>2</sup>	0.1	400 - 500

<sup>1</sup>Power for refrigerations, lights, sterilizers, radio

<sup>2</sup>Power for education TV, lights, communication equipment.

## Other PV Markets

Although the present NASA/DOE market study in Nigeria concentrated on potential market applications in the agriculture and rural development sectors, it was apparent that an effective demand for PV systems already exists in other application areas or is likely to develop in the medium term.

Examples of these applications include:

- Electricity for remotely located local government centers and other public buildings;
- Communications systems power supplies in both public and private sectors;
- Rural TV receivers, battery chargers, and packaged domestic power systems;
- Cathodic protection systems.

Despite the limited experience with PV systems in Nigeria, a substantial market potential exists because of the promise of greater reliability and convenience of PV in comparison with systems now in use. In order to be accepted, PV systems must demonstrate this advantage effectively. Because of the lack of trained engineers, system assemblers and technicians, it will be necessary for PV companies to provide complete systems (as opposed to providing just the modules and conditioning equipment, for example) as well as service guarantees.

## Potential for PV Use

The potential for utilization of PV systems in the Nigerian agriculture sector is high based upon the results of a cost analysis performed on the agricultural applications. The market size estimates are based upon this cost-analysis which predicts the year in which PV systems are expected to be competitive with conventional power systems. The cost comparison shows that in the majority of agriculture applications analyzed, PV systems become competitive (on a life cycle cost-basis) in the 1982-1983 timeframe. The two major factors influencing PV competitiveness are the poor lifetime for diesels (2-4 years in Nigeria) and the lowered cost of PV cells in future years.

The market estimates for PV were calculated using two scenarios: a "current business" base case and an "increased promotional activity" case. These two cases were used to allow variations in how the institutional factors will effect development of the PV market. The base case assumes a continuation of current business practices with no increased PV market development activity. The increased activity case assumes aggressive marketing by PV companies, an early successful PV demonstration, a healthy Nigerian economy, and a general increase in PV related activity.

Market estimates were derived for the two cases by factoring in institutional and non-cost factors. Table 4 is an estimate of the future PV market, based on life-cycle cost comparisons and other factors.

Table 4

Estimates of PV Market in Nigerian Agriculture Sector (KWp)

<u>Year</u>	<u>Current Business Base Case</u>		<u>Increased PV Promotional Activity Case</u>	
	<u>Annual</u>	<u>Cumulative</u>	<u>Annual</u>	<u>Cumulative</u>
1981	15	15	50	50
1982	70	85	150	200
1983	350	435	400	550
1984	480	925	700	1250
1985	750	1675	1300	2550
1986	1250	1925	2100	4650

## Current Level of Awareness and Entrepreneurial Interest in PV Systems

The level of knowledge about PV systems is in general very low throughout Nigeria. The most knowledgeable individuals interviewed were university and agricultural ministry personnel. The Ministry of Science and Technology appears to have the highest degree of understanding of PV systems within Nigeria. Limited awareness of PV systems is part of an overall low level of awareness about energy systems in general. Thus, a major problem in developing a PV market in Nigeria will be the development of an understanding of the potential of PV and PV system applications.

Almost all groups interviewed indicated that a key to development of the PV market in Nigeria will be installation of operational-size demonstrations with high visibility. If these demonstrations are successful, the purchase of PV systems would probably follow. Capital cost, although a factor, did not appear to be the major determinant if the demonstrations proved successful. Reliability and low maintenance factors were perhaps the most critical issues. Some form of cost-sharing will most likely be the quickest route to demonstration of PV capabilities.

Little current entrepreneurial interest in photovoltaics in Nigeria was found. However, in the instances where businessmen came to understand PV systems and their potential, a large degree of interest was generated. This level of interest in PV will be directly related to the technical feasibility of PV systems operating in Nigeria and the potential for profit. In general, Nigerian businessmen are interested in entering into partnerships with American businessmen.

To date, PV activities have been limited to preliminary operations by two U.S. PV firms with Nigerian partners and a French PV manufacturer. Given that no major PV system sales have occurred, the low level of entrepreneurial interest is understandable. However, based on numerous discussions, it is believed that once the general level of understanding is raised, greater entrepreneurial interest will arise.

## Capital Availability Issues

Interviews with representatives of a number of private and government financial institutions were held to assess the attitudes of the financial community toward photovoltaic systems. There was a general willingness of high officials to consider photovoltaic systems for loans. At the loan analyst level, however, there was a sense of skepticism as to how photovoltaics would pass the loan criteria analysis. There is almost no use of life cycle cost analysis techniques so that the following factors are impediments:

- High initial capital cost of PV systems;
- Lack of information and operating experience for photovoltaics systems; and
- Lack of credibility that photovoltaics will have a sales and service infrastructure in Nigeria.

Capital for early PV system purchase is expected to be available from three sources; 1) the federal government; 2) the state government; and 3) private sources. Of these three, federal funds will be available first, followed closely by private funds (currently available if packaged systems were available) and lastly state funds. Private sources of capital are the most difficult to estimate. However, they are assumed to be large, judging by the high demand for luxury consumer items in Nigeria. Capital available to states is in part a function of the national development plan. Total capital expenditure budgets for the 19 states over the next five years is approximately \$50.4 billion. Approximately \$10 billion of this will go for water and rural development projects. Federal funding would be available for PV systems if PV systems are demonstrated, have high reliability, and meet some measure of cost-competitiveness.

#### Summary of Barriers and Incentives to PV Sales

Nigeria presents a mixture of incentives and disincentives to PV use. Whereas the federal government has no explicit policies on alternative energy, there are a variety of government policies, business and financial practices, which affect PV system utilization. The factors which act as incentives to the use of PV systems in agriculture include:

- 1) The availability of capital in the form of low-cost credit for agriculture, e.g., \$14 billion during 1981-1985 for the Green Revolution Plan. Investment capital for agricultural sector projects will be primarily available from the Nigerian Agriculture and Cooperative Bank and the private merchants bank. Initial PV project funding will most likely be by the federal government.
- 2) Commitment of federal government to assisting small-scale agriculture and rural development, through supply of input factors including energy and the provision of basic amenities in the rural sector (i.e., potable water, agriculture produce grinding and storage).
- 3) The limited rural utility grid and the probability for slowed rural electrification program. High costs of rural electrification (\$35,000/km) combined with demand out-stripping supply in urban areas are primary reasons for Nigerian officials' lowered expectations for rural electrification.
- 4) The low maintenance aspect of PV systems in a nation plagued by maintenance problems for conventional energy systems. Officials of all levels of government reported severe problems with maintenance and spare parts for engine generator sets.

Disincentives are:

- 1) The relatively cheap and stable price of oil in urban areas, although price and availability varies significantly in remote rural areas;
- 2) The existence of a general unfamiliarity with PV technology and successful PV demonstrations;
- 3) Conservatism towards "unproven" technologies which PV is perceived to be;



- 4) The possibility of foreign competition, particularly from the French, Germans and Japanese, with the French currently active in the area and the others monitoring the situation. (This is a plus if competition raises awareness and fosters more demonstrations);
- 5) The lack of distribution, parts and service networks for PV; unavailability of skilled labor is an especially critical factor.

#### Business Environment

There are difficulties that will be encountered by U.S. firms doing business in Nigeria that are not particular to PV. It is necessary to find reliable, well connected Nigerian partners and to establish good working relationships with federal and state government officials since their agencies do most of the purchasing. Representatives of U.S. firms should have the authority and ability to quote prices and enter into contracts without undue delay. Representatives must be prepared to follow-up initial contacts prior to sales and be prepared to provide service and technical follow-through for installation and maintenance. The U.S. Embassy staff in Nigeria and the U.S. Consulate in Kaduna are very supportive of well organized efforts by U.S. firms to penetrate the Nigerian market.

#### Conclusions

If present U.S. PV development practices continue, the future market for PV power systems in the Nigerian agricultural sector will be large. The most important local factors are the availability of investment capital and the premium placed on high reliability, low maintenance systems. The market will be primarily small government funded power and communications projects with some sales going to affluent individuals and corporations. The market for larger systems would develop in the 1982-83 period and beyond, or as soon as integrated PV systems become competitive and are available.

MARKET ASSESSMENT OF PHOTOVOLTAIC POWER SYSTEMS  
FOR AGRICULTURAL APPLICATIONS IN NIGERIA

1.0 INTRODUCTION

1.1 Background

The United States National Photovoltaic (PV) Program has been established by the U.S. Department of Energy (U.S. DOE) to evolve PV power systems to the economic marketing stage where they can contribute significantly to the U.S. energy requirements by the end of this decade. Ongoing research, development and demonstrations are directed at achieving major system cost reductions and field experience with PV power systems. The program is managed by the U.S. DOE and consists of several project offices, one of which is the Photovoltaic Stand-Alone Applications Project Office at NASA Lewis Research Center, Cleveland, Ohio. This project office is conducting international market assessments to ascertain whether stand-alone PV power systems can provide useful and economically productive power for various applications in developing countries during the next several years. This report on Nigeria is the fourth in a series on PV applications in agriculture (Philippines, Mexico, and Morocco).

1.2 Objectives

The types of potential photovoltaic applications considered in this study are those requiring less than 15KW of power and operating in a stand-alone configuration without back-up power. These applications include: irrigation, rural water supply, post-harvest operations, food and fiber processing and storage, and livestock operations. A team composed of representatives from NASA-Lewis Research Center, DHR, Incorporated, and Associates in Rural Development, Inc. visited Nigeria during January and February 1981. The purpose of this report is to provide an assessment of the market for stand-alone photovoltaic systems in Nigerian agriculture.

During the course of the team's visit it also became apparent that some rural sector non-agricultural applications may represent a significant PV market in Nigeria. Some of these are potable water supplies, health and education centers, and communications stations. This report considers these applications, although in considerably less detail than those in agriculture.

This study proposes to identify applications with high PV sales potential so that photovoltaic suppliers and distributors may develop appropriate marketing strategies. The market analysis provides the following essential information for Nigeria:

- Level of interest, awareness and experience with PV power systems,
- Estimates of potential market size for PV power applications in the agriculture sector,
- Operating and cost characteristics of gasoline and diesel power systems that compete with PV,
- Energy, agriculture and national development goals, programs and policies which will influence PV sales,
- Appropriate financing mechanisms and capital available for PV system purchases,
- Investment climate for U.S. companies and appropriate methods for conducting business in the country.

In addition to the data collection activities, the team members gave presentations on current applications of PV energy systems to a wide variety of audiences, including a major international trade fair. They also distributed sets of brochures consisting of technical and promotional material obtained from PV companies and from U.S. Government sources.

### 1.3 Study Approach

The approach consists of a focused data collection effort in the country followed by a detailed analysis and a market assessment based on this data. This process is described in greater detail below.

#### 1.3.1 Nigerian Information and Data Base

The major activity of the team members was a series of meetings with a variety of Nigerian experts to obtain current data and their evaluations of factors important to introducing PV power systems in agriculture. Site visits were also made to obtain power requirements and energy usage profile data for several agricultural applications. Agencies and individuals contacted include businessmen, officials and scientists at the following:

- Ministries of Agriculture--Federal and State Governments
- Ministries of Rural Development--Federal and State Governments
- Ministry of Health
- River Basin Development Authorities
- Nigerian Electric Power Authority
- University Research Centers and Independent Research Institutes
- Weather Bureau
- Banks -- Central, Development, Merchants and Commercial
- U.S. and International Aid Organizations
- Energy Systems Distributors
- Agricultural Machinery Dealers and Associations
- World Bank Regional Agricultural Projects
- Farmers and Agribusiness

Appendix A gives the names and addresses of about 50 individuals who were interviewed during the Nigerian visit. A cautionary word is needed about statistical data in Nigeria; data are generally incomplete and limited in scope and availability. The following points should be kept in mind with respect to statistics and data collection within Nigeria:

- 1) Data on demographics varies widely. All current population estimates and projections are derived from the 1963 census which was controversial.
- 2) Internal commercial and trade statistics are poor. Much of Nigeria's rural economic activity is subsistence level in nature, making it difficult to measure.
- 3) Nationally published statistics are generally two to three years out of date. However, unpublished estimates of current economic activity are available from both governmental and private organizations.

This lack of quantitative data has necessitated a reliance on subjective information gathered from interviews, observations and relevant literature in Nigeria. Wherever possible sources for information have been noted and information was corroborated by more than one source. The type of data collected included the following:

- Aggregate statistics including: level and types of agricultural production; distribution of production by size of operation; solar insolation; production trends.
- Characterization of current agriculture practices in terms of: operations, machinery used/duration of use, availability of resources (labor parts, energy, etc.); economics; financing; diesel/gasoline/electricity use; and costs of competing with PV.
- Barriers to the implementation of PV systems that are related to: costs and availability of balance-of-system parts or equipment; skills of workforce.
- Government energy policies, both existing and planned, relative to: rural electrification; prices/supply; renewable energy; consumption; type of energy used; PV systems.
- Government agricultural policies, both existing and planned, with regard to: crop production; introduction of new techniques and equipment; role of renewable energy systems in agriculture; incentives (financial and other); land reform/land use; employment generation; imports of agricultural equipment; storage; research marketing.
- Financing mechanisms and availability of credit for PV use in agriculture.

In addition, information was sought in areas specific to PV systems:

- Government attitudes toward renewable resources and the level of awareness or interest in PV - and policies conducive to, or hindering, PV marketing and use.
- Marketing channels and identification of potential barriers/incentives in the marketing of PV systems, including the present structure of markets; buying patterns; service/installation; profits; and availability of equipment.
- Business environment, incentives and barriers that U.S. companies face when planning to conduct PV business or organize joint ventures.<sup>1</sup>

### 1.3.2 Data Analysis and Market Assessment

The information gathered during the visit is used to characterize the environment in which PV systems would be marketed and to develop an integrated market assessment for PV systems in Nigeria. The assessment pays particular attention to:

- National development plans in agriculture, energy and overall economic development.
- Funding availability and mechanisms.
- Status of existing energy sources in Nigeria, and the implications for PV system introduction.
- Awareness and attitudes toward investing in PV systems, for both agricultural and other rural applications.
- Suitability of existing infrastructure for distributing, installing and maintaining PV systems.
- Cost-competitiveness of PV systems compared to other practical alternatives.

For economic comparisons of PV power systems to alternatives, the study uses a life-cycle costing computer model which computes life-cycle costs and projects the year in which the PV system first becomes cost-competitive with its nearest competitor. The data requirements of the model include power requirements, usage profiles, the extent of current and future use in Nigerian

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<sup>1</sup>An excellent and up-to-date assessment of the overall agribusiness environment in Nigeria is found in "Agricultural Investment in Nigeria: The Opportunities and Realities for U.S. Agribusiness Companies," OECD/U.S. Department of Agriculture, Washington, D.C., January, 1981.

agriculture; competing systems; cost, financial and economic parameters; solar insolation data; and estimated PV system costs. The objective of the analysis was to determine for various agricultural applications the first year of cost-competitiveness and the market potential thereafter. This market estimation procedure is shown in Figure 1-1.

The outputs of the model are combined with an overall assessment to give an estimate of the potential PV market size for applications in Nigeria. It should be noted that market size estimation procedures used in this analysis assume that if PV is to obtain a significant market share, it must be cost-competitive with the least-cost, practical alternative.

#### 1.4 Report Organization

Chapter 2 of this report presents a brief overview of Nigeria in terms of important economic and demographic characteristics, its energy situation, relevant government organizations, climate, agricultural regions, and major domestic export crops. Chapter 3 describes development plans and policies as they influence PV systems use in agriculture. Chapter 4 describes the financial institutions and funding programs that can play a major role in financing PV sales. Chapter 5 describes in detail potential applications, their power and energy requirements and the possible extent of use. Chapter 6 describes economic and financial analyses for selected applications and estimates the probable size of the market in the agricultural sector. Chapter 7 describes the potential for PV systems in non-agricultural and non-rural development applications. Chapter 8 describes the business environment in Nigeria which, together with Appendix B, provides an overview of the relevant Nigerian business community and the advantages and disadvantages for developing PV markets.

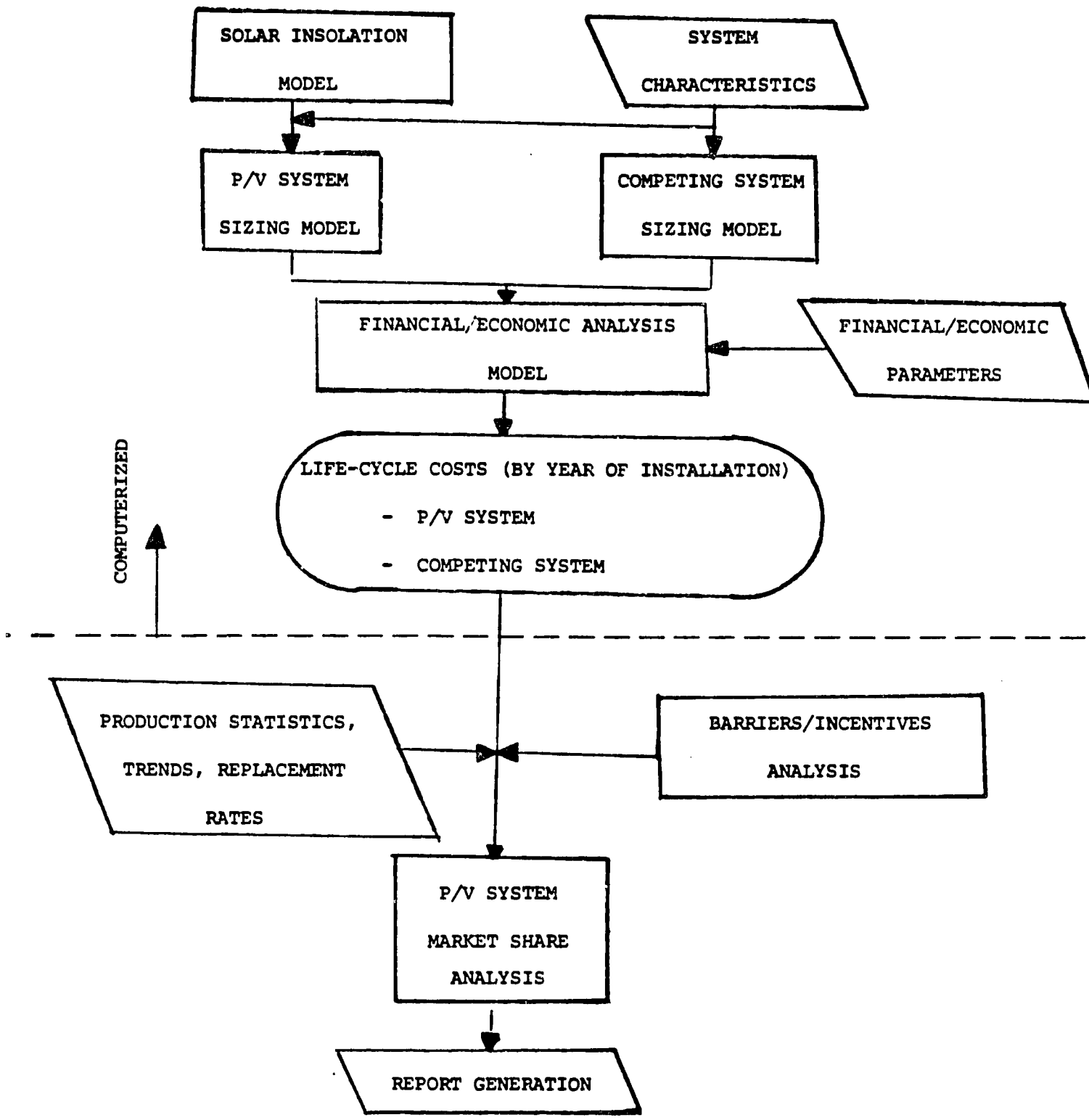


FIGURE 1.1 DHR P/V MARKET SIZE ESTIMATION PROCEDURE

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## 2.0 NIGERIA OVERVIEW

Nigeria has a population of over 80 million, the most populous African nation and the eighth most populous country in the world. Approximately one-quarter of the population is urban (cities over 20,000) while over 70 percent is classified as rural, consisting mainly of subsistence level farmers. The labor force is approximately 30 million, with 70 percent engaged in agriculture, 15 percent in the public sector, and 10 percent in industry, commerce and services. Per capita GPD is about \$600\*, while total GDP is estimated to be \$50 billion in 1981.

Nigeria is located on the west coast of Africa between four and thirteen degrees north of the Equator (Figure 2.1). It is bounded by Cameroon to the east, Benin to the west, and Niger and Chad to the north and west. About the size of Texas and New Mexico combined, Nigeria is comprised of humid tropical forest and coastal swamps in the south and Savannah and Sahel in the north. There are three areas of high population density--the Port Harcourt oil-producing area to the southeast; the Kano area in the northern agricultural belt, and the ever widening Lagos-Ibadan commercial and manufacturing area to the southwest.

The Nigerian political system is modeled after the U.S. federal system. After 14 years of military rule, Nigeria returned to civilian rule in October 1979 with the election of Alhaji Sehu Shagari. The period of military rule was marked by three military leaders and the Biafran civil war from 1967-1970. The transition to a civilian government occurred in a controversial election in October 1979. The major efforts of the Shagari administration have been to build a consensus between the states, promote the concept of national unity, and develop a favorable performance record, knowing that it faces re-election in two years. The present government is favorably inclined to foreign investment and seeks to assure foreign businessmen that despite domestic political "growing pains" investments will not be affected.

### 2.1 The Economy

The Nigerian economy is dominated by the petroleum sector which has supported the economy's expansion at approximately an eight percent annual growth rate since the oil boom of 1973-1974. The oil sector accounts for about 30 percent of GDP and approximately 90% of export earnings, while agriculture, including livestock, fishing, forestry and related activities represents only 18 percent of GDP despite its overwhelming dominance in employment. Table 2-1 shows a

\*Nigeria Area Handbook, Department of State and American University, Government Printing Office, Washington, D.C.



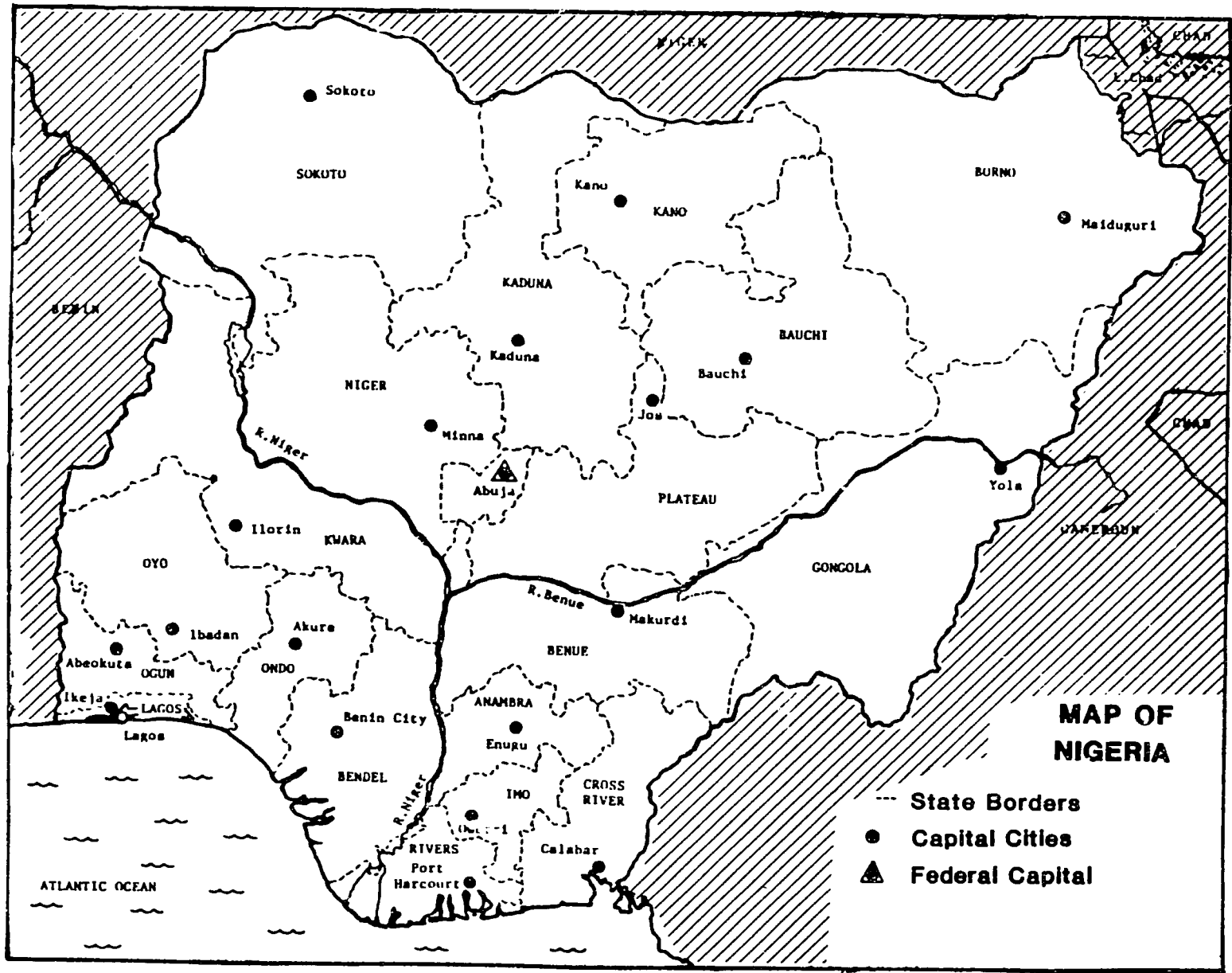


Figure 2.1

9.

breakdown of Nigeria's 1980 GDP by sector (1 ₦ = \$1.70 at official exchange rates (February 1980) although many monetary experts believe the Naira to be overvalued by 20-30%).

TABLE 2-1

Breakdown of Nigeria's Gross Domestic Product--1980

<u>Sector</u>	<u>Naira Billion</u>	<u>Percent</u>
Agriculture	5,205	10.3
Livestock, Forestry and Fishing	3,733	7.4
Mining and Quarrying	16,640	32.9
Manufacturing	4,043	8.0
Utilities	181	0.4
Construction	3,482	6.9
Transport	2,194	4.3
Communications	116	0.2
Wholesale and Retail Trade	8,543	16.9
Housing	2,176	4.3
Producer of Government Services	2,908	5.7
Other Services	1,378	2.7
<hr/>		
TOTAL	50,599	100.0

SOURCE: Federal Ministry of Planning. Outline of the Fourth National Development Plan 1981-85.

The importance of oil to Nigeria's economy is central. When the world oil market softened in 1977-78, real GDP growth slowed to 5 percent. The oil sector projection of the Nigerian oil authorities is shown in Table 2-2 and implies level output. However, current world oil over-supply has forced production to be reduced to 800,000 barrels per day and may force a reduction in price to maintain even this reduced level of production.

Public sector revenues created by the oil boom have enabled the Nigerian government to undertake ambitious economic development plans in every sector. The goal of both past and present development plans is a more diversified economy. This can be seen in Table 2-3, GDP Projections--oil (mining and quarrying) decreases in percent of GDP over the period, while manufacturing and other sectors increase. However, these development plans have been placed in jeopardy by the reduction in oil revenues currently being experienced. The critical role played by oil exports is a central element in any market assessment for Nigeria since the government, the primary purchaser of goods and services, depends on these revenues for financing development plan.

Table 2-2.

## OIL SECTOR ACCOUNT

Item	1980	1981	1982	1983	1984	1985
1. Output in Million Barrel/Day	2.15	2.19*	2.24	2.28	2.32	2.37
2. Domestic Demand in Million BBL/Day	0.25	0.28	0.31	0.35	0.39	0.44
3. Exports in Million Barrel/Day	1.90	1.91	1.93	1.93	1.93	1.93
4. Exports in Million Barrel/Year	694	698	702	705	706	706
5. Price in Naira per Barrel	20.10	21.31	22.50	23.94	25.38	26.90
6. Exports at Current Price $10^6$ ₦	13,939	14,877	15,854	16,867	17,012	18,980
7. Exports at 1977 Prices $10^6$ ₦	6,595	6,640	6,676	6,701	6,713	6,710

SOURCE: Outline of Fourth National Development Plan: 1981-1985.

\*Current World over supply of oil has forced production to be reduced to 800,000 Barrel/Day.

Table 2-3  
GROSS DOMESTIC PRODUCT AT CURRENT PRICES: 1981-85  
(10<sup>6</sup> Naira)

Sector	1981	%	1982	%	1983	%	1984	%	1985	%
1. Agriculture	5,684	10.0	6,207	9.7	6,778	9.3	7,401	9.0	8,082	8.7
2. Livestock, Forestry and Fishing	4,076	7.2	4,451	6.9	4,861	6.7	5,308	6.5	5,797	6.2
3. Mining and Quarrying	17,991	31.6	19,452	30.3	21,032	29.0	22,739	27.7	24,586	26.4
4. Manufacturing	4,973	8.7	6,117	9.5	7,523	10.4	9,254	11.3	11,382	12.2
5. Utilities	208	0.4	239	0.4	275	0.4	317	0.4	364	0.4
6. Construction	3,875	6.8	4,313	6.7	4,801	6.6	5,343	6.5	5,947	6.4
7. Transport	2,611	4.6	3,107	4.8	3,697	5.1	4,400	5.3	5,236	5.6
8. Communications	133	0.2	153	0.2	176	0.2	203	0.2	233	0.2
9. Wholesale and Retail Trade	9,995	17.6	11,695	18.2	13,683	18.9	16,009	19.5	18,730	20.1
10. Housing	2,350	4.1	2,538	4.0	2,741	3.8	2,960	3.6	3,197	3.4
11. Producer of Government Services	3,431	6.0	4,049	6.3	4,778	6.6	5,638	6.9	6,653	7.2
12. Other Services	1,612	2.8	1,886	3.0	2,207	3.0	2,582	3.1	3,021	3.2
<b>TOTAL</b>	<b>56,941</b>	<b>100</b>	<b>64,208</b>	<b>100</b>	<b>72,552</b>	<b>100</b>	<b>82,154</b>	<b>100</b>	<b>93,228</b>	<b>100</b>

SOURCE: Outline of Fourth National Development Plan: 1981-1985, Federal Ministry of Planning, Lagos, Nigeria.

## 2.2 Agriculture

Nigeria has a land area of 98.3 million hectares with 71.2 million hectares of arable land. Only 34 million hectares are currently under cultivation. Agricultural methods in Nigeria are largely traditional and labor intensive. The sector employs 70 percent of the labor force, 95 percent on small farms of 2 hectares or less. Once the backbone of the economy, the agriculture sector currently is growing at an annual rate of only 1 to 2 percent in real terms--significantly slower than the population. A detailed description of the major crops of Nigeria are presented in Appendix C.

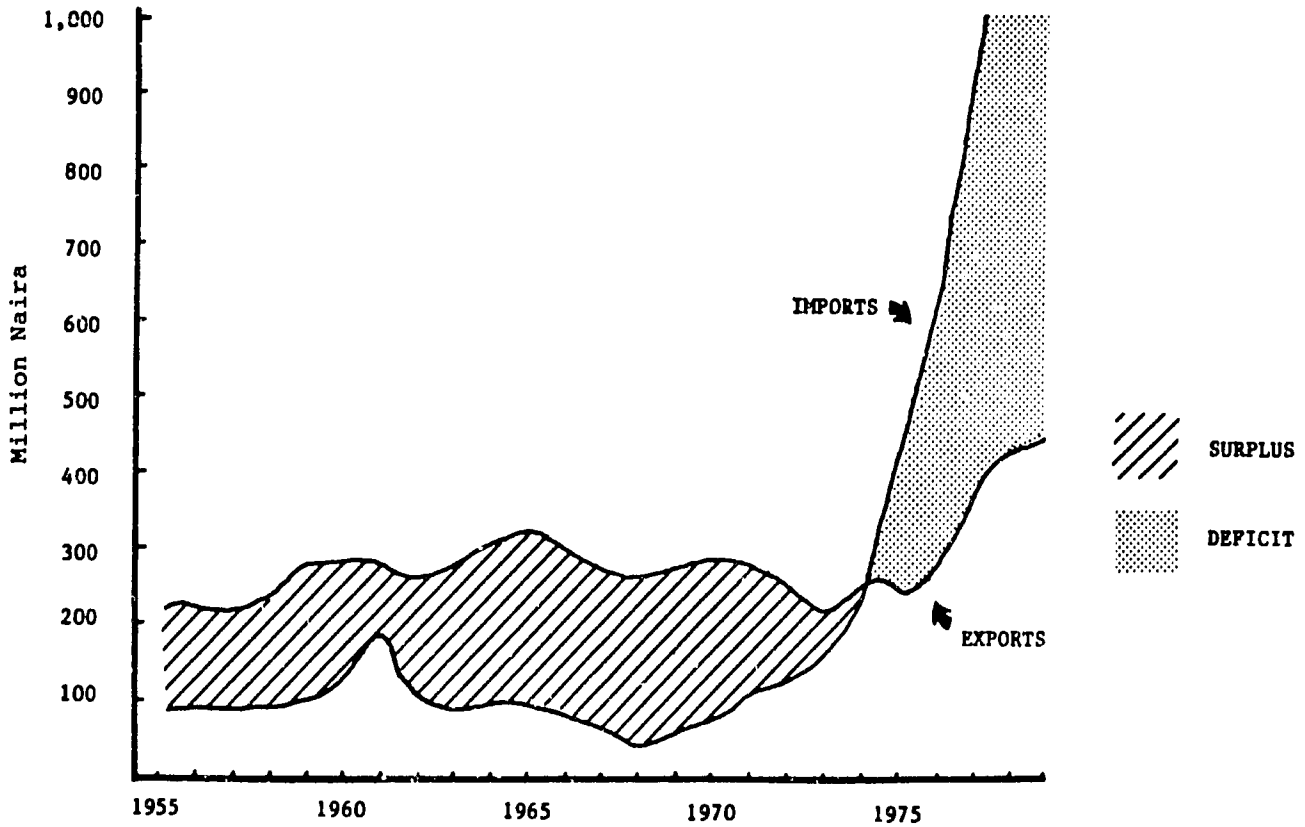
Nigeria once exported substantial amounts of cash crops, including cocoa, palm oil, groundnuts (peanuts) and rubber. As recently as the early 1970's Nigeria had been a net exporter of agricultural commodities. But after independence in 1960, agricultural production began to falter and decline. Large food deficits arose a decade ago and were aggravated by the neglect to agriculture during the civil war and the oil boom. Consequently, Nigeria has become a net food importer in a relatively short time (Figure 2.2) and food and agriculture have become major generators of inflation. During 1980 Nigeria's food import bill was \$3.2 billion, and future demand is expected to continue exceeding supply.

Although Nigerian agricultural performance has been poor, 1980 indicators show either a stabilization or some improvement in virtually all commodities. These include oilseeds, cocoa, sugar, grains, tubers and tobacco. Nigeria has the conditions necessary for vigorous agricultural development of many crops for internal consumption as well as for export, and recently the sector has been the focus of much national and international programmatic attention. Nigerian agricultural policy takes a positive position toward participation by foreign firms.

### 2.2.1 Agricultural Institutions in Nigeria

The Ministry of Agriculture is the primary federal agency for agricultural affairs. It is the responsibility of the Ministry to develop and implement agricultural policy in consultation and collaboration with various state agencies and other federal ministries. Since 1970, the federal government has assumed a steadily increasing role in agriculture. Its responsibilities include programs in rural development, cooperatives, fisheries, livestock, etc.,

FIGURE 2.2 Nigerian Agricultural Imports and Exports



SOURCE: "Agricultural Investment in Nigeria" USDA/Agribusiness Associates, Inc., January 1981. Prepared for OIDC and USDA, Washington, D.C.

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as shown in Figure 2-3, as well as important parastatal corporations.

The two most important parastatal organizations are the National Grains Production Board and the National Livestock Production Company. The major function of these government controlled corporations is to develop and promote agricultural projects which aid in the development of the agricultural sector. These profit-oriented companies identify and develop commercial agricultural projects often in joint ventures with foreign firms and the state governments. Federal Ministry of Agriculture officials expect that these companies will contribute significantly to commercial agriculture development.

The state ministries of agriculture have primary responsibility for planning and implementing all agriculture projects at the state level. For commercial projects those agencies will work with foreign firms and parastatals. However, most of their effort will focus on agricultural development projects for small farmers. These agencies also provide extension service and technical assistance to individual farmers and/or cooperatives. Although projects developed at the state level must be approved at the Federal level for funding, it is expected that the state agencies will play a significant role in the carrying out of the Green Revolution Plan devised by the Ministry of Agriculture in 1980.

A recent development in many state agriculture agencies has been the establishment of state owned agricultural companies. The companies farm large sectors of land (sometimes up to 2,000 hectares) often incorporating modern agricultural practices and mechanization. The ventures have generally been allocated large equipment purchasing budgets and are expected to be self-sufficient within a few years of organization. Observers in the agricultural sector believe that these enterprises will meet with mild success.

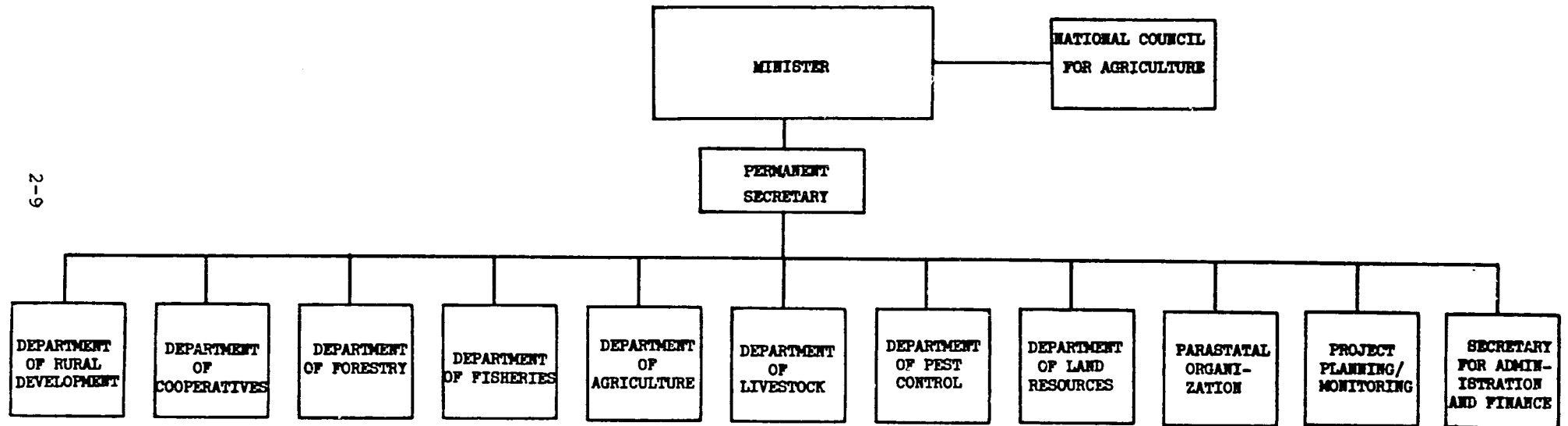
Other federal institutions which play an important role in Nigerian agriculture are as follows:

- River Basin Development Authorities, coordinated by the Federal Ministry of Water Resources, are becoming increasingly involved in agriculture and livestock development in their regions. Important areas are irrigation and water supplies.
- The Nigerian Agricultural and Cooperative Bank Limited promotes and finances cooperatives as a means of making agricultural loans throughout Nigeria (for more detail see Chapter 4).
- Agricultural research institutes (23) throughout the country conduct research for most major commodities.

There is also a variety of agricultural programs at each of the 19 states of Nigeria. Recently there has been a proliferation of semi-independent state agencies dealing with agriculture. In a number of states, wholly owned agricultural development corporations with significant equipment purchasing budgets have been created to engage in large-scale farming and other commercial ventures.

FIGURE 2-3

Organization Chart of the  
Federal Ministry of Agriculture



2-9

6



### 2.3 Energy Overview

The predominance of the oil economy tends to conceal the real energy problems in Nigeria. These problems include:

- limited availability of gasoline and diesel fuel in rural areas
- low reliability of national electric power grid
- limited expectations for expansion of electric grid to rural areas
- low reliability of and large maintenance problems with diesel and gasoline generator and pumping systems in rural areas
- limited experience and knowledge of energy conservation and renewable energy technologies.

Despite petroleum abundance, Nigerian refining capacity is limited and Nigeria is a net importer of refined oil products. Diesel and gasoline prices are reasonable, regulated at \$0.90/gal. and \$1.15/gal. respectively, but supplies are poorly distributed and are more expensive outside the urban areas, often 2 to 3 times the official price. Refining capacity and internal distribution systems are undergoing major expansion in the third and fourth national plans.

Electricity is supplied by the grid (National Electric Power Authority) and is also relatively reasonable at 9¢-12¢/Kwh. Grid power is available in a number of cities, but the entire system is very limited (less than 2,000 MW capacity) and suffers severe reliability problems due to the great demand. The system is undergoing considerable expansion in both urban areas and extensions to rural areas, but most rural sites will continue to use diesel and gasoline generators, both as stand-alone and back-up electric power, for some time to come. Because of its importance to the potential market for PV the electricity sector is discussed in more detail in Chapter 3.

Natural gas, produced mostly in association with crude oil production, is being flared at a rate exceeding 2 billion cubic feet per day. Less than 1 percent is being recovered and used domestically. Joint venture partners for a proposed liquified natural gas (LNG) plant are expected to begin gas gathering projects within 3 years. Plans have also been discussed by the Nigerian Petroleum Production Corporation for an internal gas distribution network to be used by industry and the utility. However, no budget allocations have been made at present for such a scheme.

The utilization of solar and renewable energy in Nigeria is currently on a small scale with the exception of firewood use. In the north, for example, in Kano and Kaduna States, there is ample evidence of previously greater rural use of wind power for water pumping, both in agricultural and water supply applications; however, most machines have fallen into disuse and have been replaced with diesel pumping systems. Although solar insolation appears adequate for PV applications throughout the country, complete insolation data was collected at only one location in Nigeria. Data for other locations is very limited (see Appendix D).

With respect to PV utilization, a French government backed demonstration project is being developed in Sokoto state. Presently, the funds and equipment have been committed but installation has not occurred. The project will demonstrate PV use in waterpumping and the powering of small electric appliances. The size of the PV array is expected to be 5-6 KWp. While interest in PV technology appears to be enthusiastic, especially as a replacement for unreliable diesel generator sets, policy attention to solar energy in general is low.

### 3.0 NIGERIAN DEVELOPMENT PLANS

#### 3.1 Overview

The Fourth National Development Plan (1981-1985) represents the most ambitious goals and highest level of effort toward Nigerian development to date. The federal government, utilizing oil export revenues, is the major force within this plan whose stated goal is to harness Nigeria's natural resources in order to improve living conditions of the people. Total anticipated investment for the five year period is \$127 billion of which \$105 billion would be in the public sector.

The two major operational themes of the Fourth Development plan are to place an increased emphasis on rural and agricultural development and to diversify the economy away from oil. Agricultural sector improvement is the major development priority in Nigeria. The second priority is the improvement of education and manpower skills which the government feels are the single largest barrier to the efficient absorption of oil revenues by the economy. The next priority is the strengthening of the economic infrastructure, particularly electric power, water supply and telecommunications, which at present seriously limit the economy's ability to operate effectively. Housing, health and manufacturing, particularly petrochemical and steel, will also receive emphasis in the next plan period.

The following table approximates the Federal Government's expenditures over the five year plan period in areas of major emphasis. These figures include Federal monies which will go to state governments for their individual projects. These figures however, do not include funds or resources contributed by the individual states, the donor agencies, or other countries. However, these figures are thought to represent approximately 70-80% of the resources which will be available in the sectors over the five year period.

TABLE 3.1: Nigerian Federal  
Government Development Investment Plan

<u>Sector</u>	<u>5 Year funding level</u>
Agriculture & Rural Dev.	\$14.4 billion
Power	4.5 billion
Water	3.8 billion
Health	2.2 billion

SOURCE: "Outline of the Fourth National Development Plan (1981-1985)", Fed. Ministry of Planning, Lagos, Nigeria, 1980

These funding levels represent major shifts from past development plans which emphasized industrial and urban development at the expense of the rural/agricultural sectors. The present plan represents a return to the development of the country's agricultural and rural sector.

The Federal government also recognizes the role and need for further development of the private sector in helping to achieve the country's development goals. Moreover, the government is very receptive to foreign government and foreign private sector ventures or partnerships assuming they are consistent with plan objectives.

In general, energy is not a major concern in the development effort. Oil resources and reserves are plentiful although energy distribution networks and the maintenance of those systems are problems. The major effort in the area of energy will be to provide better delivery systems and skilled personnel to maintain the systems. In terms of alternative energy technology, the Ministry of Science and Technology is beginning an evaluation program, but it has a relatively low priority.

Interest in alternative energy systems such as PV within the context of Nigeria development plans will be limited by the degree to which they can assist in achieving the major development goals. Photovoltaic systems deployment in rural/agriculture systems would assist development objectives through: 1) the provision of power sources in isolated sites to provide basic amenities (e.g., pumps for village water supplies); 2) assisting in increasing agricultural productivity and decreasing agricultural spoilage losses; 3) assisting development of a more diversified economy away from the petroleum sector.

### 3.2 Agricultural Development

Current agricultural policies and development efforts are aimed at reversing net food imports through increased agricultural productivity and decreased product loss. Shortfalls in agricultural output are exacerbated by the fact that the annual demand growth rate for food is 3-5%, whereas the annual production growth rate is only 1%, resulting in 2.6 million tons of grain equivalent being imported in 1979.

The basis for Nigeria's agricultural problems are numerous and include:

- drawing off of skilled rural labor to non-agricultural sectors and in general an increased rural-urban migration since the large flow of oil money began in 1974;
- past agricultural policy and development efforts emphasizing increasing cultivated land, primarily through large mechanized farms, rather than focusing on increasing productivity of the small subsistence farmer who accounts for over 90% of the agricultural output. (In the fourth development plan emphasis is placed on helping the small farmer increase productivity while development of large mechanized farms is left to commercial ventures and state run farms);
- lack of adequate rural infrastructure such as feeder roads, water supply storage and marketing facilities.

Objectives for the agricultural sector in the Fourth Plan are geared to overcoming these problems. It is realized that to stem rural-to-urban migration it is necessary to improve the quality of rural life as well as to increase agricultural productivity. Thus, many of the Fourth Development Plan programs include provisions for the improvement of rural amenities. The basic objectives of the plan include:

- increased production of food and other raw materials to meet the needs of a growing population and rising industrial production; a basic objective in this respect is the attainment of self-sufficiency in food in about five years;
- increased production of livestock and fish to meet domestic needs and create a surplus for export;
- increased production and processing of export crops with a view to expanding and diversifying the country's foreign exchange earnings; in this respect a target of seven years is being set for the revival of cash crops;
- expansion of employment opportunities to absorb the increasing labor force of the nation; and
- the evaluation of appropriate institutional and administrative mechanisms to facilitate the rapid development of the country's agricultural potential.

To accomplish these objectives a number of specific initiatives, policies and programs have been included for the agricultural/rural sector in the Fourth Development Plan. The balance of this chapter first describes the agricultural related policies associated with the Plan followed by specific development programs. These program initiatives will form the focus of the Federal Government's activities.

### Agricultural Policies

#### 1) Price Incentives Policy

The Nigerian government will constantly review the minimum guaranteed prices to ensure that they serve the desired purpose of encouraging basic food production.

#### 2) Direct Government Production Policy

During the Fourth Plan period, the Federal Government will place emphasis on encouraging private entrepreneurs to establish large-scale farms. Government participation in direct production will mainly be as an equity holder in commercial joint ventures with the private sector. The fiscal incentives already provided by the government for companies wishing to go into large-scale agricultural production; e.g., income tax relief for pioneer enterprises, duty-free importation of farm machinery, additional investment allowance of 10 percent for carrying forward of losses, etc., will be maintained and expanded as may be appropriate. Already agricultural production and processing has been transferred from Schedule II to III of the Nigerian Enterprises Promotion Act, meaning that foreign companies can now own up to 60 percent of the equity in an agricultural enterprise. The Commodity Boards, National Grain Production Company and the state agricultural development corporations will be prepared to go into partnership with private Nigerian or foreign investors in establishing large-scale farms. However, the government fully expects the small land holders to be the major supplier of foodstuffs and rural jobs in the future.

#### 3) Credit Policy

A major instrument of government agricultural policy during the plan period will be to make short and medium-term capital available to farmers to encourage investment and to increase their access to productive inputs. The

government has established the Agricultural and Cooperative Bank<sup>1</sup> and the Agricultural Credit Guarantee Scheme<sup>2</sup> as two main institutions for funding agricultural production. However, to date, the direct lending schemes have tended to favor corporate, large-scale farms and farmers who possess adequate collateral. A new strategy has been developed which will increase credit flows to small farmers (see Section 4.2).

#### 4) Agricultural Inputs Policy

The government policy of subsidizing essential inputs such as fertilizers, pesticides, and improved seeds will continue. A package approach rather than single input supply will be followed. Also improved storage and distribution will be pursued to reduce waste.

#### 5) Agricultural Development Projects Policy

During the Third Plan period, seven state governments with the assistance of the federal government and the World Bank introduced Integrated Agricultural/Rural Development pilot programs (ADPs). The projects involved diverse activities such as agriculture, rural road construction, dam construction, water supply, livestock production, etc. The ADPs aimed to provide improved services in the form of an integrated package to existing small holder farming communities with the objective of increasing productivity, raising farm income and bringing overall socio-economic development to the rural areas. The ADPs have been successful and the attempt will be made to replicate them throughout the country.

### Fourth Development Plan Agricultural Programs

#### 1) Crop Production Program

The purpose of this program is to provide assistance to farms and plantations, and to promote agricultural cooperatives and provide agricultural

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<sup>1</sup> Annual Report, 1979, Nigerian Agricultural and Cooperative Bank, Ltd., Kaduna, Nigeria, October 30, 1979.

<sup>2</sup> Annual Report, 1978, Agricultural Credit Guarantee Scheme Fund, Central Bank of Nigeria, Lagos, Nigeria, 1979.

inputs. Assistance will be in the form of preparation of new agricultural lands, cash-crop plantations, and rehabilitation of older tree crop plantations, i.e., palm-oil, cocoa, rubber.

#### 2) Agricultural Mechanization

Mechanization of agriculture will be implemented through provision of services to farmers and through subsidizing purchase of mechanical equipment. About 285 agro-service centers will be established to provide seeds, fertilizers, pools of tractors and processing equipment. In addition, subsidies will be provided to farmers to mechanically clear approximately 250,000 hectares between 1981 and 1985. The state governments will establish mechanical equipment hiring units for land clearing and preparation.

#### 3) Crop Storage

An allocation of \$180 million has been earmarked for the provision of grain processing and storage facilities. This will be carried out by the Nigerian Grains Board and the National Grains Production Company.

#### 4) Water Resources Program

The most significant of the federal programs providing infrastructural facilities for the agricultural sector consists of the various water resources projects that the River Basin Development Authorities and others are undertaking. Irrigation facilities involving construction of dams and boreholes will be provided to facilitate double cropping in most parts of the country. Authorized funds amount to \$1,700 million during the Plan period. Under the program, facilities to irrigate about 1.4 million hectares will be constructed while over 1,500 boreholes will be drilled.

Most states are covered by minor irrigation schemes. It is envisaged that over 76,730 hectares will be irrigated. This will mainly be in the form of small plot irrigation systems.

#### 5) Livestock Production Program

The government has allocated a total sum of \$360 million to the livestock sub-sector program which broadly covers meat production, veterinary and health services and training, feed production and marketing facilities. These funds will be used to establish cattle, goat, and sheep ranches, piggeries and a poultry program to produce chicks and broilers. Assistance will be provided to the states by the federal government by the provision of grazing reserves for cattle. Under this scheme, five million hectares will be acquired and demarcated for settlement, pasture development and livestock services in 38 settlements covering 10 states.



In order to improve the livestock marketing network, cold stores of 20 to 50 cubic meters capacity will be constructed by both the federal and state governments at strategic locations all over the country. About 123 of such stores will be established.

The state program closely parallels the federal programs. Cattle, sheep and goat multiplication centers, poultry demonstrations and holding centers, cattle ranches and poultry expansion programs will be undertaken and livestock feed mills will be established by several of the states. Existing grazing reserves, control posts and veterinary clinics will be properly maintained and expanded in some states and a number of new ones will be established in other states.

#### 6) Fishery Production Program

The programs of the various governments (Federal, state and local) indicate a new awareness of the potential of the fishing industry in improving the protein consumption of the population. The sub-sector program falls into the broad areas of fishery, manpower development and research.

### 3.3 Agricultural/Rural Development Investment Summary

Table 3.2 outlines the expected level of federal expenditures over the next five years in the above described program areas, and not including expenditures of individual states, donor agencies or other countries. In some areas such as rural water resource development, many states are undertaking ambitious plans for providing village water systems.

As noted in Chapter 2, the various states will receive approximately \$50 billion of the total \$127 billion to be spent in the Fourth Development Plan. Thus, in many cases, the states will expend more funds in some program areas than will the federal government. This is especially true in cases of ADP funding where the Federal government is supplying only \$1.350 billion out of the total \$6.748 billion. This is also true in water resources programs where the Federal government will drill 1,500 boreholes while many individual states have plans of drilling as many.

### 3.4 Electricity Sector Development Plans

Nigeria recognizes the importance of electric power to the nation's development. The electricity sector will continue to receive much attention and finance, as it comprises an essential element of the developing infrastructure. The importance of the electricity grid to market potential of PV systems justifies inclusion here of detailed discussion of the present grid system as well as development plans.

TABLE 3.2

Agriculture Development Funding Levels  
1981-1985

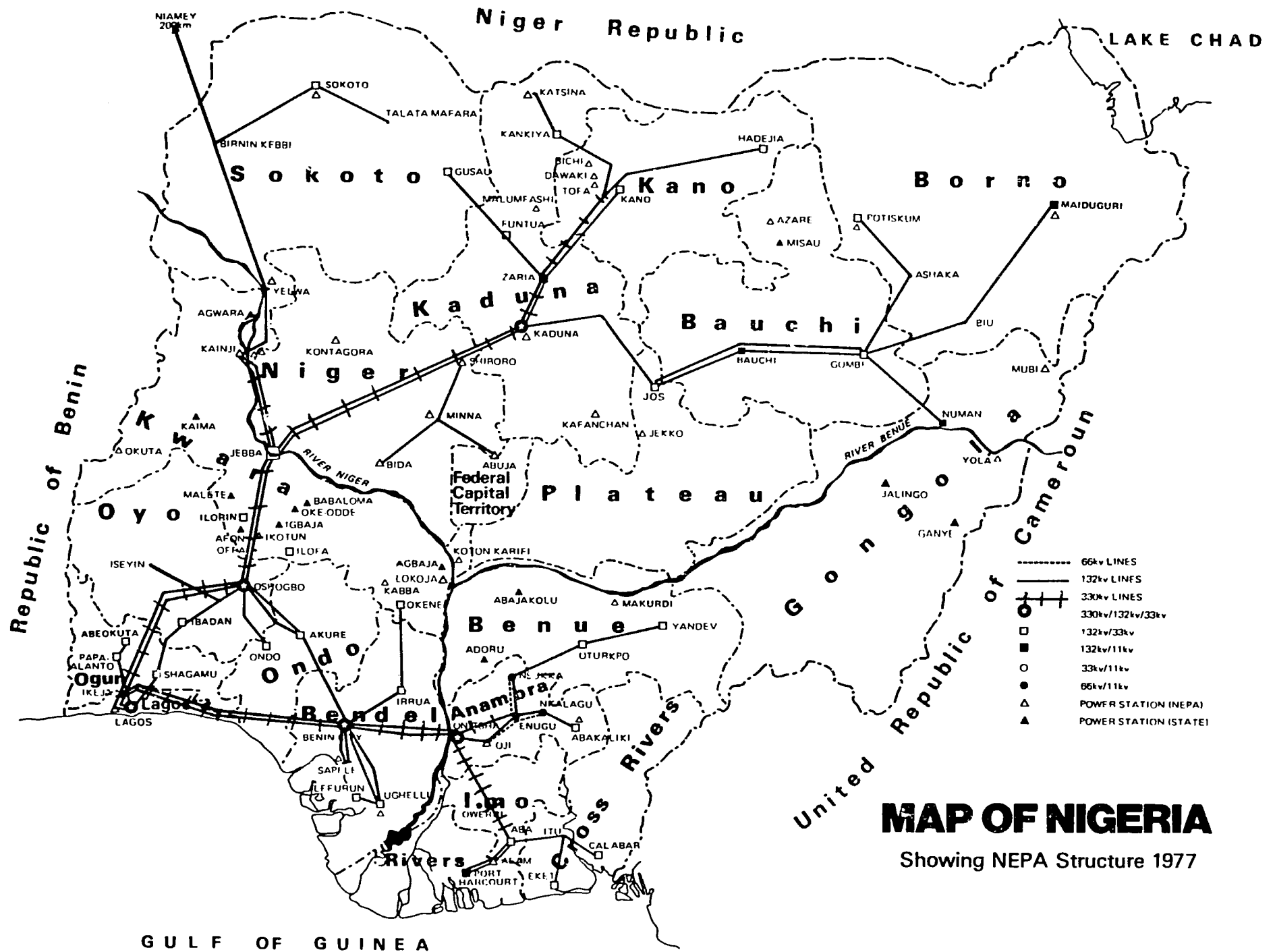
<u>Program</u>	<u>(\$ Million)</u>
Crop Production	5,400
Food crop	117
Tree crop	446
Agriculture inputs	1,749
Agriculture crops	117
Rural Development	1,044
Agricultural Mechanization*	
Tractor purchases	142
Agro-service centers	189
Implement Development	45
Crop Storage	180
Institutional Agriculture Development	1,348
Water Resources Program*	1,663
Boreholes*	187
Livestock Development	432
Fishery Production	156

\*Indicates that state funds will be made available.

SOURCE: Outline of the Fourth National Development Plan, Federal Ministry of Planning, Lagos, Nigeria, 1980.

The National Electric Power Authority (NEPA) operates the majority of electric generation and distribution systems within Nigeria. The rest are operated by a few state utility boards, which often serve a captive user, e.g., Nigerian Electricity Supply Company services a major mining operation.

The national grid currently supplies the major urban and commercial areas, while very little of the rural areas, particularly in the north, are electrified. From 1970 to 1974 annual electricity consumption rose from 1,100 million Kwh to 2,000 million Kwh, representing an annual growth rate of 20.5%. Annual per capita electricity consumption during this period increased from 17 Kwh to 29 Kwh. Since then, this growth rate has been exceeded every year. Annual current consumption is over 6,000 million Kwh. Figure 3.1 shows the current transmission and distribution network. Table 3.3 shows the current generation capacity.



GULF OF GUINEA

Figure 3-1

2/2

TABLE 3.3

POWER DEVELOPMENT PROGRAM 1976-1985  
 INSTALLED GENERATING CAPACITIES (MW)\* AND  
 PLANNED EXPANSION

	1976	%	1980 EXISTING (EST.)	%	1985 4TH PLAN	%	DEVELOPMENT COMMITTED IN 4TH PLAN PERIOD 1981 - 1985
HYDRO	520	50.4	650	40.5	1900	41.2	\$6.3 BILLION
GAS	378	36.6	578	36.1	1738	37.7	
DIESEL/OIL	133	12.9	373	23.3	373	8.0	
COAL	-	-	-	-	700	15.2	
TOTAL	1031	100%	1501	100%	4711	100%	

\*INCLUDES ONLY NEPA

SOURCE: NATIONAL ELECTRIC POWER AUTHORITY, ANNUAL REPORTS, AND OUTLINE OF THE FOURTH NATIONAL DEVELOPMENT PLAN 1981-1985.

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Present small user service is for users whose load does not exceed 75 KVA and consists of 50 Hertz, 400 Volt, three-phase 3 or 4 wire service. Tariffs for this service are: Power Demand Charge

First 5KVA	₦ (\$5.40)
Next 5 KVA	50 Kobo (0.5 ₦) per 100VA (\$.90)
Next 10 KVA	₦ 5 per KVA (\$9.00)
<u>Energy Charge</u>	
6.5 Kobo per Kwh (11.7¢)	

These rates are set by the Nigerian Electric Power Authority with approval from the Ministry of Power and Mines. It is expected that they will increase as the costs of capacity expansion and rural electrification are realized.

The great demand for electric power during the next ten years will certainly exceed the supply, but Nigeria does have the capability for attaining electricity self-sufficiency. The hydro capacity has not yet been fully exploited and the plentiful supply of coal, oil and natural gas can allow expansion of thermal generation systems.

Currently there is no overall masterplan for electric power. NEPA's failure to achieve previous goals has led to severe criticisms. Discussions about restricting this sector suggest that NEPA maintain the responsibility for generation and transmission of power, but with distribution authority going to the individual states.

Another means for accelerating development would be to require that power-intensive industries and other institutional consumers generate their own electric power. Individual private enterprises may be allowed to produce and to distribute power again.<sup>3</sup> Smaller private systems to meet local and isolated demands could also be in operation soon. Such a policy will open a large market and investment opportunities to American firms.

NEPA's capacity expansion plans are shown in Table 3.3. These plans call for an increase from the present estimated 1600 MW system to 4600 MW by the end of the plan; of this increase approximately 1200 to 1400 MW will be hydro with the balance in large coal and gas fired thermal plants. NEPA

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<sup>3</sup>"Electricity Highlights," American Embassy, Econ/Commercial Section, Lagos Nigeria, February, 1981.

officials expressed concern over the ability to increase capacity at the required rate over the plan period. Concern was also expressed as to whether transmission, distribution and support service networks (especially skilled manpower) could keep up with the planned expansion.

The distribution network expansion plans are much less defined. The most detailed plans to date call for connecting all local government headquarters (approximately 400) to the national grid by the end of the fourth year plan, although the cost of doing this is unknown. Many officials interviewed in the Ministries of rural development, power and mines and state governments considered this goal unrealistic. At present most government centers are served by diesel generator sets of varying degrees of reliability, some of which are operated by NEPA. These systems will be phased out as the transmission network expands.

NEPA is reluctant to project at what rate rural electrification will take place due to the large distances, high costs and low loads at end of line associated with rural electrification. The transmission and distribution network will continue to be the major problem in rural electrification. At present, rural electrification officials within NEPA estimate average costs would be approximately \$35,000/Km for 33KVA lines. The estimate may become considerably higher, especially in the northwest and northeast portions of the country. Although there is a federal commitment to rural electrification, NEPA officials expect the rate at which it will occur will be considerably slower than expected; due primarily to high costs and lack of manpower.

In addition to NEPA's expansion of generating capacity and distribution networks (funded through utility revenues), the federal government plans to spend \$1.8 billion for improvement and extension of distribution facilities and for providing power to rural areas all over the country.

Each state has a rural electrification board which sites isolated diesel and gas turbine systems. These systems are scheduled to be phased out when the grid system arrives at the load center. The state rural electrification boards will spend \$1.85 billion over the next five years, mainly in the form of isolated diesel and gas turbine plants. Even in the smaller facilities (5 to 10 KWe) the boards are envisioning the necessity of having maintenance/operator personnel at each site. The high cost of maintaining these systems, combined with the potential delay in rural electrification, suggests a high

potential for PV use in rural areas. However, NEPA has expressed little interest to date in PV or other alternate energy power sources.

### 3.5 PV in Development Plans

Energy is not explicitly addressed in either Nigeria's agricultural sector development plans or overall non-petroleum development plans. However, the potential applications identified in Section 5.0 correlate very strongly with the program areas to receive emphasis in the national development plan. In particular, water systems for villages, livestock, irrigation, and veterinary centers receive much attention. Numerous state and Federal agriculture officials expressed the opinion that if PV systems can meet reliability and cost criteria, the potential for stand-alone energy systems for various agricultural applications for small farmers will be high.

#### 4.0 AGRICULTURAL FINANCING

##### 4.1 Overview of the Nigeria Banking/Investment System

The financial system of Nigeria is a network of private, federal and state banking institutions subject to extensive credit allocation policies of the Federal government. The formal system in Nigeria includes the Central Bank under the auspices of the Ministry of Finance, 17 commercial banks, 5 merchant banks, 3 development banks, including the Nigerian Agriculture and Cooperative Bank, the Federal Mortgage Bank, the Federal Savings Bank, several finance corporations and insurance companies, and 3 stock exchanges. Each of these specializes in certain types of credit service.

The two major classes of private banks, commercial banks and merchant banks, account for the overwhelming majority of loans in the Nigerian financial sector. Commercial banks, with over 500 branches, are involved in all commercial banking services and customer loans, but only minimally in long-term lending. Merchant banks concentrate on larger and longer-term loans to industrial and commercial clients and on wholesale banking. All merchant banks are foreign-affiliated. Both classes are subject to credit allocation policies promulgated by the Central Bank.

Lending to the private community expanded rapidly with the oil boom and the tremendous increase in foreign reserves. As part of the government's anti-inflation monetary policy, limits on the further growth of commercial bank lending and credit allocation requirements were introduced in 1976, to promote the flow of credit to what were termed "directly productive sectors," particularly agriculture and manufacturing. Thus, bank loans are divided into two categories: the preferred sectors and the less preferred sectors. The Central Bank publishes yearly guidelines on how much of a bank's portfolio can be in each sector. These are:

	<u>Preferred Sector (Minimum %)</u>	<u>Less Preferred Sector (Maximum %)</u>
Commercial Banks	75%	25%
Merchant Banks	79%	21%

##### 4.2 Agricultural Credit

The availability of credit is a major determinant of the level of private investment in agriculture. Access to institutional credit has traditionally been difficult for the average farmer due to inability to satisfy loan conditions. Even when some form of credit is available returns to investment are typically low, given the low production capacity and the limitations of the traditional agricultural system.



Agriculture is in the designated preferred sector; consequently the government requires that a given percentage of bank's loan portfolio must be committed to agribusiness. This is as follows:

	<u>Agricultural Production</u>	<u>Agro-Allied Industries</u>
Commercial Banks	8%	3%
Merchant Banks	5%	5%

Banks which do not satisfy these percentages lose the difference between the percentage of their portfolio committed to agriculture and their required percentage. The difference is removed from deposits with the Central Bank and deposited in the Nigerian Agricultural Bank. In addition, there are maximum interest rates allowed for agricultural loans, currently 6 percent for agricultural production and loans carrying credit guarantees.

It has recently been reported, and corroborated during interviews in Nigeria, that despite these credit provisions, private banks in Nigeria generally have difficulty making loans to the agricultural sector. The lack of attractive commercial projects, the inherent riskiness of agriculture, the attractiveness of alternative sectors, the poor record on loan repayments and the lack of developed banking in the hinterland all contribute to these difficulties. However, contrary to the majority opinion, some banks are actively seeking agricultural loans and believe that the agricultural sector offers promise for future growth.<sup>1</sup> It was also discovered that some banks prefer not to bother at all with the low profit loans guaranteed by the government. Instead, they find it more profitable and easier to make loans at commercial rates to the agricultural sector and have their portfolio percentage removed by the Central Bank.

The major instruments for achieving agricultural sector lending are the Central Bank, the Nigerian Agricultural and Cooperative Bank, and the Agricultural Credit Guarantee Scheme Fund. The role of the Central Bank is primarily to control credit ceilings, liquidity/debt ratio cash reserves, and interest rates and to prescribe credit guidelines for the preferred sector. The Central Bank policies have been fairly consistent over the past five years and are expected to remain the same in the near future.

The Nigerian Agricultural and Cooperative Bank, established in 1973, lent close to \$100 million in 1979 to both large and small agricultural projects,<sup>2</sup>

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<sup>1</sup>"Agricultural Investment in Nigeria," op. cit., p. 31.

<sup>2</sup>Nigerian Agricultural and Cooperative Banks, Ltd., Annual Report, 1979.

as shown in Table 4.1. The Bank's original funding size was \$200 million with maximum guarantees of up to \$100,000 for an individual and \$2 million for a cooperative or limited liability company.

The NACB expects to increase its lending activities considerably over the next 2 years. Some bank officials suggested a doubling of loans. The NACB recently implemented (Jan. 1981) the Smallholder Direct Loan Scheme which allows waiving of many normal loan requirements for loans of up to \$9000 to small land holders who have difficulty obtaining credit. A simplified application form and provision of assistance on a local level is intended to encourage its use. Loan periods are 2 years and the interest rate is 6%, although no annual loan fund figures were available.

The Agricultural Credit Guarantee Scheme Fund was established in 1977 to guarantee 75% of the value of loans made for agricultural purposes. In 1979 a total of 1,105 loans were guaranteed by the fund amounting to \$70 million.<sup>1</sup> The commercial banks accounted for the vast majority of these loans. The types of projects that were guaranteed under this scheme are shown in Table 4.2.

Additional agricultural funding is available through parastatal corporations such as the National Livestock Production Corporation. In the past these have tended to favor corporate, large-scale farms and operations with sufficient collateral. Loans on a more limited scale are also available from a few of the states' own development banks.

#### 4.3 Attitudes of Financial Institutions Towards Photovoltaics & Availability of Loans

Interviews with a number of private and government financial institution representatives were held to assess the attitudes of the financial community toward photovoltaic systems. There was a general willingness of high officials to consider photovoltaics systems for loans. At the loan analyst level, however, there was a sense of skepticism as to how photovoltaics would pass the standard analysis. There is little understanding of PV systems and almost no use of life cycle cost analysis techniques. Skepticism appeared to be also influenced by the following factors:

- High initial capital cost of photovoltaic systems;

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<sup>1</sup> Agricultural Credit Guarantee Scheme Fund, Second Annual Report, 31 December, 1979.

TABLE 4-1: Nigerian Agricultural and Cooperative Development Bank

**CUMULATIVE VOLUME OF OPERATIONS AS AT 31/3/79.**

(Amounts in N'000)

PROJECT TYPE	1978/79			DISBURSEMENTS	No.	1977/78		DISBURSEMENTS
	APPROVALS					APPROVALS		
	No.	AMOUNT	% OF TOTAL			AMOUNT	% OF TOTAL	
<b><u>ON-LENDING</u></b>								
Marketing	38	130,520	41.86	88,644	25	97,929	34.20	13,680
Tree Crop	1	196	0.06	--	2	6,921	2.42	--
Arable	18	52,491	16.83	30,175	14	40,619	14.19	19,051
Integrated	8	20,396	6.54	7,677	7	20,396	7.12	6,177
<b>SUB-TOTAL A</b>	<b>65</b>	<b>203,603</b>	<b>65.29</b>	<b>126,496</b>	<b>48</b>	<b>165,865</b>	<b>57.93</b>	<b>88,908</b>
<b><u>DIRECT LENDING</u></b>								
Tree Crops	16	41,257	13.24	14,612	15	34,532	12.06	11,846
Mixed Farming	14	3,890	1.25	2,913	15	3,947	1.38	2,634
Feed Mill	1	479	0.15	40	--	--	--	--
Arable Crop	31	27,392	8.78	7,302	31	27,392	9.57	5,923
Rabbitry	1	57	0.02	16	--	--	--	--
Poultry	54	5,969	1.91	4,387	52	5,679	1.96	3,849
Cattle	20	9,785	3.14	703	3	3,663	1.28	635
Horticulture	2	75	0.03	73	2	74	0.03	73
Forestry	1	3,224	1.03	2,680	1	3,224	1.13	2,000
Fishery	6	15,383	4.93	9,318	6	41,209	14.39	8,090
Piggery	4	717	0.23	474	4	718	0.25	468
<b>SUB-TOTAL B</b>	<b>150</b>	<b>108,228</b>	<b>34.71</b>	<b>42,518</b>	<b>129</b>	<b>120,438</b>	<b>42.07</b>	<b>35,518</b>
<b>GRAND TOTAL A + B</b>	<b>215</b>	<b>311,831</b>	<b>100</b>	<b>169,014</b>	<b>177</b>	<b>286,303</b>	<b>100</b>	<b>124,426</b>

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TABLE 4-2

LOANS GUARANTEED BY THE AGRICULTURAL CREDIT GUARANTEE SCHEME FUND  
BY PURPOSE : 1978 & 1979

Purpose	No. of Loans		Amount ₦'000		% in Total Loans Amount	
	1978*	1979	1978*	1979	1978	1979
LIVESTOCK	137	339	6,040.0	21,442.5	53.5	63.8
Poultry	109	285	5,680.0	19,904.6	50.3	59.2
Cattle	22	40	347.0	536.9	3.1	1.6
Other Livestock	6	14	13.0	1,001.0	0.1	3.0
FOOD CROPS	116	391	2,868.2	7,456.1	25.4	22.2
Grains	79	306	2,277.7	6,707.6	20.2	20.0
Tuber & Root Crops	37	85	590.5	748.5	5.2	2.2
MIXED FARMING	35	27	1,555.5	2,220.0	13.8	6.6
OTHER CROPS	53	349	820.7	2,477.8	7.3	7.4
Total	341	1,105	11,284.4	33,596.7	100.0	100.0

\*The scheme came into operation on 3rd April, 1978.

- Lack of information and awareness on photovoltaics' limitations and advantages;
- A belief that photovoltaics will not, in the near future, have a sales and service infrastructure.

Although bank officials remained skeptical after being interviewed, there appeared to be a consensus that they would consider photovoltaics as one energy alternative and would finance photovoltaic projects if they proved to be economically and financially viable and the borrower satisfied cash flow criteria corresponding to the size of the loan.

#### 4.4 Conclusions

Nigeria has an extensive financial network composed of both private and government owned financial institutions. The majority of investment funds are controlled by the privately owned commercial and merchant banks. These funds are available as short to medium-term capital loans primarily invested in industry, commerce, agriculture, real estate and public utilities. The Nigeria Agriculture and Development Bank and merchant banks are the major sources of long-term capital for agriculture.

A clear breakdown of what end-uses agricultural loans are applied to is unavailable. It is clear that capital availability for loans to the agricultural sector will not be a major problem facing use of PV systems. However, the creditworthiness of the borrower is generally of chief importance.

That photovoltaics is a reliable technology which enables the end-user to increase productivity remains to be demonstrated in Nigeria. For this reason it is believed that a large portion of early PV funding will not come through commercial financial institutions, but rather through government purchases.

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## 5.0 AGRICULTURAL SECTOR APPLICATIONS

In examining the most promising potential applications for photovoltaic systems in agriculture for Nigeria, several factors predominate. First, the key element which influences the photovoltaic market positively is the immense difficulty in rural areas of Nigeria of maintaining small gasoline and diesel engines. This was repeatedly mentioned during interviews with public sector individuals responsible for rural development and with private agricultural experts. The combination of local problems, such as dust in the north, and the difficulty in obtaining parts and in finding knowledgeable mechanics provide a major opportunity for PV systems, as small engine sets are currently the primary power sources in most rural areas of Nigeria. This situation is expected to improve slowly as Nigerians gain more familiarity and skill with mechanical systems and spare parts networks extend beyond the major cities.

Second, the key decision-making role of the Nigerian government, particularly with respect to agricultural activities, must be emphasized. As outlined in Chapter 3.0, the federal and state governments will play a major role in all aspects of rural and agricultural development.

Third, given the Green Revolution Plan, heavy reliance is being made on the Nigerian small holder as the centerpiece for indigenous food production increases. The Green Revolution Plan was developed by the Federal Government and the World Bank to improve Nigerian agriculture productivity. The plan provides the basis for the agriculture development activities called for in the fourth development plan. At present, the small holder cultivates almost entirely by hand without extensive use of draft animals, let alone tractors or other agricultural equipment. The Accelerated Development Areas (ADA), stemming from successful Agricultural Development Projects funded in part by the World Bank, provide an organizational mechanism for giving the small holder access to production inputs, expertise, and markets. Consequently, the federal and state governmental units are the most likely potential consumers of equipment such as photovoltaic systems for agricultural applications. In some cases, this equipment would be sold by the government to the farmers or to agricultural cooperatives at approximately half the original purchase price.

Fourth, loss of agricultural products from harvest to the table is extremely high. The state and Federal ministries of agriculture indicated that losses range from 35 percent to 60 percent or more, depending on the commodity. Consequently, preservation and loss reduction are considered a major area for investment, even greater than investment in technologies to increase production.

Finally, critically important to the small holder production strategy is the commitment, as part of the development of agriculture in Nigeria, to improve the quality of life in rural areas by bringing amenities to the villages. The emphasis on combined agricultural productivity increases and improvement in rural life is a centerpiece of the government's development plans for the next five years. The first priority is the provision of adequate supplies of safe drinking water, followed by access to health care facilities, improved access to education, and finally rural electrification. The commitment of the government to rural development is underscored by the level of funding and the schemes that have recently been announced.

Given the importance of rural and agricultural development in Nigeria, this study examined PV uses in agriculture and rural services.

The application evaluation was based on the following criteria:

- level of production and/or importance of the application to agriculture/rural development;
- type of operation and its adaptability to a PV power source;
- current and planned use of the application in Nigeria;
- costs of competing systems; and
- power and energy use profile required.

This process identified the following applications:

- Production Applications
  - Micro-irrigation
- Processing Applications
  - Grain-grinding
- Preservation Applications
  - Fans for dryers
  - Produce coolers

- Ice makers for fish preservation
- Refrigerators/freezers for veterinary applications
- Amenities for Small-Scale Producers
  - Village water suppliers
  - Village health centers
  - Education centers
  - Extension audiovisual aids.

### 5.1 Production Applications - Micro Irrigation

By far, the majority of agricultural production in Nigeria is rainfed. Large-scale irrigation is virtually unknown in Nigeria. River Basin Development Authorities in a number of states have large-scale water-control schemes, primarily utilizing large impoundments with extensive dam construction and some irrigation canals. The next five year development plan calls for 75,000 hectares to be irrigated (primarily in Imo, Niger, and Kano states) with over half of this resulting from large hydro-electric projects.

In the north, however, a traditional form of micro-irrigation is practiced in small river valleys called fadamas. These areas fill with water during the rainy season (May through August) and often become completely dry before the onset of the next rains. As the waters begin to recede, peasant farmers begin cultivation of rapidly growing fruit species and market vegetables. These intensively farmed patches (2 to 5 hectares) are irrigated using intricate channels and the traditional "shadouf" for lifting the water into the channels. The shadouf is a counterbalanced pole attached to a large calabash or gourd. The shadouf lifts the water approximately two to three meters at a rate of 20 to 30 liters per minute. It utilizes local materials for construction and human labor for power. The shadouf is portable and is moved as the water in the fadama recedes. Pumping systems would permit continuation of farming throughout the year by accessing sub-surface reservoirs of water. This would act to increase output as production levels are a direct function of water application.

Through observation and discussions it was determined that small pump-array sets lifting water from 5 to 30 meters would have many irrigation applications. The two primary applications would be: 1) in and around



fadama areas which would permit year round cropping in a single area, and;  
 2) use in areas where surface water is limited in the dry season to enable double cropping. The characteristics for these applications are shown below.

	<u>head</u>	<u>rate</u>	<u>land area</u>	<u>No. of applications</u>	<u>yearly operation</u>
Fadama	5-10 meters	20- 40 l/min.	3-5 hectares	5-10,000	7-8 months
Double cropping	10-30 meters	80-120 l/min.	4-9 hectares	NA	8-9 months

Such a pump would have to be durable, require very little service, and be protected against overheating if clogged or removed from the water.

The critical factor in such an application would be the cost. The issue for the farmer would be whether his income growth utilizing such a system would be sufficient to justify the expense. The team was not able to determine the economic benefits of such a system, but demonstration should be simple and straightforward. The pump systems would be eligible for government loans for agricultural inputs.

## 5.2 Processing Applications - Grain Grinding

In every village market, on the days when the markets are active, small gasoline-powered grinders can be found. These market grinders utilize one to two horsepower engines and grind a variety of cereal grains, nuts, etc. The pattern of operation is determined by the local conventions for market, which in some regions is daily, weekly, or every fourth day. The grinder operation times vary, ranging from intermittent to nearly continuous use (8-10 hours).

The most vulnerable aspect of these 2-5 hp grinding systems is the gasoline or diesel engine providing mechanical power. Even more than the usual problems associated with these small engines, the chaff and dust associated with threshing and milling causes filters to clog and the engines to fail frequently.

Small PV powered grinding power mills operating five to six days a week up to 8 hours/day could be a feasible alternative to gasoline and diesel powered mills. These types of grinding operations currently exist in most

market centers of over 500 people. Purchase of PV powered grinders would be either through local agricultural cooperatives, local governments or the National Grain Production Company. Approximately 1,000 conventional grinding/milling systems of this type are sold annually.

### 5.3 Preservation Applications

#### 5.3.1 Fans for Dryers

One of the primary causes for low agricultural productivity in Nigeria are losses associated with inadequate grain drying, and improper ventilation during storage. At present almost all grain is sun dried. The federal and state ministries of agriculture estimate that losses range from 35 to 60% per year. This problem will be exacerbated when double cropping is introduced since crops will then be harvested during the rainy season. The Nigerian government has recognized this problem and has allocated \$200 million for grain storage to the Nigerian Grains Board and the National Grains Production Company under the Fourth National Development Plan.

Currently small diesel powered dryers are being developed under the auspices of the Green Revolution Plan. The U.S. Agency for International Development supports 25 grain drying and storage facilities (each with a capacity of 100-200 tons of grain) in various locations in Nigeria. However, possibly due to cultural reasons, these facilities are rarely used. If the cultural biases can be overcome, small PV powered dryers could be effectively used in Nigeria. They could be similar to the dryers being developed by the International Rice Research Institute (1-2 hp electric fan, rice hull furnace, 1 MT/day capacity). They would effectively compete with the diesel dryers under development. The dryers' utilization rate would range from 4-10 hours/day for about 9 months of the year. The pre-1986 market for such dryers (if successfully demonstrated) would be on the order of 500-1000.

#### 5.3.2 Produce Coolers

Perishable fruits and vegetables are tremendously vulnerable to loss in tropical regions. If reliable produce coolers could be developed utilizing photovoltaic power supplies they would be ideal for providing high quality food for village consumption. Coolers of 12 to 15 cubic meters would be sufficient for small villages.

For larger applications a modular approach could be developed whereby these coolers could be aggregated into larger units. Such systems are not presently being utilized, so the development and design of such systems needs to be carried out in cooperation with local experts in agricultural production and marketing.

Power requirements for produce coolers would run approximately 1.5 KW\* and maintain a temperature of between 45 and 50°F. They would be in use year-round and be designed with a two day cold storage capability. The potential market for the coolers would be about 2,000-4,000 with the federal government and local agricultural cooperatives being the initial customers.

### 5.3.3 Ice Makers for Fish Preservation

Nigeria has reasonably rich marine and freshwater fishery resources. Lack of suitable preservation facilities and poor transportation infrastructures severely limits catch and consequent sales. Smoking and drying of fish are the most common means of preservation. However, due to poor technique losses are as high as 60-70%. Small ice production units producing 500 to 1,000 kilograms of ice per day would be suitable for fish preservation purposes. Such a unit would be sufficient for an equal weight of fish for a 48 hour preserving period.

The Ministry of Agriculture and local fishing cooperatives would be the initial buyers of these ice makers. The market for about 150 units exists. PV systems will compete with diesel powered compressors. The low maintenance characteristics of PV systems would be less of an advantage here, since most fishing villages have some experience in maintaining diesels.

### 5.3.4 Veterinary Units/Refrigerator-Freezers

The Ministry of Agriculture, Department of Livestock Production is endeavoring to improve practices in animal husbandry in Nigeria using modern methods of vaccination for disease prevention and control, and artificial insemination for herd improvement. These efforts are complicated by the difficulty of obtaining reliable refrigeration and freezer storage for vaccines, semen and medicines. In those rural areas where the grid is

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\*Thermoelectric heatpumps due to their lack of moving parts and low maintenance needs, could be an ideal source of cooling. However, their costs are greater than conventional refrigeration units.

available, it is unreliable; diesel and gasoline engine-generator power supplies too are of limited reliability. In the past, kerosene refrigerators have been utilized with difficulty. Thus, no feasible alternative to a reliable PV refrigeration unit exists.

The potential for use of photovoltaic-powered, small volume, high reliability, freezer-refrigerator systems is excellent. Contacts with several veterinarians in various levels of government in Nigeria have indicated enthusiasm for such systems. Each refrigerator would require approximately 200 watts of power. It might be desirable to provide PV generation capacity for veterinary centers for fluorescent lighting and other small electrical uses in addition to the refrigeration-freezer power needs.

The total power required for each of these facilities would be about 800-1000 W. This would include lights, refrigerator, sterilizer/distiller and a water pump. Currently, there are very few of these centers throughout the country; most of these are without power. The Fourth National Development Plan calls for an increase in veterinary centers although a specific number is not mentioned. Sources at the National Veterinary School in Jos suggest most of these would have no access to grid power. Each local government agency would have one. In the area of heavy livestock population, multiple centers would be required. The state and federal governments would provide the funds for these centers.

#### 5.4 Amenities for Small-Scale Producers

##### 5.4.1 Village Water Supplies

The greatest priority for rural development in Nigeria is providing rural villages with a clean, reliable source of drinking water. Minimally, this means sealing the dug well and providing a means of lifting the water. In most cases, however, it means drilling bore holes and providing a pump. In the northern states of Nigeria, water tables range from 10 to 100 meters deep.

In such schemes, water storage in 10,000 to 18,000 liter tanks is presently planned. This approach probably would allow PV systems to be installed with minimal or no battery storage. The sizing of pumps will depend on the required capacity, depth, etc., with 10 to 15 meters being

typical. Power requests are about 1.5-3 KW.

The life of diesel systems in pumping applications is estimated at between 3 months and 2 years, with most estimates suggesting the shorter time periods. The major problems facing diesels are availability of qualified maintenance labor, spare parts and fuel.

Many groups are involved in drilling bore holes and providing pumps: the state ministries of rural development, Federal Department of Rural Development in the Ministry of Agriculture, River Basin Development Authorities, Federal Ministry of Water Resources, and World Bank-funded Accelerated Development Projects. They will be potential buyers of PV powered pumps. In all cases, discussions yielded consistent responses concerning the inability to maintain and service the diesel or gasoline powered pumps. In Kano State, where the ministry of rural development plans 1,000 boreholes in the next five years, officials are considering use of an operator in each village to turn the pump on and off several times per day, and to service it as needed. These officials were not optimistic that even this measure would be effective, although they felt alternatives were extremely limited. It is estimated that as many as 10,000 boreholes may be drilled nationwide over the next five years, with the vast majority of these relying on diesel or gasoline powered pumping systems. The fourth development plan allocates over \$400 million for the drilling and powering of these water supplies.

#### 5.4.2 Village Health Centers

The unavailability of reliable electrical power poses severe limitations on small clinics in rural villages. Power is needed for: 1) small refrigerators and freezer units (200W) for storage of vaccines, perishable medications, and other supplies; 2) fluorescent lighting for examinations and operations (10-20W each); 3) halogenic or UV sterilizers (100W); 4) audio-visual equipment (400W); 5) radio transmitter (100W); and 6) a water pump, if a central water source is not available. The total load for these facilities would run about 1 kw and operate 9 to 10 hours/day. Reliability and low maintenance will be the major factors in purchase of any systems. A demonstration of the effectiveness of PV systems will be necessary for any significant number of sales to occur.

The Ministries of Health and Agriculture, and the Office of Rural Development will be the primary purchasers of such systems. Current plans

call for the expenditure of over \$200 million over the next five years on basic health service schemes, the primary element of which is development of local health clinics serving 2,000-5,000 people and providing basic medical care. The state governments are placing top priority on development of these clinics. It is expected that 100 to 200 of these local clinics may be built over the next five years.

#### 5.4.3 Education Centers

The application of diesel generators for school compounds is considered a necessity for staffing village schools in many parts of northern Nigeria. In many states there is great difficulty in obtaining the teachers for schools without at least a diesel generator. The generators which provide lighting for the compound and the other amenities necessary for the staff are subject to frequent breakdown. PV power supplies for school compounds could provide a relatively trouble-free source of power for isolated schools, allowing, in addition, the use of video cassettes and educational television, and lights for adult education programs. Sizing of systems will depend on the extent of electrification of each compound, but lighting and TV would require only modest systems.

The primary function is to provide power for lighting, water pumping and small motors. Depending on the size of the school, the load would fall somewhere between 400 w and 1.5 kw, operating for 5-10 hrs./day. The Nigerian Ministry of Education and the state governments plan to spend over \$500 million on renovation and construction of new secondary and technical schools throughout Nigeria over the next five years and the number of PV powered systems for such purposes could be about 500-1000.

#### 5.4.4 Extension Service Audiovisual Aids

Project directors in several agricultural development projects were interested in the potential for PV to power audiovisual equipment. Use of video cassettes or slide projectors should be possible with a simple battery charger utilizing PV cells. The Accelerated Development Projects planned for all the states in Nigeria are intending to utilize at least one extension agent per 500 farmers. Purchase of these systems would be through the Ministry of Agriculture and the state governments. The extension agent program is being

developed. The demand for PV powered systems might be about 80-100 systems per year. These systems would supply a load equivalent to about 100W operating for 1 to 2 hrs./day.

### 5.5 Summary

Table 5.1 shows a compilation of the estimated power requirements and the expected number of installations for the applications described in this chapter. These estimates form the basis for the cost analysis and market estimate conducted in the next chapter.

TABLE 5.1:

Agriculture/Rural Development Applications

<u>Application</u>	<u>Estimated Power Rating (KW)</u>	<u>Expected No. required 1982-1986</u>
Micro-Irrigation	1 -1.2	5,000
Veterinary Units	.8-1.0	200
Grinding	1.5	3,000-4,000
Dryer Fans	1 -1.5	500
Produce Coolers	1.5	2,000-4,000
Ice Makers	5	200
Water/Boreholes	1.5-3	5,000-10,000
Health Centers	1	100- 200
Education Centers	1 -1.5	500- 1,000
Extension Service	0.1	400- 500

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## 6.0 MARKET ASSESSMENT

### 6.1 Introduction

The PV market size estimates for the applications described in Chapter five are based upon a comparison of life-cycle costs for PV systems and conventional engine generator sets. Although cost comparisons is the major criterion, a number of other factors are critical to any decision making process in Nigeria. As a result market estimation included factors such as:

- reliability of system
- maintenance requirements and service network availability
- status associated with new technology
- Nigerian business practices which often encourage high initial costs.

A major factor influencing the market assessment was the lack of authoritative data or large variations in available data. For instance, the official national price for fuel is 90¢/gallon for diesel and \$1.15/gal. for gasoline. In major cities fuel was often available at these prices, whereas in rural areas prices ran as high as \$3.40/gallon for diesel, when it was available. Similarly, the lifetime of small diesel generator sets (under 15KWe) was estimated at anywhere from 2 months to three years, with no one interviewed reporting lifetimes greater than 4-5 years.

Given the importance of non-cost factors in Nigeria, the market estimation approach was to perform a cost-competitiveness analysis to obtain a preliminary estimate and then impose the non-quantitative factors to arrive at a final market estimate for PV system use in the Nigerian agriculture sector. Thus, the analysis is a blend of a formal cost-analysis and a more informal assessment of how markets may develop in Nigeria.

Section 6.2 briefly describes the methodology used in the market size assessment analysis. In Section 6.3 a series of cost-competitive analyses are described. These analyses identify the year in which PV becomes competitive (on a life-cycle cost basis) to conventional systems. Section 6.4 summarizes the market and institutional factors that constitute incentives and barriers to PV use. Section 6.5 presents potential market size estimates.

### 6.2 Market Assessment Methodology

Market size estimates are developed in two stages. In Stage 1, the life-cycle cost of PV systems is compared to that of the most competitive conventional power system for a variety of applications. For example, for



applications requiring a power capacity of about 1KW or less, the competitor is gasoline generators. For larger systems it is diesel generators. The life-cycle costs of PV systems and the competing conventional systems are calculated on an annual system purchase basis, from 1980 to 1990. When costs become equal, a PV system installed in that year costs as much as a conventional system installed in the same year, as measured on a life-cycle basis. Thus, the analysis enables one to determine when PV systems become competitive with conventional systems.

The second stage combines the results of the cost-analysis with non-cost factors to develop market size estimates for PV systems in the agricultural sector. Factors described in section 6.4 such as financing availability, equipment replacement rates and national development priorities are included to determine final market estimates.

### 6.3 Cost Analysis

The cost analyses are based on accepted life-cycle costing principles. The economic analysis compares to the life cycle costs of PV systems to its conventionally powered competitor to determine the first year of cost competitiveness of the PV system.

The analysis was run for the following four applications: 1) borehole pumps for village water supplies; 2) produce coolers; 3) veterinary centers; 4) micro-irrigation. These four applications were chosen, in part, because more data was available relative to other applications where the potential for PV may be as high. The basic assumptions used in the cost analysis are as follows:

Inflation*	0%
Discount Rate	12%
Loan Fraction	0
Life of Diesel/gasoline sets	5,000 hrs.
Fuel cost (diesel, gasoline)	\$0.90, \$1.15/gal.
Fuel Escalation rate	3%
PV system lifetime	20 years
Salvage Value	0
Labor Cost	
PV	\$2/hr.
Conventional	\$4/hr.

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\*All costs, and financial parameters measured in real terms after factoring out inflation.

Other assumptions used in the cost analyses are shown in Table 6.1 and 6.2. Table 6.3 shows the results of the analyses for the four applications indicating the necessary peak array size, the first year the PV system is competitive, and the life cycle cost per Kwh (1980\$) in the first year of cost-competitiveness.

In general, the cost-competitiveness of PV systems is most sensitive to the lifetime assumed for diesel systems. When short lifetimes are assumed (2-3 yrs,) most PV applications become cost-competitive by 1982. A major drawback to the credibility for this type of analysis in the Nigerian context is the use of life-cycle costing, a concept not widely used in Nigeria. Although some groups are beginning to use life-cycle analysis, usually the low-first cost approach to system or equipment selection is taken. Thus, greater awareness of life-cycle cost analysis, although slow in coming, will be of benefit in trying to sell PV systems in in Nigeria.

#### 6.4 Summary of Incentives and Barriers to PV Use in Agriculture

The purpose of this section is to summarize the major non-economic incentives and constraints to PV use in Nigerian agriculture. There are a variety of government policies, business and financial practices, and social/cultural factors which impact upon PV system utilization. For American PV manufacturers the constraints or barriers to the development of a PV market in Nigeria include:

- 1) The unfamiliarity with PV technology and lack of successful PV demonstrations;
- 2) The relatively cheap and stable price of oil in urban areas, although price and availability varies significantly in remote rural areas;
- 3) The conservatism in Nigeria towards "unproven" technologies. PV unlike other developed country technologies has not been thoroughly proven in the U.S. or Europe;
- 4) The possibility of foreign competition, particularly from the French, Germans and Japanese;
- 5) The lack of distribution, parts and service networks for PV; unavailability of skilled labor is an especially critical factor.

The major factors which will act as incentives to the use of PV systems in agriculture include:

- 1) The availability of capital through numerous channels, mostly resulting from oil revenues, particularly in the form of low-cost credit for agriculture;

Table 6.1 Cost Analysis Assumptions

1. Diesel Engines	<u>1KW</u>	<u>2KW</u>	<u>3KW</u>	<u>4KW</u>	<u>5KW</u>	<u>8KW</u>
cost (1980\$)	2,200	3,600	4,840	5,670	6,840	8,500
Fuel Consumption	0.26	0.33	0.37	0.43	0.52	0.64
gal/hour at full load						
2. PV System Costs *	1980	1982	1984	1986	1988	1990
\$/Wp (in 1980\$)	20.85	11.73	9.14	6.55	5.28	4.40
inclusive of batteries						
3. Average daily insolation = 390 langleys.						
4. O & M for PV system = 0.02 hours/KWp/operating day						
5. O & M for diesel system = 0.15 hours/hours of operation.						

\*Source: JPL, 1980 Program Summary Document

TABLE 6.2  
SYSTEM FACTORS\*

<u>System Factor</u>	<u>Borehole Water Supply</u>	<u>Micro-Irrigation</u>	<u>Produce Cooler</u>	<u>Veterinary Center</u>
Load Size Kw	3.1	1.2	1.2	1
Hrs used/day	8	6	9	8
Months used/yr.	12	8	12	12
Annual Kwh	8710	3700	4100	2880
Battery Storage Amp hrs.	0	0	eutectic salt & batteries	150
Conventional Engine Size (Kw)	4.0 diesel	2.0 diesel	2.0 diesel	1.0 gasoline

TABLE 6.3  
COST ANALYSIS

<u>Application</u>	<u>Array Size KWp</u>	<u>First Year of Cost-Competitiveness</u>	<u>Life Cycle Cost in \$/Kwh in First Year of Cost-Competitiveness</u>
Borehole pumping village water supply	6.0	1982	0.36
Micro-Irrigation	2.6	1983	0.45
Produce Cooler	3.7	1982	.51
Veterinary Center	2.1	1981	0.57

\* Specific details of the systems are provided in chapter five, i.e., gallons of water pumped/hr. and depths.

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- 2) Commitment of federal government to assisting small-scale agriculture and rural development, through supply of input factors including energy and the provision of basic amenities in rural sector (i.e., potable water, agriculture produce grinding and storage).
- 3) The limited nature of the utility grid including its unreliability and the prospects for slowed rural electrification program.
- 4) The low maintenance aspect of PV systems in a nation plagued by maintenance problems for conventional energy systems.

A summary of the relative degree of constraint/incentive for current Nigerian business and financial practices is provided in Table 6.4.

TABLE 6.4

CHARACTERIZATION OF BUSINESS ENVIRONMENT/FINANCIAL BARRIERS,  
CONSTRAINTS AND INCENTIVES TO PHOTOVOLTAICS

<u>Area</u>	<u>Present Status</u>	<u>Degree of Constraints /Incentives Towards Photovoltaics Relative to Conventional Power Generator Sets</u>
BUSINESS ENVIRONMENT		
Dealer/Importer/Manufacturer Relationship	● Dealers often act as exclusive agents for products	No effect
	● Credit terms range up to 60 days for small equipment-- installment payment terms for large items (25% deposit, two-year monthly installments).	Moderate disadvantage
Service/maintenance	● Dealers do not usually stock high value parts	Moderate disadvantage
	● Maintenance of small systems left to purchaser--large systems serviced by dealer.	Small disadvantage
	● Warranty terms are very limited on small conventional systems.	No effect
	● Major shortage of skilled workers for conventional generators.	Large advantage
Foreign Competition	● U.S. is 2nd or 3rd in motor generators set field.	No effect
	● U.S. technology generally well respected	Small advantage
	● Strong competition by Europeans and Japanese in alternators and motor market.	Moderate disadvantage
	● French and Germans are interested or are currently developing PV market. Japanese are monitoring situation.	Moderate disadvantage

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TABLE 6.4 (Cont.)

<u>Area</u>	<u>Present Status</u>	<u>Degree of Constraints/Incentives Towards Photovoltaics Relative to Conventional Power Generator Sets</u>
Investment Climate	● Investment in high cost projects are often preferred.	Large advantage
	● Government offers a number of financial incentives to manufacturers to site plants in Nigeria.	Moderate advantage
Standards and Regulations	● Generally, all U.S. standards are acceptable.	Small advantage
FINANCIAL PRACTICES		
Role and Responsibilities	● Government funded financial system would provide both long-term and short-term financing at low rates.	Small advantage
	● Privately-owned financial system provides short-term working capital.	Small advantage
Attitudes to PV	● Skepticism until technical feasibility demonstrated	Moderate disadvantage
Long-Term Investment Capital	● Capital available from both private and public sources	Large advantage
	● Total long-term capital available for agriculture and rural development is large.	Large advantage
	● Funding will be provided for many energy related public works projects.	Large advantage
	● Competition of PV for loans to provide other basic agricultural inputs	Moderate disadvantage
	● Interest rates between 3-11%	Moderate advantage
Loan Terms for Long-Term Loans	● High debt-equity ratio	Small advantage

TABLE 6.4 (Cont.)

<u>Area</u>	<u>Present Status</u>	<u>Degree of Constraints/Incentives Towards Photovoltaics Relative to Conventional Power Generator Sets</u>
	<ul style="list-style-type: none"> <li>● 2-6 year maturity</li> <li>● Loans range from \$10,000 to \$100,000 or more</li> </ul>	<p>Small disadvantage</p> <p>No effect</p>
<p>AWARENESS AND INTEREST IN PV</p>		
Public Sector	<ul style="list-style-type: none"> <li>● Lack of information on PV by government decision-makers.</li> <li>● Wait and see attitude towards PV by energy officials</li> <li>● Skepticism by planners that PV could compete with oil and gas</li> <li>● High interest in PV once characteristics are understood</li> </ul>	<p>Disadvantage</p> <p>Moderate disadvantage</p> <p>Moderate disadvantage</p> <p>Moderate advantage</p>
Private Sector	<ul style="list-style-type: none"> <li>● Active and enthusiastic entrepreneurial interest in PV by Nigerian businessmen</li> </ul>	<p>Small advantage</p>

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## 6.5 Market Size Estimation

Estimation of the number of sites for different applications is difficult in Nigeria. Furthermore, PV market size estimation methodologies that use current and projected gasoline and diesel generator sales as an indicator of possible PV sales can be misleading. This is so for two reasons: 1) in Nigeria most large diesel generators are used to provide back-up power in the case of grid power failure; 2) In many agricultural applications, gasoline and diesel engines are directly coupled to equipment, without the need for an electricity generator. Thus, even if fully known, generator sales are an inadequate indicator since they do not take into account a large segment of the feasible agricultural sector market. Secondly, in Nigeria, cost is often not the only major assessment factor. In many potential PV applications conventional systems are currently not used or are used with limited success. The market size estimation procedure begins by establishing a preliminary market size. This market size is defined as the KWh equivalent of the total number of cost-competitive applications in the 1981-86 timeframe. The preliminary estimates is then modified to reflect the non-economic constraints and incentives to achieving the potential market.

The primary criteria used were as follows:

- Extent of potential applications;
- Capital availability;
- Perceived problems of conventional energy systems;
- Technical barriers to PV use; primarily lack of demonstrations and incompatible load schedules;
- Institutional barriers; primarily hesitancy to accept new technologies, lack of awareness of PV possibilities and limitations, lack of awareness of life-cycle cost concepts, unique problems of conducting business in Nigeria (i.e., infrastructure problems, business practices).

These factors are subjectively weighted to reflect their relative importance to PV market penetration. One factor of particular importance is capital availability. Capital for PV system purchase is expected to be available from three sources; 1) the federal government; 2) the state governments; and 3) private sources. Of these three, federal funds will be available first, followed closely by private funds (currently available if packaged systems were available) and state funds. Private sources of capital are clearly the most difficult to estimate. However, they are assumed to be very large, judging by the high demand and even higher prices paid for luxury

consumer items in Nigeria. Capital available to states is in part a function of the national development plan. Federal support normally makes up about 60-70% of the states' budget. Total capital expenditure budgets for the 19 states over the next five years is approximately \$50.4 billion. Approximately \$10 billion of this will go for water and rural development projects. Federal funding available for PV systems is expected to be large (upwards of \$50 million) if PV systems are demonstrated to be technically feasible, have high reliability and meet some measure of cost-competitiveness.

Since there is considerable uncertainty in an estimating market size, two predictions are made based on two scenarios. The two scenarios used were as follows:

- The base case assumed a continuation of present conditions for PV awareness in Nigeria, and barriers and incentives summarized in the previous section continue to be relevant and applicable.
- The increased activity scenario assumes the PV systems are successfully demonstrated at an early date, increased government interest is realized, aggressive marketing is pursued by PV companies, and little improvement is made in use and service of conventional power systems.

The market estimates include those applications for which a formal cost-analysis was not applied. These additional applications have been described in Chapter 5. These applications have similar power and energy use characteristics to the ones for which a cost analysis was conducted. Thus, they will have similar cost-competitiveness characteristics. Estimates are also made for non-agricultural applications many of which are described in Chapter 7.

Table 6.5 gives estimates of market for PV systems in Nigeria for each scenario.

TABLE 6.5  
Estimates of PV Market Size  
in Nigerian Agriculture Sector (KWp)

<u>Year</u>	<u>Base Case</u>		<u>Increased Activity</u>	
	<u>Annual</u>	<u>Cumulative</u>	<u>Annual</u>	<u>Cumulative</u>
1981	15	15	50	50
1982	70	85	150	200
1983	350	435	400	550
1984	480	925	700	1250
1985	750	1675	1300	2550
1986	1250	1925	2100	4650

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## 6.6 Conclusions

There are many characteristics of the Nigerian agricultural sector and economy that will influence the market for PV systems. Below are listed the most and least favorable:

### Advantages

- Stated government policies towards rural and agricultural development;
- Availability of capital from both government and private sectors;
- Shortage of skilled labor for maintaining conventional systems;
- Short-life of conventional generating sets in rural applications.

### Disadvantages

- Potentially stable price of oil;
- Need for clear demonstration of technical reliability;
- Potential lack of marketing and service channels for PV systems;
- Lack of awareness of potential and possibilities for PV systems.

If present business practices continue, the market for PV power systems in the Nigerian agricultural sector and for rural services will be large. The most important factors are the availability of capital and the high premium placed on high reliability, low maintenance systems. The market will consist primarily of government-funded small power applications and government communications projects with some sales going to affluent individuals and corporations. In the 1982-1983 timeframe and beyond, the market for larger systems would begin to develop as soon as products are available in packaged systems. Cumulative market size in the 1981-1986 timeframe is estimated to be about 1.9 to 4.7 MWp.

The decision on whether to attempt penetration of Nigerian markets with PV systems must obviously be a careful one on the part of the U.S. companies, however it is, one that warrants serious consideration in view of the large potential market. Section 7 on other PV markets and Section 8 on Business Environment complete the picture of the Nigeria market potential.

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## 7.0 OTHER PV MARKETS

Although this study concentrated on potential market applications in the agriculture and rural development sectors, a significant demand for PV systems already exists for other applications or is likely to develop in the medium term. These applications are largely in the area of remote power for all types of communications systems. Other uses include cathodic protection, signalling devices, and domestic power systems.

It is important to note that these applications demand high reliability and convenience. In order to be competitive, PV systems must demonstrate this advantage effectively. Because of the lack of trained engineers, system assemblers and technicians, it will be very important for PV companies to provide complete systems (as opposed to providing just the modules and power conditioning equipment, for example) as well as making available service guarantees.

### 7.1 Electricity for Public Buildings

A high priority in Nigeria's Fourth National Development Plan and NEPA's rural electrification plans is the electrification of all local government centers. However, because of the slow pace of grid expansion, relatively more important facilities such as police headquarters may require electric power and communications links before grid connection takes place, thus necessitating stand-alone power systems. Already many facilities have diesel electric generator sets but experience serious maintenance and fuel supply problems as well as difficulty in keeping operating personnel in more isolated locations. Discussions with local government officials as well as high-ranking Federal Government sources indicated that because of these problems and also the political benefit to be gained from a PV demonstration in a local government headquarters, PV power systems may find a market in this sector. Marketing would be targeted directly toward state and local government officials.

### 7.2 Relay Stations for Military Communications

The Nigerian military has a great need for more reliable long-distance communications as the network of military posts and communication links expand. Currently, problems with diesel systems are sufficiently severe that the Army is often forced to use the commercial telephone network.

The military is known to be interested in alternate power systems for remote relay stations and the potential for replication of a successful PV demonstration could be significant in this high-priority application.

The stations operate twenty-four hours per day, but the exact power requirements of these systems are not known. These are typical military communications systems with all the associated redundancies of equipment. Many systems are grid connected using diesel generators as back-up sources of power. Although the military is known to be interested in alternate power supplies they are also known to be very cost-conscious. Officials indicated that total electric power for these stations including buildings, may be desired. Systems sold in this market would require high reliability, implying fully integrated systems with automatic back-up power and/or substantial battery snortage. Marketing should be directed toward the telecommunications and signalling divisions of the Nigerian Army, Air Force and Navy.

### 7.3 Rural TV Receivers

The number of TV sets in Nigeria is expanding rapidly, as are all markets for consumer electronics. Many sets are owned by consumers in rural locations which have no source of electric power and are operated by batteries which must be recharged approximately every week. The costs of battery recharging are not insignificant (about \$3 to \$4), and the inconvenience of this method provides an incentive for alternate systems. If PV-powered television sets became widely available at a reasonable price, this market could represent one of the largest potential applications for PV in Nigeria. Development of this potential will depend on:

- design of a PV module which is specifically made to fit the TV sets and batteries commonly in use in rural Nigeria, which contains all the necessary elements (including connecting cables, mounting rods, etc.) and which is of the minimum size required for powering the TV set (not a system designed to power TV, lighting and various home appliances);
- proper advertisement of the systems, emphasizing convenience and prestige aspects; and
- encouraging competition among various dealers to keep dealer margins to a minimum.

Marketing would be directed toward electronics dealers and consumer advertising channels.

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The market potential of PV for other home appliances such as lighting, fans and air conditioners is probably a small fraction of the potential for PV TV. For these other appliances, less expensive and relatively reliable alternatives do exist, and consumers are unlikely to invest in these appliances the relatively large sums which they would pay to have an independently-powered TV set.

#### 7.4 Television Relay and Repeater Stations

As part of its policy to expand national information and communications capabilities the federal government has required that Nigeria Television Authority programming be available anywhere in Nigeria. This will require microwave links or relay stations which are used to transmit signals from one major TV station to another and to zonal switching centers for local broadcasting. In general, a relay station needs a power source of about 1KW, necessitating a PV array of 3-4KWp in Nigeria. Over \$5 million has been committed to establishing this network of television links in the Fourth National Development Plan\*, and it is believed the Nigeria Television Authority is interested in PV power as an alternative to diesel generators. Marketing efforts should be directed toward the transmission division of the Nigeria Television Authority.

Repeater stations are smaller than relays and are used largely in rural areas to receive signals from the main TV stations and broadcast them to TV receiver sets in the surrounding area. Their power requirements are smaller than for relay stations, generally in the 120 to 600 W range and only operating during broadcasting hours. Because of the number of repeater stations necessary to provide TV to the whole of Nigeria, they will be well dispersed throughout the country with many requiring stand-alone power systems. Again marketing should be directed toward the Nigeria Television Authority.

#### 7.5 Cathodic Protection

Despite oil's importance to Nigeria's modern economy, the distribution network for petroleum products within Nigeria has remained relatively undeveloped. Many large pipeline and storage projects were started in

\*Fourth National Development Plan, p. 72

the previous development plan period in order to improve the existing network and are still under construction. Over \$1 billion is committed in this plan period for a variety of refinery, pipeline, storage and maintenance projects. Cathodic protection for pipelines and storage, and also for offshore drilling and production equipment in Nigeria's oil industry could be a significant PV market, especially given the highly corrosive conditions of Nigeria's coastal climate, where much of the oil industry is located. Marketing should be directed toward the Nigerian National Petroleum Corporation, which manages all oil sector programs.

#### 7.6 Transportation Applications

The use of PV power for small isolated transportation signalling devices is well known in the U.S. and is an application which makes equal if not more sense in developing countries where energy is a problem. The transportation sector in Nigeria is allocated over \$11 billion in the Fourth Development Plan, with funds going to virtually every aspect of road, rail, aviation and water transport systems. Both for replacement and installation of new signalling devices, the following applications are seen to represent substantial market potential for already available U.S. PV products:

- Marine Signals: light buoys, lighthouses and radio signallers in Nigeria's increasingly busy ports. Contact is the Port Authority within the Ministry of Transport.
- Airport Signals: advance landing strip radio beacons for Nigerian airports (3 international and 14 other commercial airports). Contact is Airports Authority within the Ministry of Transport;
- Rail Signals: switching devices, and lights for level crossings. Contact is the Nigerian Railway Corporation in the Ministry of Transport.

#### 7.7 Conclusions

It is difficult to know the size of these potential markets without exact knowledge of specific system expansion plans and the current power usage patterns. In some areas, such as the oil sector and transportation sector, data is likely to be available on existing equipment usage. The amount of funding for these growing sectors in Nigeria, coupled with a prevalent interest in new and alternate systems throughout the country, indicate strong market potential for PV.

## 8.0 BUSINESS ENVIRONMENT

### 8.1 U.S.-Nigerian Business Relations

Nigeria has a mixed economic system with both the public and private sectors involved in investment. Many activities such as utilities and transportation, petroleum production and all communications are state owned and controlled. Further, the Federal government exerts a large influence over other sectors of the economy through various policies, controlling investment priorities and participation in large projects as a minority or majority shareholder. However, private enterprise is strongly encouraged in commercial, industrial and agricultural-related activities, and fields such as mechanical and electronic equipment, textiles, food and manufacturing (although government is often a partner in many large enterprises). Both the Nigerian government and Nigerian businessman are keen to increase business ties with the U.S. The U.S. is Nigeria's largest trading partner and they are interested in continuing to expand these relationships. Although there is enthusiasm on the part of the Nigerians for doing business with the U.S., from the American business point of view Nigeria represents a large but not totally understood market. Although the potential problems of doing business in Nigeria have probably been exaggerated, differences from the American way of doing business do exist. Probably the most useful summary of these problems is contained in an OICD/USDA report,<sup>1</sup> which details prospects for U.S. agribusiness firms in Nigeria.

In general, business practices in Nigeria are similar to those of many developing countries, where firms will often be required to be flexible and creative in order to succeed. The Joint Agriculture Coordinating Committee (formed between Nigeria and the U.S. to promote agricultural related business) suggested basic guidelines for U.S. firms wishing to do business in Nigeria and are listed in Appendix B.

Since Nigerian law requires that any business in Nigeria be at least partially owned by Nigerians, obtaining a partner is an essential issue. Such partnership can be with federal or state governments or government backed organizations, private corporations, or individuals. A good partnership is essential so a careful choice is extremely important.

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<sup>1</sup>"Agricultural Investment in Nigeria," Op. Cit. - See P. 4-2



The issue of "payments" is one causing consternation to many U.S. firms and individuals. There are two general categories. The first, known as "dash", is generally a small amount paid as a "generous tip," operating as the "grease which keeps the cogs and wheels of business moving." Large commissions to government officials for assistance in securing contracts or reward for contracts secured are another matter. This category of payment for U.S. firms doing business in Nigeria falls within the purview of the Foreign Corrupt Practices Act of 1977. The penalties for actions covered by this act are significant for companies and corporate officers involved. Moreover, the Act requires "affirmative action" regarding nonviolation.

## 8.2 Level of Public Awareness

The level of knowledge about PV systems is in general very low throughout Nigeria. The most knowledgeable individuals interviewed were associated with universities, followed by agricultural ministry personnel. The Ministry of Science and Technology, is reported to have the highest degree of understanding of PV systems within Nigeria. Thus, an educational effort to raise the general level of awareness about PV systems must be undertaken. The awareness of PV systems is directly related to the overall general low level of awareness about energy systems. Thus, with the exception of a few key people, a major problem to developing a PV market in Nigeria will be the development of an understanding of the potential and limitations of PV and PV system applications. However, once the concept of PV is demonstrated or explained, a great deal of enthusiasm was developed during discussions with Nigerian officials.

A key to development of the PV market in Nigeria will be operational size demonstrations with high visibility. Throughout the trip this point was emphasized as basic before any substantial purchases would occur. If these demonstrations were successful, the purchase of PVs would surely follow. Capital cost, although a factor, did not appear to be the major determinant if the demonstrations proved successful. Reliability and low maintenance factors were perhaps the most critical factor. A number of options for demonstrations exist ranging from PV manufacturer funding to

total Nigerian government funding. Some form of cost-sharing will most likely be the quickest route to demonstration of PV capabilities.

### 8.3 Entrepreneurial Interest

There is currently little entrepreneurial interest in photovoltaics in Nigeria. However, in the instances where businessmen began to understand PV systems and potentials, a large degree of interest was generated. It was felt by most that PV could develop as a large industry within Nigeria, if it were demonstrated to be technologically feasible and highly reliable. Given the Nigerians' high business acumen, their level of interest in PV will be directly related to the technical feasibility of PV systems operating in Nigeria and the potential for profit. In general, Nigerian businessmen are interested in entering into partnerships with American businessmen.

To date, PV activities have been limited to preliminary operations by two U.S. PV firms with Nigerian partners and a French PV manufacturer. Given that no major PV system sales have occurred, the low level of entrepreneurial interest is understandable. However, based on numerous discussions, it is believed that once the general level of understanding is raised, a surge of entrepreneurial interest ranging from import to manufacturing enterprises will arise.

### 8.4 Summary of Nigerian Electric Generating Equipment Market

The bulk of small electric generating systems are sold from manufacturers through importer/dealers to end-users. A broad range of generating and water-pumping equipment is available through distributors in all major cities. Lagos is the main import center and supplies most of the country with equipment and parts. Most retailers only handle one or two brands of equipment which are supplied by a major import house (usually in Lagos) which handles only one brand of equipment. The major brand names are subsidiaries of foreign companies with Nigerian partners (up to 40% foreign equity) which normally act as the sole importer and wholesale distributor for that brand of equipment.

Credit is not generally extended in equipment purchases, particularly for small types of equipment. For larger generating sets, credit is sometimes available depending on the purchaser and the particular company selling the equipment.

Service on equipment sales and spare parts is limited outside of the major cities. The shortage of trained mechanics and parts outside of Lagos,

Kaduna, Port Harcourt, Enugu and a few other cities is severe. Even within the major cities service is a problem, due to the large number of private generating sets and the limited number of service personnel. In the case of large generating sets, 100KW and up, the supplier will sometimes extend a service contract (especially if a government agency is the purchaser). For smaller systems, however, either the end-user repairs and maintains the system, or it must be brought back to the place of purchase for service.

End-users in Nigeria tend not to be highly price-sensitive. Prices vary considerably throughout the country and often within the same city. Availability of equipment at the time of purchase is often a larger consideration than price.

Presently, British suppliers lead in the electric generator set field, followed by the Germans, Americans and Japanese. The largest British suppliers include Lister, Blackstone, and Perkins. The Germans who dominate the large diesel generator markets with MAN, Dentz and Mercedes Benz sets, also sell smaller sized (5-20KW) Bosch equipment in Nigeria. American equipment distributed in Nigeria includes Caterpillar (soon to be assembled in-country), Cummins, Wisconsin, Briggs and Stratton, Homelite, and McCulloch. The American equipment tends to be small, portable generating and pumping equipment (1 - 15KW) and to compete directly with the smaller Japanese equipment. The exception is Caterpillar, which sells larger generator sets to building constructors, etc., based upon their success with construction equipment. The Japanese sell small Honda and Yamaha engines, with Yamaha sets being assembled in Nigeria and receiving a direct price break as a result. The Japanese have been in the market only a short time and are the fastest growing segment of the sector.

The majority of engine sets are not sold for use in the agricultural sector. Larger systems 25KW and above are sold to private individuals and business as back-up to the often unreliable utility grid system. Smaller systems find large use in urban areas for construction projects, small power requirements and water pumping. Rural applications

of this type of equipment are limited primarily to applications requiring small, intermittent power, e.g., threshing.

Most equipment is imported fully assembled, the major exception being Yamaha generators which are assembled in-country (this does not include assembly of some larger systems broken down for transport).

The government is encouraging in-country manufacture of equipment, but realizes that this will be a slow effort given the low availability of mechanically skilled labor.

#### 8.5 Foreign PV Competition

Presently the French (Elf Oil) are the only country active in PV within Nigeria. They are currently developing a 5KW demonstration in Northwest Nigeria. This demonstration is being funded in part by the French government. The German MAN company has begun tentative discussions in Nigeria, but at present does not have any representation in Nigeria. The Japanese are not currently active in Nigeria, but have been monitoring the Nigerian market.

#### 8.6 Climate for Investment

The climate for U.S. investment in Nigeria is very good. The Nigerians wish to strengthen ties with the U.S. No specific provisions with respect to taxes, equity and tariffs for PV importation or in-country manufacture have been designated. As interest in PV develops, their status with regard to imports and in-country manufacture may change to favor use of this technology. An additional incentive to PV firms interested in Nigeria is Nigeria's central role in the Economic Community of West African States.

#### 8.7 Standards and Regulations

Generally, all U.S. standards are acceptable in Nigeria. The technical orientation of industry in Nigeria is British, with a major leaning towards U.S. standards.

#### 8.8 Government Regulations

Specific tariffs for PV systems have not been declared. In general, tariff rates vary depending upon the need for the product, whether there is an indigenous industry, or whether the product is brought in

fully assembled or requires in-country assembling. The rate for energy systems equipment is 15%. However, PV systems may be included in agricultural inputs and hence be subject to a very low tariff rate.

Foreign PV firms would be permitted to hold 40% equity in any Nigerian operation under present law. As the Nigerian foreign ownership schedule is presently structured, if PV systems were assembled in Nigeria foreign equity could be as much as 60%. The whole foreign ownership scheduling structure is currently under review with the likely outcome being that a loosening of the classifications and criteria will occur.

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ADVICE FOR DOING AGRIBUSINESS IN NIGERIA

THIS SECTION PRESENTS ADVICE TO U.S. FIRMS INTERESTED IN DOING AGRIBUSINESS IN NIGERIA. ADMITTEDLY SUBJECTIVE, THE ADVICE IS INCLUDED BECAUSE THERE EXISTS A STRONG OPINION AMONG MANY OBSERVERS--NIGERIAN, EUROPEAN AND AMERICAN--THAT U.S. COMPANIES MAKE SIMILAR MISTAKES IN THEIR APPROACH TO NIGERIA. AGRIBUSINESS ASSOCIATES HAS COMPILED THIS LIST BASED ON THE MOST FREQUENTLY REPEATED COMMENTS, COMPLAINTS AND SUGGESTIONS IN THE HOPE THAT IT WILL FACILITATE THE FORMATION OF NEW VENTURES.

AS A GENERALIZATION, THE ADVICE GIVEN BY MOST PEOPLE IS TO FOLLOW THE SAME PROCEDURES ONE WOULD NORMALLY FOLLOW WHEN EVALUATING A REGULAR PROJECT IN THE U.S., AND TO BE ADAPTIVE AND FLEXIBLE WHEN IMPLEMENTING IT. ONE FREQUENTLY HEARS ANECDOTES ABOUT THE U.S. BUSINESSMAN WHO MAKES A MILLION DOLLAR DEAL ON A HANDSHAKE AT THE AIRPORT--ONLY NEVER TO GET PAID. OR OF THE U.S. BUSINESSMAN WITH THE POTENTIAL OF DOING A LEGITIMATE MILLION DOLLAR DEAL WHO LOSES IT BECAUSE HE WILL NOT ADAPT TO A DIFFERENT STYLE OF BUSINESS. TO BUSINESSMEN WITH EXTENSIVE EXPERIENCE OVERSEAS, THIS SECTION WILL BE SIMPLISTIC AND OBVIOUS. TO THOSE WITHOUT SUCH EXPERIENCE, IT SHOULD HELP.

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1. Disregard Rumors; Come See for Yourself

It has been said that many decisions not to do business in Nigeria are made on the golf courses of U.S. corporate suburbia. American companies with business prospects in Nigeria sometimes abandon their investigation because of rumors from friends, bankers and competitors. Although it is true some companies have had bad experiences in Nigeria, many more have had good ones. Companies are well advised to investigate Nigeria on their own by actually visiting the country.

U.S. Agribusiness firms should conduct preliminary research about Nigeria in the U.S. Having identified promising areas in one's business field,

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send someone to investigate the business environment in person. Only if there is overwhelming evidence that Nigeria provides no opportunities should companies decide against visiting because the country defies judgment from afar. Some companies will be able to narrow significantly their scope of activity through research in the U.S. Other companies will have to visit Nigeria early in the process to gather needed data and develop initial leads. If one has heard rumors about business practices or bad experiences that competitors have had in one's line of business, verify or discount them scientifically by approaching the people who were involved or are familiar with the facts. Rumors normally distort facts and favor one perspective.

2. Come with Names if Possible

One's early experiences in Nigeria can be improved greatly if one has specific names of contacts or appointments. Letters of introduction are also very useful, especially if one anticipates making unannounced visits. Names of initial contacts can be obtained through several sources, including the various chambers of commerce, the Nigerian Embassy in the U.S., the U.S. Embassy in Nigeria, banks, consultants and other U.S. firms already established in Nigeria. Remember that the business culture is British derived and is sometimes more formal than in the U.S.

3. Allow Enough Time

Business in Nigeria, especially in the development stage of a project, moves slowly. To investigate the situation in Nigeria properly, allow more time than would be typical in the U.S. Broken phones, traffic jams, missed appointments and a generally slower business pace all consume time. U.S. firms sometimes schedule only a few days to "check out Nigeria" and leave unfulfilled, or worse, with a distorted and incomplete impression of the country and business opportunities. Completing three appointments per day as a newcomer is a reasonable objective. It is not unusual to spend a full

day in Lagos without successfully completing one appointment. As a basis for comparison, the record for any member of this report's study team was six. Having a sponsor, e.g., a possible venture partner, who uses his contacts to expedite interviewing can increase one's efficiency. It is not unusual for a person with whom one has an appointment to be out of town or the country without notice. Ask to see the person's assistant if this happens. The assistant may be able to help you.

Two weeks is a good length of time to visit on an initial exploratory trip. In that time, one can become acclimatized and gain a well-balanced first impression of the business environment and opportunities. If this amount of time is unacceptable for a senior executive, (remember it takes at least an additional day to travel each way), it might be advisable to send a junior executive first. The senior executive can follow one week later after the junior has sorted out some of the initial problems (hotels, cars, learning to get around town). This will save the senior executive time.

One should also be realistic about the amount of time it takes to plan and execute a project. U.S. firms are often criticized for spending too little time on the planning stage which causes problems during implementation. Few projects have been completed on time in Nigeria with margins of error for project timing as high as 100-200%.

4. Come as an Equal, Be Willing to Learn

Nigerians complain that U.S. executives sometimes come to Nigeria with an air of superiority. They also complain that U.S. businessmen arrive with a "know-it-all" attitude. This frequently alienates local businessmen who normally are well-educated and sensitive to their own business needs and options. Although Nigerian firms gladly admit the technical and managerial superiority of U.S. firms, they are offended when foreign firms disregard

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their accumulated experience in the local environment. The traditions, customs and style of Nigerian business are different from those in the U.S. The U.S. firm that does not learn from his Nigerian counterpart is likely to encounter problems. Nigerians have a strong sense of their own independence and prerogatives and appreciate recognition of this.

5. Study Your Market

Before committing substantial resources to a joint venture, undertake a complete feasibility study which examines the market in detail and analyzes how one's particular business relates to that market. U.S. companies have a reputation among some observers as being too cautious in the early stages of a project and too careless and impatient in the implementation of the project. A cautious attitude throughout the project will help avoid serious problems. Careful market analysis will often reveal subtle distinctions in a market which can affect profitability. For example, although eggs sell at a very high price throughout most of the country (about \$3.50 a dozen), which might lead one to conclude an egg farm would be a good venture, there have been instances where local egg gluts have depressed prices below the cost of efficient production. A study which examined local conditions would reveal this. Normal project selection criteria used in the United States should be used for project feasibility studies in Nigeria including consideration of price, labor, management, local and national politics, Government policy, location, logistics, cash flow--to name but a few.

Be sensitive to ulterior motives that partners might have for favoring a particular project (e.g., it is located in his home state, his friend controls the land), and do not hesitate to suggest alternatives.

When studying a project, do not make assumptions about important links in the project, such as ownership of assets, access to markets, licensing and

sources of capital. Sometimes U.S. companies are unwilling to get involved in important parts of the business which they do not understand. Rather, they take their partner's word that particular conditions for the project have been met. Some U.S. companies take leaps of faith in Nigeria that they would never take for a project in the U.S. and have subsequently poor experiences. Objectively identify and analyze which aspects of the project have been relegated to the partner and request empirical verification of their completion. For example, a partner who says he has access to land should be asked to present a Certificate of Occupancy. A partner who claims to have sources of financing for the project should be asked for a bank statement. A partner whose "well placed friend" will buy 50% of your production should present his friend for discussions or contract negotiations. As simple as it sounds, naive assumptions have spoiled more than one venture in Nigeria.

6. Follow Procedures Correctly

The American philosophy that the shortest distance between two points is a shortcut does not work in Nigeria. One of the vestiges of the British colonial system is a set of bureaucracies that operate by well-defined procedures. Whereas in the U.S. business ventures can often be expedited by short-circuiting or innovating with procedure, in Nigeria this usually causes problems. For any venture, identify what steps must be taken, the order in which they must be taken and then proceed meticulously along that path. Although it is possible to avoid or delay certain steps in the process of establishing and operating a business in Nigeria, such shortcuts will normally cause complications in the future.

7. Follow the Spirit of Government Policy

Related to the issue of procedure is the issue of supporting the spirit of the law as well as its letter. Businesses in the U.S., as a rule, are geared to satisfying the nominal requirements of law and policy. In

Nigeria, U.S. firms are well advised to follow and act consistently with the spirit of what the Government is trying to accomplish. Foreign ventures are visible and are looked to by the Government to help pioneer and implement the country's development objectives. Moral suasion is often used by the Government with foreign firms. Firms can greatly ease their experience in Nigeria by anticipating, interpreting and supporting Government objectives. This process is sometimes complicated by the promulgation of laws which are difficult to obey and hence, are sometimes disregarded (e.g. price controls). Properly interpreting the importance of laws and deciding how to act to support them is a skill which can be acquired only through experience. Nigerian partners are a good source of advice on this issue.

8. Commit Yourself

Another complaint about U.S. firms is that they do not adequately commit themselves to projects. Commitment can be measured by either financial participation, physical presence or attitude. The venture partners or government will probably require some type of financial participation, either in equity or debt. The amount of financial commitment a firm is willing to assume can best be judged by the specific firm. More important, however, is physical presence and attitude. Some U.S. firms try to manage their operations in Nigeria from home. A physical presence either through full-time U.S. personnel or third-party expatriates (e.g., Indian or British) greatly improves the chances of a project's success.

9. Remain Sensitive to Local Politics

Nigeria has a long history of tribal and political rivalry. Today, the rivalries continue in varying degrees and sometimes strongly influence economic relationships. Any U.S. company planning business in Nigeria should be sensitive to the dynamics between the State and Federal governments, the political parties and local traditional leaders. By allying oneself too closely with a particular interest group, one risks complications if a particular aspect of one's business later depends on cooperation by rivals. By building a staff which represents all major political groups and by avoiding the appearance of associating oneself too closely to a particular power base, one can avoid such complications.



## Appendix C

### Nigerian Agriculture

Production from smallholders makes up about 90-95% of agricultural production in Nigeria. Mechanized production is relatively insignificant, perhaps covering 1.3% of the total land area cultivated. Mechanized large-farm government schemes have not met with much success, and yields have been disappointing. Many schemes have been abandoned or scaled down. There are only a few privately operated large scale commercial farms. Almost every state has a government tractor hiring unit (THU), but cost per cultivated hectare to both government and farmers, plus high rate of break downs with lack of spare parts, and poor quality of tractor operators and lack of trained managers, has caused underutilization of this equipment.

Large-scale irrigation schemes have been planned by the government which would eventually cover some 66,000 hectares.

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#### Cocoa

3% of the arable land devoted to this crop; 210,000 MT of production; an export value of \$502,000,000

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Nigeria has slipped from second world producer of cocoa to a position of fourth, though cocoa still accounts for 40% of all export earnings except petroleum. Ninety-five percent of the cocoa is produced in the cocoa belt of the West and is raised almost exclusively by traditional farmers on an average of one hectare.

Food crops are raised on the cocoa farms during the first four years when the cocoa is not bearing any fruit. Harvest of cocoa takes place between October and February when the farmer is usually obliged to employ hired labor to gather the crops and tend beans during fermentation. Fermentation consists of heaping beans from newly harvested pods together and covering them with plantain leaves so that white pulp around the beans can turn into liquid and be drained away. Care is required in turning the heap at least twice so as to ensure even fermentation.

Three hundred thousand farmers in Western Nigeria are directly engaged in cocoa production, and about a third of the region's population are

dependent on the various processes of cocoa production. Large-scale spraying against black pod and capsid started in 1956, and today all farmers are capable of using spraying equipment which may be purchased in any central place within the cocoa belt.

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Rubber

Around 200,000 hectares in rubber;  
\$28,000,000 in export value

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Rubber is primarily produced in the Benin lowlands in the West and around Calabar in the East. In Benin, traditional smallholders on ½-10 ha. of land predominate, and produce over 75% of the export rubber of the country. The quality of rubber is often poor because of poor smoking and excess tapping by share-tappers. Recently the government has given assistance in the building of smokehouses where better rubber sheets can be produced.

Rubber production has declined by 25% since the early 1970's, and some plants have been forced to shut down.

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Palm Products

340,000 MT production of palm kernels;  
660,000 MT production of palm oil;  
\$3,750,000 export value of both crops,  
mostly palm kernels

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Southeastern Nigeria is the main producing area of palm oil and palm kernel. The oil palm is indigenous to this forest belt. A few farmers now cultivate palm trees, but by far the greater majority cultivate the wild trees from which comes about 90% of the oil. Oil palms on compoundlands belong to the owner of the compound, and this applies to palms on farmland under cultivation. Wild palms are under communal ownership, often harvested for the common purse of the village for community development projects. Pioneer oil mills are faced with problems of inadequate and irregular supply of fruits.

At least 85% of the palm oil exported from Nigeria comes from the Eastern States. For good quality oil the fruit must be processed not more

than 48 hours after cutting, but in most villages it takes as much as five to seven days to extract the fruits from the bunch in readiness for steaming. The fatty acid which forms during this period, in which considerable fermentation takes place, is largely responsible for the poor quality.

Pounding separates the pulp from the nuts, the former being squeezed by hand to produce the oil. The hand press extracts more oil, but it is still necessary to steam and pound the fruits before feeding the pulp to the press. The economics of using the press therefore depend largely on whether the two hours saved per gallon of oil extracted is worth the tariff paid for using the press. Pioneer oil mills extract up to 85% of the oil but were met with firm opposition from the women who feared the loss of their traditional share of the proceeds. Many of the mills have failed to pay their way and have since been demolished.

Palm fruits gathered in the eastern delta are, after cutting, softened under a leaf cover in the sun for a few days before being stripped off from the bunch. They are then thrown into large canoe-like troughs and trodden on by 2-4 men until the fruits are reduced to pulp, nuts and oil. The oil is scooped out at one end of the trough and stored in kerosene tins or calabashes. Water is then added to the remaining pulp which is retreaded so that oil comes to the surface to be collected. The oil is then boiled to remove impurities.

Palm oil has declined in production, edible oil unable to meet even domestic demand. Export is in palm kernels and palm kernel oil. Six companies are engaged in kernel crushing and fifteen in palm oil processing.

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Pulses

18% of the arable land devoted to pulses;  
800,000 MT production

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Pulses are an important protein source for the diet of Nigerians and important as a feedstuff for livestock. Cow-peas are the most widely distributed and produced legume in the country, and almost always grown in mixed cultivation. It is cooked and eaten with nearly every other food product in Nigeria--from fish to grain. The stems and leaves, as well as

husks, are a valuable food for livestock. Under present practices yields are extremely low, less than 200kg/hectare. Insects are the principal constraint to higher yields. Storage losses amount to another 2% of production.

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Groundnuts

4% of the arable land devoted to this crop; 800,000 MT production; \$4,000,000 in export value

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Nigeria used to be the largest exporter of groundnuts in the world. Production dropped drastically in the 1970's to an average of 200,000 MT due to drought and declining yields. There has been a steady deterioration in price relationships between groundnuts and food crops leading to some smuggling for alternate markets though the area planted to groundnuts has remained the same.

The groundnut belt lies almost wholly within the Kano region where the crop was formerly grown for subsistence. As with cocoa in the South, groundnut expansion in the Kano region has been carried out by the local farmers. Harvesting consists of pulling out the plants by hand and hoeing the ridges to uncover nuts. Nuts are then picked and dried in the sun after which they may be shelled or sold unshelled. Nuts meant for export are usually shelled, the shelling and winnowing done by women who use wooden mortar and pestle to beat out the shell.

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Cotton

2% of the arable land devoted to this crop; 220,000 MT production of seed cotton; 73,000 MT production of cotton lint; \$2,000,000 export value

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Cotton is a traditional export crop, but sometimes erratic production means that even local demands are not met and mills (15 ginneries and 70 textile mills) are run at less than full capacity. Cotton is grown in the northern region by traditional farmers.

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Sorghum

25% of arable land devoted to this crop;  
a production of 3,750,000 MT

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Sorghum, or guinea corn, is the most important staple cereal crop grown in Nigeria. Its cultivation is primarily in the North, most often in mixed cultivation with millet, and produced by smallholders. Sorghum takes 4-6 months to mature; harvesting takes place between November and January; and collected heads are allowed to dry. The grain is used primarily as dawa, a fermented food, and provides a valuable source of carbohydrate in this form. Sorghum is richer in protein than any other cereal in West Africa and ten times richer than root crops.

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Millet

22% of arable land devoted to this crop;  
2,600,000 MT of production

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Millet is the staple cereal where the climate is too dry for sorghum. It can grow and thrive in arid areas better than any other crop. The crop is grown by smallholders, usually in mixed cultivation with sorghum or with cow-peas and groundnuts. The grain is used in the same way as sorghum.

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Maize

8% of arable land devoted to this crop;  
a production of 1,400,000 MT

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Maize is the third most important cereal crop in Nigeria and is grown largely in the rainforest and savanna zones by smallholders. It is widely used as food for man and livestock. Fresh unripe maize is eaten, or it is roasted or boiled. Ripe, dried grains are cooked in combination with pulses and oil and eaten as adalu. Dried grains are also milled and made into a porridge, most often combined with other foods. Corn mills are to be found near most large market areas. Corn is also widely used as feed for all livestock.

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Rice

1% of the arable land devoted to this  
crop; 600,000 MT of production

Swamp rice along the Niger and Kaduna fadama constitute one of the major rice producing areas in Nigeria where irrigation canals carry water to the rice fields. Mechanization has been introduced but payment prices are high enough so that many farmers do not make use of the service. In Sokoto, in the Northern Region, 10,000 hectares of rice are at times mechanically plowed. The Western Nigeria Development Board offers mechanized cultivation services for about 40% of the crop.

Improved varieties are already extensively cultivated. It has been estimated that better water control could increase yields from 1.3 MT/hectare to 3-4 MT/hectare.

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Cassava

5% of arable land devoted to this crop;  
10,600,000 MT of production

Cassava and yam make up most of the root crop production of Nigeria. Cassava is grown all over the country (yam being restricted by water requirements), and both crops are grown by smallholders and generally in mixed cultivation.

Apart from weeding, cassava requires very little attention; it is highly productive even in poor soils, and can remain in the ground for long lengths of time before harvesting is required. Harvesting is done by digging the tubers by hand after the plant has been topped. Mechanical harvesting reduces yields considerably due to the percentage of roots left in the ground.

Gari and fufu are the popular ways of eating cassava. In the traditional method, gari is made grating the tuber in a flat-shaped tin grater, collecting the pulp in a knit bag and weighing it down with stones for 2-3 days while moisture is lost and some fermentation occurs. Then it is passed through a sieve to remove lumps and heated over a slow fire until dry. Fufu

is prepared by peeling and slicing the root, drying slices in the sun, then milling it into fufu powder. Some mechanized commercial production of gari is now available through gari factories in three states to supply the increased urban demand for this food.

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## APPENDIX D

### SOLAR INSOLATION IN NIGERIA

Present solar insolation data is limited to two sources in Nigeria, the Tropical Agricultural Research Institute in Ibadan and the University of Nigeria at Nsukka. The major factors affecting insolation are the rainy season (May-September) in which there is intermittent sunshine, and the Harmattan season (dusty winds of the Sahara desert which blow from November through March). These winds virtually preclude the use of concentrating systems due to the high dust content in the air, particularly in the north.

The insolation data was taken from Ibadan (southwest Nigeria 100 miles north of Lagos) and represents the most complete data found during this study. No data was found for the more Sahelian-like part of the country. The data from the Nsukka site was written up in the first volume of the Nigerian Journal of Solar Energy. The summary of the insolation data analysis is shown below.

#### Conclusions

A preliminary analysis of the insolation data obtained at Nsukka using a pyranometer has been carried out. Some of the main conclusions are:

- (a) Most of the days are cloudy giving rise to a relatively small average fractional insolation of about 0.47. Also a large part of the observed insolation is due to diffuse scattering so the use of solar concentrators may not be feasible.
- (b) The average daily insolation is  $311 \pm 24$  langelys per day and is not subject to wide fluctuations. About 90% of this value is obtained in the period between 08 hours and 18 hours local.

TABLE 1. SUMMARY OF CLIMATIC DATA FOR 1979: - IITA CENTRAL STATION

MONTHS	TOTAL RAIN- FALL (MM)	TOTAL EVAPO- RATION ( MM )	SOLAR RADIA- TION langleys/day	TEMPERATURE °C		REL-HUM %		MEAN TEMP °C	MEAN REL-HUM %
				MIN	MAX	MIN	MAX		
JAN.	0	120.84	375.43	22.8	32.5	42	98	27.8	70
FEB.	3.6	170.26	470.72	23.9	34.9	32	97	29.4	65
MAR.	76.5	181.10*	480.19	23.4	33.7	42	96	28.5	69
APR.	178.1	146.97*	493.04	23.7	32.3	53	97	28.0	75
MAY	205.4	139.70*	465.83	22.8	30.4	61	97	26.6	79
JUN.	133.8	98.30	392.47	23.0	29.1	66	97	26.1	82
JUL.	290.6	100.20*	398.39	22.6	28.5	67	97	25.5	82
AUG.	184.8	94.96*	371.61	22.7	28.0	68	97	25.4	83
SEPT.	259.4	111.10*	411.84	22.0	28.6	65	97	25.4	81
OCT.	156.4	112.13*	424.12	22.6	29.8	61	96	26.3	79
NOV.	18.1	101.71	414.12	23.2	30.4	57	96	26.8	77
DEC.	0	109.60*	405.49	20.3	31.1	41	97	25.7	69

\* Values adjusted for days with missing data.

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TABLE 2. SUMMARY OF CLIMATIC DATA: 1978  
 Weather Bulletin (IITA) Jan-Dec. 1978

	J	F	M	A	M	J	J	A	S	O	N	D
Wind Speed mph	2.27	3.16	2.9	2.6	2.4	2.78	3.1	2.9	2.83	2.4	1.79	2.1
Solar Radiation langleys/day	427.6	465.0	478.1	448.7	424.5	388.8	302.1	301.6	336.1	411.4	463.1	410.4
Min. Temperature (°C)	19.7	20.3	23.2	23.1	22.9	22.8	21.6	21.7	21.5	22.5	21.3	22.1
Max. Temperature (°C)	33.1	35.0	32.7	31.0	30.5	29.1	26.7	27.3	27.6	29.3	30.9	31.4

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TABLE 3. SUMMARY OF CLIMATIC DATA: 1977

Weather Bulletin (IITA) Jan.-Dec. 1977

	J	F	M	A	M	J	J	A	S	O	N	D
Total Evaporation	120.68mm	146.72	170.4	191.7	168.8	111.99	97.3	84.36	93.85	126.35	134.1	134.48
Average Rainfall	1.7 mm	0	0.65	3.1	3.27	4.88	3.05	1.92	4.7	6.67	0	-
Average Windspeed	2.2 mph	2.4	3.1	3.3	3.08	2.94	2.92	3.38	2.5	2.20	1.8	2.08
Average Solar Radiation langleys	350.7	411.57	429.26	441.84	458.25	365.25	308.2	274.72	342.72	412.23	471.16	371.6
Average Min. Temp.	22.6°C	22.2	23.6	22.7	27.7	22.3	22.1	21.6	22.0	22.0	22.0	20.4
Average Max. Temp.	31.6°C	32.2	35.3	33.5	31.5	28.9	27.5	26.7	28.4	29.6	31.9	31.8

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TABLE 4. SUMMARY OF CLIMATIC DATA: 1976  
 Weather Bulletin Data 1976

	J	F	M	A	M	J	J	A	S	O
TOTAL Rainfall mm	0	13.3	79.7	97.1	131.1	265.3	44.6	22.0	78.2	232.6
AVERAGE Wind- speed mph	2.0	3.1	3.02	3.0	2.5	2.53	3.1	2.9	3.0	2.5
Solar Radia- tion langleys	375.74	393.31	407.1	410.74	418.11	398.64	288.78	250.31	328.37	345.06

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Table 5. SUMMARY OF CLIMATIC DATA FOR 1975 :- RUN-OFF STATION

MONTHS	TOTAL RAINFALL mm	TOTAL EVAPO- RATION mm	SOLAR RADIATION langleys/day	TEMPERATURE °C		RELATIVE HUMIDITY %		MEAN TEMPE- RATURE °C	MEAN RELATIVE HUMIDITY %
				MIN	MAX	MIN	MAX		
JAN.	NIL	142.12	372.41	16.9	34.0	21	91	25.5	56
FEB.	74.4	136.12	435.77	21.6	34.7	35	92	28.2	64
MAR.	89.5	165.83	460.42	23.3	34.7	46	95	29.0	71
APR.	194.1	145.80*	499.71	22.3	33.1	56	98	27.7	77
MAY	203.7	133.92*	441.94	22.2	31.9	62	97	27.1	80
JUNE	190.6	121.87*	446.41	22.5	31.1	62	97	26.8	80
JULY	147.1	96.52*	349.06	22.1	29.3	68	97	25.7	83
AUG.	94.0	76.87*	287.22	22.0	27.9	73	97	24.9	85
SEPT.	112.9	79.33*	284.32	21.1	28.4	69	98	24.8	84
OCT.	205.1	117.59	377.26	20.9	30.2	58	97	25.6	77
NOV.	58.3	110.92*	371.11	22.3	31.8	52	99	27.0	75
DEC.	18.8	100.66*	368.11	19.3	31.9	40	95	25.6	68

\* Values adjusted for days with missing data.

TABLE 6.. SUMMARY OF CLIMATIC DATA FOR 1974: IITA (BLOCK A)

MONTHS	TOTAL	TOTAL	SOLAR	TEMPERATURE		RELATIVE		MEAN	MEAN
	RAINFALL	EVAPOR-	RADIATION	°C		HUMIDITY %		TEMPE-	RELATIVE
	mm	RATION	langleys/day	MIN	MAX	MIN	MAX	RATURE	HUMIDITY
		mm						°C	%
JAN.	1.9	115.33	330.26	20.1	32.5	32	91	26.3	62
FEB.	NIL	136.17	397.41	22.9	35.1	29	91	29.0	60
MAR.	85.1	174.22	501.51	23.9	35.5	37	91	29.7	64
APR.	172.3	134.70	468.56	22.5	32.6	54	93	27.6	74
MAY.	129.0	121.83	422.65	22.7	31.9	57	93	27.3	75
JUNE	172.0	115.20	427.26	22.1	30.9	61	94	26.5	78
JULY	232.1	97.35	381.37	22.0	28.9	64	93	25.5	79
AUG.	47.8	90.21	354.66	22.3	29.6	63	94	25.9	78
SEP.	134.2	86.40	374.61	22.1	29.2	65	94	25.6	80
OCT.	170.9	99.20	401.75	21.9	30.4	61	92	26.1	77
NOV.	34.8	105.00	455.47	21.8	32.9	46	93	27.4	69
DEC.	NIL	119.82	394.03	19.2	32.8	37	96	26.0	67

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Table 7. Summary Of Climatic Data For 1973: IITA (Block A).

Months	Total Rainfall (mm)	Total Evaporation (mm)	Average Solar Radiation langleys/day	Average Temperature °C		Average Relative Humidity		Average Mean Temperature (°C)	Average Mean Relative Humidity
				MIN	MAX	MIN	MAX		
JAN.	1.3	132.6	367.0	24.1	34.6	58	95	29.4	77
FEB.	13.3	159.6	455.4	24.5	35.5	46	95	30.5	71
MAR.	64.4	167.2	451.6	23.2	34.1	35	92	28.7	64
APR.	134.4	143.0	495.9	24.1	33.1	52	95	28.6	74
MAY	73.	142.9	470.5	22.7	32.2	53	95	27.5	74
JUN.	175.1	110.0	401.4	21.9	30.1	61	93	26.0	77
JUL.	176.8	108.7	393.9	21.8	29.1	62	92	25.5	7
AUG.	292.0	92.2	396.7	21.6	28.7	63	92	25.2	78
SEP.	243.3	96.3	420.3	21.5	29.0	64	95	25.3	80
OCT.	170.8	122.1	463.6	21.8	31.4	57	92	26.6	75
NOV.	T	121.4	471.6	21.9	33.6	40	94	27.8	67
DEC.	7.2	103.8	380.5	22.8	33.2	43	94	28.1	69



APPENDIX E  
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