SOLAR ENERGY RESEARCH CENTRE

SOKOTO

A DESIGN PROPOSAL

BY

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DECLARATION

I hereby declare that the information contained in this Thesis is the result of an honest research undertaken by me and that no part of it had been accepted for publication in any journal or magazine.

All sources of information have been duely acknowledged or otherwise direct references to texts have been quoted with sources and also acknowledged.

RAJI MOHAMMED HADDY	30102007 **DATE**

CERTIFICATION

This Thesis entitled: **Solar Energy Research Centre Sokoto** meets the regulations governing the award of the Degree of Master of Science in Architecture (M.Sc. Arch) of Ahmadu Bello University, Zaria, and is approved for its contribution to knowledge and literary presentation.

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DEDICATION

This thesis work is dedicated to my parent Alhaji A. P. Raji and my mother Mrs. M. A Raji.

ACKNOWLEDGEMENT

I am most grateful to Almighty God, the giver and the sustainer of life who made everything I have achieved possible.

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ABSTRACT

Global energy demand has increase tremendously overtime; constraints impose by the prevailing energy crises resulted in the search for a viable alternative of energy development. Energy sources from fossil fuels and related renewable types arc not enough due to shortage, fluctuations and the hike in price.

This research intends to highlights the imperatives of Solar Energy as an alternative source of energy supply. The research focuses its attention to the fundamentals of International Energy Agency (I.E.A), which encourages energy potential nations in Solar and Nuclear etc to established energy research commissions. This led to decree establishment of Solar and Nuclear Centres in Nigeria, as a potential energy zone. The essence of which is to see to the development of Solar and Nuclear raw materials as a viable means of power supply, for industrial, domestic and even export demand. The Nigerian Solar and Nuclear Energy Commission, which is under the Presidency, is affiliated and sited in some academic Institutions for the purpose of achieving such energy objectives.

This research is concern with the Solar Energy Programme, in terms of environmental research and Architectural requirements. Currently, the main Solar Energy Research Centre in Sokoto, as a research agency is in-adequately functional, there is a need for a standard and well equipped Energy Research Centre in order to achieve the goals and objective of the Solar Energy Research Development in this nation.

TABLE OF CONTENT

		Page
Title Page...		i
Declaration ...		ii
Certificate		iii
Dedication ...		iv
Acknowledgement ...		v
Abstract		vi
Table of Content...		vii
List of Table ...		xii
List of Figures ...		xiii
List of Plates...		xiv
CHAPTER ONE: INTRODUCTION		
1.1 Problem Definition ...		1
1.2 Aim and Objectives ...		4
1.3 Motivation ...		4
1.4 Architectural Significance ...		5
1.5 Research Methodology		5
1.6 Scope of Work...		6
1.7 Constraints and Limitations ...		7

CHAPTER: TWO HISTORICAL DEVELOPMENT OF SOLAR ENERGY SYSTEM

2.1. Origin and Essence of Solar Energy... 9

2.2 Type of Renewable Energy Sources... 10

2.3 The Sun... 11

2.4 Early Uses of Passive Solar Energy 12

2.5 Early Uses of Active Solar Energy 13

CHAPTER THREE: APPLICATION OF SOLAR ENERGY

3.1 Applied Solar Energy System... 15

3.2 Solar Electricity Production 16

3.3 Photoelectric Conversions 16

3.4 Solar – thermal Power Generation 16

3.5 Chemical Conversion 17

3.6 Mechanical Conversion 18

3.7 Heat Pumps 18

3.8 Solar Heating... 19

3.9 Solar Cookers... 21

3.10 Solar Pond 22

3.11 Solar Distillation of Water... ... ... **22**

3.12 Solar Cooling 24

3.13 Solar Energy and Buildings... 25

CHAPTER FOUR: CASE STUDY

4.1 Onersol, Solar Energy Research Centre, Namey... 33

4.1.1 Design/Planning Concept 34

4.1.2 Materials/Finishes... 37

4.1.3 Circulations Services... 37

4.1.4 Merits & Demerits 38

4.2. Solar Energy research Centre, Enugu 39

4.2.1 Design / Planning Concept... 40

4.2.2 Materials / Finishes... 41

4.2.3 Circulation / Services 41

4.2.4 Merits & Demerits 43

4.3 Energy Research Centre, Sokoto... 43

4.3.1 Designing / Planning Concept... 44

4.3.2 Circulation / Services... 46

4.3.3 Materials / Finishes 46

4.3.4 Merits & Demerits... 46

CHAPTER FIVE : STUDY AREA

5.1 Sokoto Climate 47

5.2 Major Seasons... 47

5.2.1 Hunturu 47

5.2.2 Bazara... 48

5.2.3 Damina... 48

5.2.4 Kaka... 49

5.3 Rainfall... 49

5.4 Wind Direction... 50

5.5 Relative Humidity 51

5.6 Sunshine 52

5.7 Air Temperature... 53

5.8 Implications of Climate on Planning 54

5.9 Site Location 55

5.10 Vegetation 56

5.11 Site Selection Creteria... 58

5.11.1 Advantages of the Site 59

CHAPTER SIX: BRIEF DEVELOPMENT AND DESIGN PARAMETERS

6.1 Design Brief 60

6.2 Design Parameters 60

6.2.1 Administration 60

6.2.2 Ancillary Facilities 62

6.2.3 Services, Operations and Maintenance 62

5.2.1 Hunturu 47

5.2.2 Bazara... 48

5.2.3 Damina... 48

5.2.4 Kaka... 49

5.3 Rainfall... 49

5.4 Wind Direction... 50

5.5 Relative Humidity 51

5.6 Sunshine 52

5.7 Air Temperature... 53

5.8 Implications of Climate on Planning 54

5.9 Site Location 55

5.10 Vegetation 56

5.11 Site Selection Creteria... 58

5.11.1Advantages of the Site 59

CHAPTER SIX: BRIEF DEVELOPMENT AND DESIGN PARAMETERS

6.1 Design Brief 60

6.2 Design Parameters 60

6.2.1 Administration 60

6.2.2 Ancillary Facilities 62

6.2.3 Services, Operations and Maintenance 62

List of Table

	Page
Table 5.3 Rainfall Data...	50
Table 5.5 Relative Humidity Data...	51
Table 5.6 Sunshine Data...	52
Table 5.7 Air Temperature Data...	53

List of Figures

Fig. 1:	Solar Coffee Coker...	28
Fig. 2:	Solar Toaster...	29
Fig. 3:	Multi Slice Toaster...	30
Fig. 4:	Hot Case...	31
Fig. 5:	Cooking Stand...	32
Fig. 5.10a:	Wooded Alluvial Valleys...	56
Fig. 5.10c:	Tree Savannah...	58
Fig. 6.2.1:	Open Ganged Work Station...	61
Fig. 6.2.4:	Typical Laboratory...	63
Fig. 6.5:	Functional Relationship Flow Chart...	73
Fig. 6.6:	Site Zoning...	75
Fig. 6.7:	Design Concept...	77
Fig. 6.8:	Site Concept...	79

List of Plates

Plate 4.1a: Internal Courtyard... 34

Plate 4.1b: Ground Floor and First Floor Plan... 35

Plate 4.1c: North and South Elevation... 36

Plate 4.2a: Solar Refrigerator... 39

Plate 4.2b: Twin Solar Water Heater.... 40

Plate 4.2c: Access Road to Centre... 42

Plate 4.2d: Front Elevation... 42

Plate 4.3a: Administration Block... 44

Plate 4.3b: Laboratory... 45

Plate 4.3c: Demonstration Area.... 45

Plate 5.9a: Map of Nigeria... 55

Plate 5.9b: Map of Sokoto... 55

Plate 5.10b: Grass and Shrub Savannah... 57

CHAPTER ONE

INTRODUCTION

1.1 PROBLEM DEFINITION

Energy transmitted from the sun in the form of electromagnetic radiation is the source of all solar energy. The major concern in solar energy research programme today is how to store large quantity of energy over a long period of time. The subject at stake concerns every energy commission world wide, and Nigeria is no exception being a prominent member of the International Solar Energy Agency.

The establishment of solar energy research Commission over a decade ago is a national response towards the realization of solar energy development in the country, as an alternative to fossil fuel.

The solar research agency is charged with the following responsibilities, namely:-

i. To organize and carry out research in the most economical and effective means available locally for harnessing solar and other renewable energy as complimentary and/or alternative sources of power.

ii. To investigate the appropriate designs for solar and other renewable energy equipment and appliances for domestic,

agricultural and industrial uses, and to develop, produce and test prototypes of same.

iii. To serve as centre for the development of manpower and training in solar and other renewable energy technology.

iv. To investigate the use of solar powered equipment in combination with other energy sources.

v. To investigate the efficiencies of solar and other renewable energy systems with a view to developing more efficient ones and the problems of solar and other renewable energy storage.

vi. To study environmental factors affecting solar and other renewable energy harnessing and for this purpose to establish and maintain filed stations elsewhere in the federation for experiments and data collection.

vii. To study the energy conservation possibilities in various sectors of energy consumption and to encourage prudent energy management principles.

viii. To study socio-economic parameters related to popularization and mass adoption of solar and other renewable energy systems.

ix. To serve as a resource centre offering advisory and research facilities especially for post – graduate work and also to other consultancy services.

x. Finally, to cooperate with similar institutions and bodies engaged in solar and other renewable energy research, development and training and to collate and or coordinate their work wherever practicable.

In view of this, the solar energy research centre at Sokoto was established within the premises of Usman Danfodio University Sokoto, but with the increasing technological complexity of passive solar thermal system and lack of standard Architectural Environment for effective solar research programme, the centre has not fully realize its energy conservation and research goal.

Though the issue of energy in Architecture has always been debatable, notwithstanding, as a science of the built environment, Architecture has always provided services to energy industry Energy types such as electrical, mechanical or radiation transmittance depending on the environment and climate require architectural design to facilitate both research and development.

1.2 AIM AND OBJECTIVES

The goal of this research are: -

i. To undertake an intensive study on the Architecture of Passive Solar Energy Research

ii. To propose a state of the art design for the energy research centre in Sokoto.

iii. To suggest architectural solutions using solar energy as alternative sources of energy.

iv. To highlight the prospect of solar energy efficacy as a sustainable energy source.

1.3 MOTIVATION

The continuous challenge to energy, incessant electricity power failure and scarcity of fossil fuel poses a threat to the people. Socio-economic development can only be enhanced when there is a steadily available energy source.

The need to improve the living standard of the people is the major motivation of this study.

As a result of this, the prospect of renewable energy source is being examined as a more efficient and economical means. Among other things, solar energy also has the following important advantages:-

i. It is inexhaustible

ii. It will reduce over dependence on fossil fuel consumption

iii. It is an insurance against an unpredictable future

iv. When employed, no pollutants are emitted into the atmosphere

From above, it is evident that the hope of sustainable energy is in Solar Energy. This is the essence of the Solar Energy Research Centre.

1.4 ARCHITECTURAL SIGNIFICANCE

The Architectural significance is the creation of a Centre, which is energy conscious. It can be better conceived as a structural convenience designed to embrace researches on the potency of solar energy and other renewable energy technologies. Functional spaces will be provided to encourage development programs as well as facilities for training Nigerians on the benefits of solar energy. This centre will no doubt act as an arena for exchange of scientific ideas.

Finally, the research takes cognizance of the solar energy potentials of Sokoto, which is the study area. It intends to identify the suitable forms, materials and finishes that will be needed in the solar energy research centre.

1.5 RESEARCH METHODOLOGY

In the course of this research, information and data shall be collect from primary and secondary sources. Basic data from the prepared

master plan of Usman Danfodio University, Sokoto will be of significant guidelines of Solar Energy Commission will be of utmost importance too.

An investigation into the environmental impact analysis of the centre would be considered. Besides, a Comprehensive library research, which involves consultation of books, past unpublished thesis projects, architectural journals, papers and seminars related to the filed of study will be employed.

A rigorous field research will be carried out, this includes traveling to Sokoto to study the existing site situation and to carry out relevant surveys, photographs, climatic data and personal observations shall be recorded and finally analyzing the climatic data to know the existing prevailing climatic conditions of the site so as to integrate or synthesize the proposal into the existing climatic conditions.

1.6 SCOPE AND LIMITATIONS

The scope of this thesis research is basically to design an energy research centre in Sokoto State within the precinct of the Usman Danfodio University. The design will lay emphasis on the architectural solution to integration of functional spaces for research convenience, as applicable to provision for research and development activities such as Laboratories,

Meeting-rooms, Library, Auditorium, Administrative offices and Documentation, Workshops as well as Residential accommodation for temporary staff.

Finally, there is also going to be a thesis write-up, which will highlight other theoretical factors, such as introduction, design report, a general survey, design concept and the general situation of the site.

1.7 CONSTRAINTS/LIMITATION

Despite the fact that Sokoto is quite some distance from Zaria, effort would be made to conduct a thorough investigation on the subject matter so as to justify the thesis proposal. It will be very helpful to carry out many more case studies in other Energy Research Centres.

Lack of adequate facilities in getting current information on foreign Energy Research Centres as case study but some secondary sources of information could be of significant assistance. The time limit for this thesis work is of great disadvantage but efforts will be made to complete it within the time limit.

CHAPTER TWO

HISTORICAL DEVELOPMENT OF SOLAR ENERGY SYSTEM

Solar Energy is a relatively new field of scientific technology endeavour and particularly so in Nigeria.

Petroleum products are the main stay of Nigeria's economy and so far the main source of energy for the world. But proven discovered reserves indicate that petroleum reserve is unlikely to last forever. Thus, the need to start looking for alternative sources of energy.

There is no better alternative than the energy from the sun. As long as there are humans there will be the need for sunshine. If there is no sun then there may be no life on earth. The sunshine, is unlimited inexhaustible, clean and has relatively no pollutant.

Nigeria has a large area of land mass and is Geographically located in the tropics. Therefore, the amount of sunshine is enormous.

Solar energy arrives at the top of the earth's atmosphere at a very close to constant intensity. However, on the earth's surface, this constant is known to vary from place to place and from time to time due to meteorological uniqueness. The average intensity on the earth's surface is 1000w/m2. The total solar power density of Sokoto State has been estimated as 984 w/m2 as measured by Dr. Gulma and his company in 1982.

Cloud and weather patterns vary and attenuate the Solar Radiation in traversing the atmosphere. Therefore, we would expect to find a region that has generally cloud free weather, such as the dry region of Sokoto State, to receive greater solar energy. Water vapour, haze, dust, and other atmospheric contaminants tend to decrease the solar energy available at the earths surface. As long as these qualities vary with altitude, the solar energy also varies with altitude. Solar radiation can be measured as direct, diffused or total radiation.

2.1 ORIGIN AND ESSENCE

All our fossil fuels were created from the sun. These fuels are energy that has been stored over a long period of time. In fact, millions of years ago chemical reactions stimulated by sunshine formed all fossil fuels. The oil and natural gas are now termed as the conventional fuels. The non-conventional fuels also known as renewable energy sources include nuclear energy, solar energy, biomass, geothermal energy, hydro-electricity, sea tidal and wave energy.

Energy has always been the medium to man's greatest goals and to his dreams of better world. It is sometimes said that the caveman started along the path of civilization after he has utilized the energy in fire for heat and light, and the energy in his body for food and survival. In the centuries since

then, man's quest for material well being has been tied largely to the harnessing of various forms of energy for one purpose or the other.

Today's world is living in a very dynamic time of history – A time when worldwide catastrophe could lie shortly before us in the area of population explosion, energy shortage, pollution and other environmental effects and shortage of food supplies, unless worldwide control measures are implemented. There are many other implications but the principal implication here is regarding energy.

2.2 TYPES OF RENEWABLE ENEGERY SOURCES

i. Nuclear Energy

Nuclear energy comes from energy incorporated in Atomic Nuclei and in the energy used to hold the atoms together. In most of the fission processes, Uranium is the most important mineral.

As every one knows, nuclear energy is capital intensive and may have undesirable side effects particularly on safety. Example such as Chernobyll in U.S.S.R. in 1986 and the accident at the Three Mile Island in the U.S.A in 1979 are fresh in our minds.

Fussion energy has not been tapped anywhere in the world. Economy fussion power would be an immense benefit to all mankind but as of now, it is not feasible at all.

ii. Geothermal Energy

In a few parts of the world, underground steam from hot, wet regions can be tapped in sufficient quantities to run large turbo-electric installations. But, in Nigeria, such efforts are not viable because of the geographic conditions and its limits.

iii. Hydro-Electric Power

This can supply us with only limited energy and thus cannot be a sufficient and adequate alternative source of energy.

iv. Sea-Tidal Energy

The costal belt for Nigeria is not big enough to give us sufficient Ocean Energy. For Sokoto State, Such energy is nil. Also, no feasible technology has been developed.

v. Wind Energy

The minimum wind speed requirement to tap this energy is 18W/hr. Nigeria climate is not very suitable and also the quantity of the energy is very small.

2.3 THE SUN

The sun is made up of extremely hot gaseous matter and is the source of heat and light for the entire solar system. Fuelled by thermo-nuclear fusion the sun radiates energy into space at tremendous rate. Less than one

thousands of a millionth of this phenomenal output is intercepted by the earth as it progresses around the sun at about 150 million kilometers away. The sun's rays take about eight minutes to reach the earth's surface. These sun's rays bathe the earth in heat, determines our weather systems. The heat from the rays provides plants with energy, which invariably become energy for animals.

2.4 EARLY USES OF PASSIVE SOLAR ENERGY

Man being the most advanced animal or thinking being has allowed his architecture to blend with natural climatic conditions. The sun and the natural forces, which are available to him, have been utilized in various ways. Technology and culture have fostered changes on his attitude concerning the utilization of nature's energy.

Solar energy in combination with the earth provides food for mankind and other living creatures. Fibres from plants resulting from this food chain provide construction materials such as wood and straw for man.

As man's needs developed, he learned that fenestration facing the sun and solid wall intercepting the harsh winter winds were most comfortable configuration.

This orientation was maintained for a long time until the advent of technology. Advancement in technology has made it possible for man to

achieve comfortable interior environment with the use of fossil fuel. This makes the orientation of the building to become secondary.

The Egyptians provide comfort in their buildings using the first known in history to use sun-baked bricks in building constructions.

The Greeks worshipped the sun, and this influenced their architecture. Their public meeting places, Agoras were situated such that they would receive the sun's natural warmth. They were surrounded on three sides by buildings while the fourth side opens to the south sun. Residential buildings were designed to have southern exposure.

2.5 EARLY USES OF ACTIVE SOLAR ENERGY

Archimedes, The Greek Mathematician and Engineer was the first person to make use of Solar Energy in a concentrated form. In 212B.C he set on fire the Roman fleet of ships by focusing rays of the sun unto their black soils using approximately 4,000 gold and bronze shields.

In 1615, Solomon De Caux invented the first machine that was able to convert Solar Energy into mechanical work.

Antoine Lavoisier (1743-1794) a Frenchman used a 128cm diameter lens to concentrate sun's ray and developed temperatures up to 1755°C which was sufficient to melt metals.

With the discovery of oil in 1859, many people lost interest in using the sun to power machinery, except in the most remote desert areas where transportation was difficult.

An American inventor, John Ericsson invented, designed and built several solar powered hot-air engines that adapted conventional steam power for cloudy day operation.

In 1901, A.G Eneas built a large reflector that was used to power water pumps on an ostrich farm in Passadena, California. The pumping system was rated at four-horse power and could pump 1,400 gallons per minute against a static head of 3.6m.

CHAPTER 3

APPLICATION OF SOLAR ENERGY

3.1 APPLIED SOLAR ENERGY SYSTEM

Solar energy could be converted into different forms of energy for subsequent end use. The following forms of energy could emerge as a result of the conversion; thermal, electrical and chemical energy, etc. The various energy may fall within the four groups below.

i. Low-temperature heat production for domestic, industrial and agricultural purposes.

ii. Photovoltaic and solar thermal electricity generation.

iii. Biomass production and conversion into gaseous and liquid fuels.

iv. Solar energy assisted hydrogen generation.

Low-temperature heat production in the temperature range below 100^0C has so far found wider application than other methods of solar energy conversion because of its high conversion efficiency and its suitability to substitute for increasing expensive oil and gas.

Low-temperature heat can be used either for water heating, space heating or industrial and agricultural drying. Some of these applications are illustrated in pages 28 – 32.

3.2 SOLAR ELECTRICITY PRODUCTION:

The most popular methods for solar electricity production are:

i. Direct conversion by photoelectric or thermo-electric processes;

ii. By producing mechanical work which will then he used to drive conventional electric generators

3.3 PHOTOELECTRIC CONVERSIONS

The principle of direct conversion of solar energy to electricity is restricted to small power generation in locations where there is no alternative form of power generation. The electricity from this source could he used in navigational aids, telephone amplifier in remote areas or as battery chargers for boats and caravans.

There is a limit to the use of this source of electricity because of the cost of photovoltaic cells and problem of storage. Batteries are also very expensive and bulky.

3.4 SOLAR-THERMAL POWER GENERATION:

There are two main approaches to solar-thermal power generation: Solar-furnace approach, and the Tower concept.

i. Solar Furnace Approach:

Here mirrors are used to reflect sunlight from different location and then concentrated on a single heat exchanger on the solar farm. The heat is then collected from the linear reflector focusing solar radiation on long pipes, which collect the heat.

ii. Tower Concept:

The tower concept was proposed in 1949 and is a good example of advance solar furnace approach. A large number of mirrors covering a large area are used to focus sunlight independently on a boiler on top of a tower. The tower is placed almost at the centre of the field covered with the mirrors. The heat reflected from these mirrors produce high temperature steam, which is used to drive turbines. The advantages of this system is that:

- Separate mirrors and steering mechanism can be mass produced
- Smaller reflectors are less subject to high wind loadings than a single large steer able concentrator of the same total collector area.

3.5 CHEMICAL CONVERSION:

The most important forms of chemical conversion of solar energy are by photo biochemical processes. Biological organisms are producers and

consumers. Plants and algae synthesize carbohydrates from carbon dioxide and water, absorbing some of the solar radiation and storing it in chemical bonds. Herbivorous animals like man, use the body tissue of producers as food. Carnivorous animals, regarded as secondary consumers eat animals, which are themselves consumers. The food chain thus continues to recycle.

3.6 MECHANICAL CONVERSION

Conversion to mechanical work is achieved by the use of solar heat engines. A flat or parabolic reflector to concentrate heat on a steam boiler or to heat the air in a vessel collects the solar radiation. The steam or hot air is used to drive a turbine.

Solar heat engines have been used for pumping of water or for low scale energy electric power generations in remote areas. The use of solar heat engines are limited and not very common because of their low efficiencies.

3.7 HEAT PUMPS

Very significant amounts of energy are available as low heat at temperature too low to be useful for any practical purpose. Heat pumps may be utilized to boost such heat to useful temperatures and also to cool as refrigerator by-product.

They can be used directly for solar energy collection when the

evaporator is the absorber plate hence it becomes the source.

3.8 SOLAR HEATING:

Heating is the most common use to which solar energy has been put. There are various devices, which utilize the heating effect of solar radiation. They consist of a blackened collector, which on absorbing radiation gets heated, and as a result of this, there is temperature increase. This can be put to use directly in meeting human needs such as heating of homes, and hospitals and the provision of hot water for domestic, social and industrial purposes. Other straightforward applications include; drying of agricultural produce, foodstuff, cooking, distillation and desalination of water. Due to simplicity of operation, devices using solar energy directly have reached a higher level of development than those whose objective is the production of electricity. The solar water heater for example is the most common solar device.

i. Industrial And Agricultural Drying:

The parabolic concentrator has provided a means of generating very high temperatures for small-scale industrial applications and for research purposes. Solar heat at lower temperatures has been used for both industrial and agricultural drying operations. These represent two or more promising commercial uses of solar energy.

ii. Solar Furnaces:

A megawatt furnace was built in France in 1950's using heliostats to direct sunlight towards a large parabolic concentrator. The furnace can produce temperature in excess of 3,400^{0}C, the melting point of tungsten. It could be used for the study of high temperature material properties.

The French furnace is located in pyrenes at Odeillo Front Romeu. At this location, the sun shines as much as 180 days a year and solar intensity is as high as 1,000 watts per square metre are common. The furnace was completed in 1970 and cost $2,000.000.

iii. Air Heaters:

Solar air heaters have great potential for improving agricultural drying operations around the world. At present, a large portion of the world's supply of dried fruits and vegetables continue to be sun-dried in the open under primitive conditions since the crops are unprotected from unexpected rains, wind-borne dirt, dust infestation by rodents, insects and other animals, the quality is often seriously degraded sometimes beyond edibility.

There are two basic methods of solar dehydration. The first method is by exposing the materials to solar radiation, which also enhances the proper colour development of greenish fruits by allowing drying by

dehydration. The major draw backs are the possible damage due to overheating and relatively low drying rate resulting from poor vapour removal in the cabinet driers.

In the second method, the foodstuff is heated by circulating pre-heated air. In this case, caramelization and heat damage do not occur because the drying materials are not exposed to direct sunshine. Another advantage being that the circulating air absorbs the water vapour from the food thus accelerating drying. Products of inferior appearance may result if immature fruit is dehydrated, since shading prevents the break down of chlorophyll.

3.9 SOLAR COOKERS:

W. Adams invented the concentrated type of solar cooker. This apparatus uses conical, octagonal box lined silvered .9lass mirrors to focus light through a cylindrical ball onto the food container.

There are generally two types of solar cookers, the one described above and the other, which depends on some concentration of radiation combined with greenhouse effect for trapping heat within a small space in which the food is placed. This second type is called solar oven.

The solar cooker has the following limitations when in use:

i. It cannot be used in the night,

ii. The maximum efficiency is obtained between 10 a.m. and 3 p.m. only,

iii. Cooking would have to be done outside the kitchen and when there is no rain.

3.10 SOLAR POND

Solar pond is another device for collection of solar radiation. This consists of a shallow body of water, which is an energy absorber. The pond is fitted with a cover plate if desired. The temperature of the water is increased by the direct absorption of solar radiation or by conduction from the bottom of the pond. The amount of energy absorbed could be increased if pond is lined with black plastic or some other black material.

The water expands with the increase in temperature and the density decreases. The hottest water has the least density and therefore, rises to the surface. Once on the surface, it losses its heat to the surrounding either by conductions or convection. The cover plate when used, is not a barrier, but keeps off dust, leaves and other debris from the pond.

3.11 SOLAR DISTILLATION OF WATER:

There are two main sources of water for mankind; they are the great oceans and the vast reserves of brackish inland water. They both contain harmful organisms. The ocean water, is largely salty while the brackish or highly mineralized water is known to contain solids chiefly, sodium,

calcium, magnesium, in the form of sulphate, chloride and bicarbonate together with dissolved gases. The most commonly available and most desirable source of brackish water is the deep wells, estuaries of some major rivers, saline rivers, lakes and vast water all of which are unsafe for human use without treatment.

There is therefore a need to purify the water obtained from these sources in order to make them safe for human use. To achieve this, various techniques such as distillation by evaporation, reverse osmosis, vapour compression, configurations, ion exchange, electro-chemical treatment, solvent extraction, freezing and electrolysis has been used and in some cases, are still being used. Some of the processes are energy intensive and operating cost is high.

Solar distillation on the other hand, utilizes the free, inexhaustible and renewable supply of solar radiation. It utilizes in common with all other distillation processes, the evaporation and condensation modes. It is a technique with no capital resources, energy requirement needing only an adequate supply of solar energy. The fresh distilled and portable water produced by this distillation of brackish water contains only a maximum concentration of 10-15 ppm (part per million) dissolved solids. Other impurities like microflora organisms dwelling in water are removed due to

the sun and infrared rays produced in the still, which are bactericidal. Such water produced by solar still is suitable for both industrial and domestic uses. The distilled water can be used in dispensaries, motor batteries, radio and meteorological stations. It can also be used directly as boiler feed water or in chemical or pharmaceutical production where a low solid content is required in the process of water supply. The aim of Solar Water Distillation is to produce pure water from non-portable water at a reasonable low cost. Solar distillation systems are relatively simple and do not require unusual manufacturing techniques or exotic materials.

3.12 SOLAR COOLING

Solar Cooling is one aspect of solar energy application where the demand for energy matches the supply, cooling is most desired when solar radiation is hottest. Cooling is required for both human comfort as well as for storage of perishable food items and preservation of drugs.

Cooling can be achieved either by radiation or refrigeration and air conditioning. In radiative cooling, the device works like a reversed heater. Heat is removed from the source by the working fluid (water or air) and delivered to the sink by the collector which is a black body. This can either absorb heat or radiate it depending on the prevailing situation.

Radiation and Air-Conditioning are just reversed heat engines, heat is

removed from a cold source and delivered to a hot sink. For solar refrigeration and Air-Conditioning absorption machines are used. A solution of an absorber liquid and refrigerant are heated in the absorber and the solution is pumped to a separator generator, where the temperature is maintained by heating in solar panels at a level at which the vapour pressure equals the saturation pressure in the condenser. The refrigerant is separated from the absorber and passes into condenser where it condenses and goes into the evaporator from which it extracts heat before going back again to the absorber via a heat exchanger and a throttle valve and the cycle is started all over.

Heat pumps requiring a small amount of electricity can also be used for heating, or cooling of buildings. Under certain conditions, they require smaller amount of electricity than that used by the conventional Air-Conditioning Units.

3.13 SOLAR ENERGY AND BUILDINGS

Solar energy could be employed in a building mainly for cooling or heating. It could also be used for lighting, cooking and water pumping. There are mainly three approaches to solar energy usage. They are either active, passive or a combination of both active and passive approaches.

Between 1945 and 1959, a variety of solar heated houses were built in

several countries. The first solar heated houses in Europe were built in the United Kingdom by Curtis and Gardner in 1956, a second milestone in European solar house development was reached in 1967 in France by Trombe and Michael who designed the first passive solar house in Pyrenes at Odeillo. In 1978, it was estimated that about 4,500 homes and several hundred large buildings used either passive or active solar heating.

i. Active Solar Heating

Active systems employ hardware and mechanical equipment to collect and transport heat. Flat or focusing collectors usually on the roof of a building and a separate head storage unit. Rock Bin, water tank, or a combination of the two are often the major elements of the system. Water or Air pumped through the collector, absorbs heat and transport it to the storage unit. This heat is then supplied from the storage unit to the spaces in a building by a completely mechanical system.

ii. Passive Solar Systems

Passive systems collect and transport heat by non-mechanical means. It employs the traditional elements of the buildings such as glazed areas, heavy walls to collect, store and distribute heat. The distribution of heat is by natural processes of conduction, convection and radiation. In the passive systems, there are no separate collectors, storage units or mechanical

elements. The most striking difference between the passive and active systems is that the passive system operates on the available energy in its immediate environment, while the active system imports energy, such as electricity to power the fans and pumps that make the system work. The passive house should be designed so that heat is stored and distributed efficiently.

Basically, all passive controls are striving to achieve an environment that lies within the comfort zone by altering one or any of the following: Air temperature, Air speed, Humidity and Radiation.

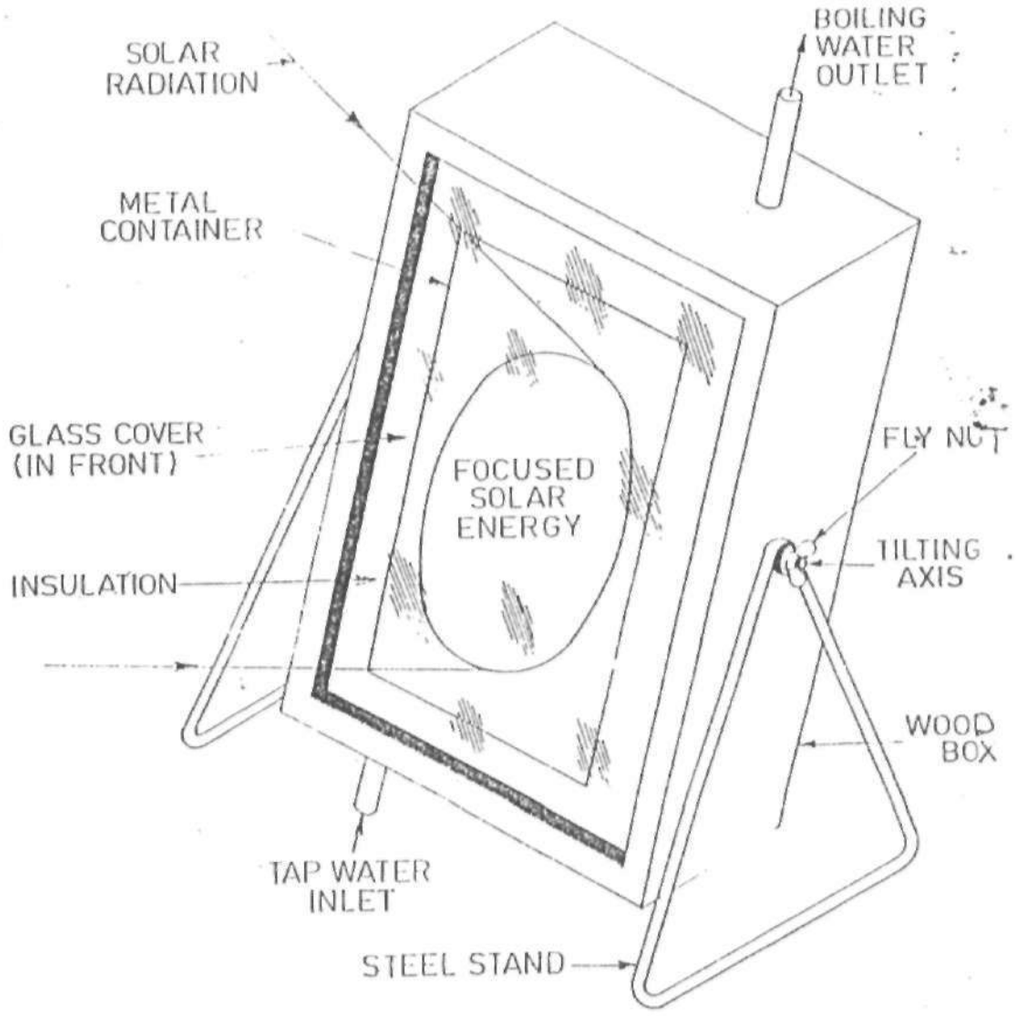


FIG. 1: SOLAR COFFEE COOKER

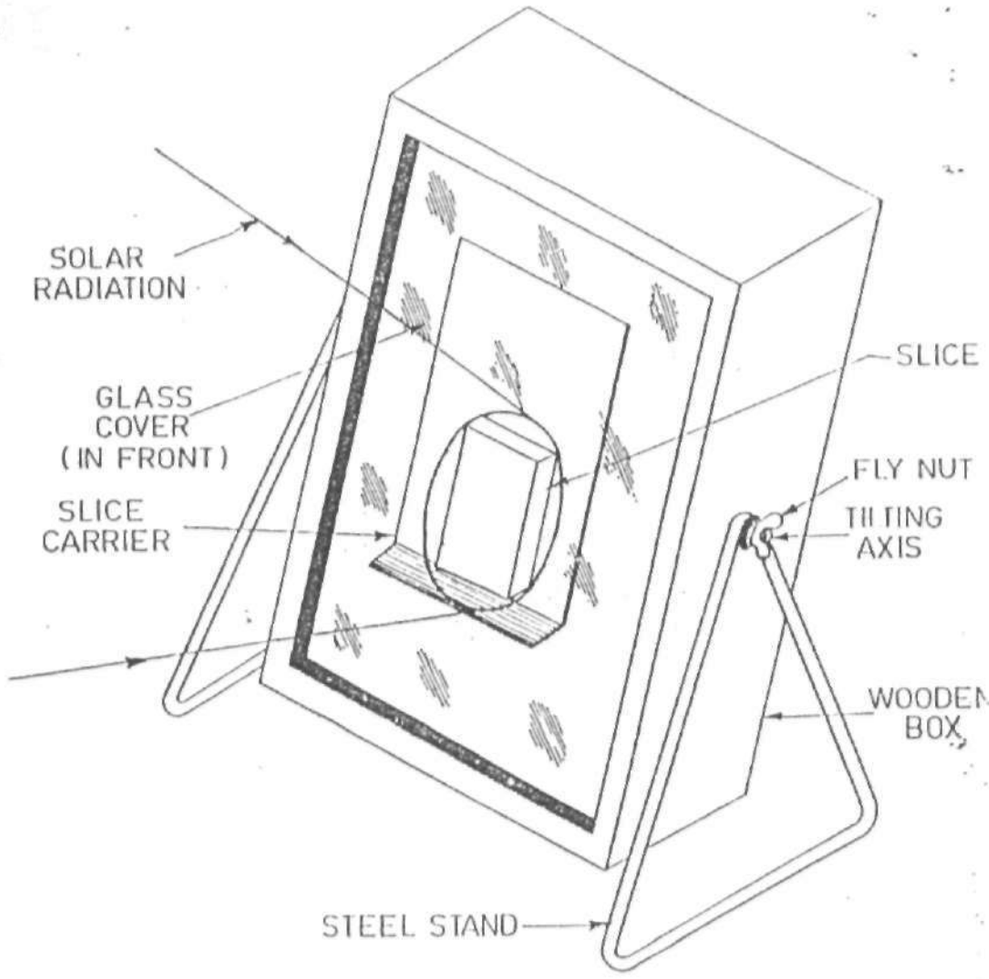


FIG 2: SOLAR TOASTER

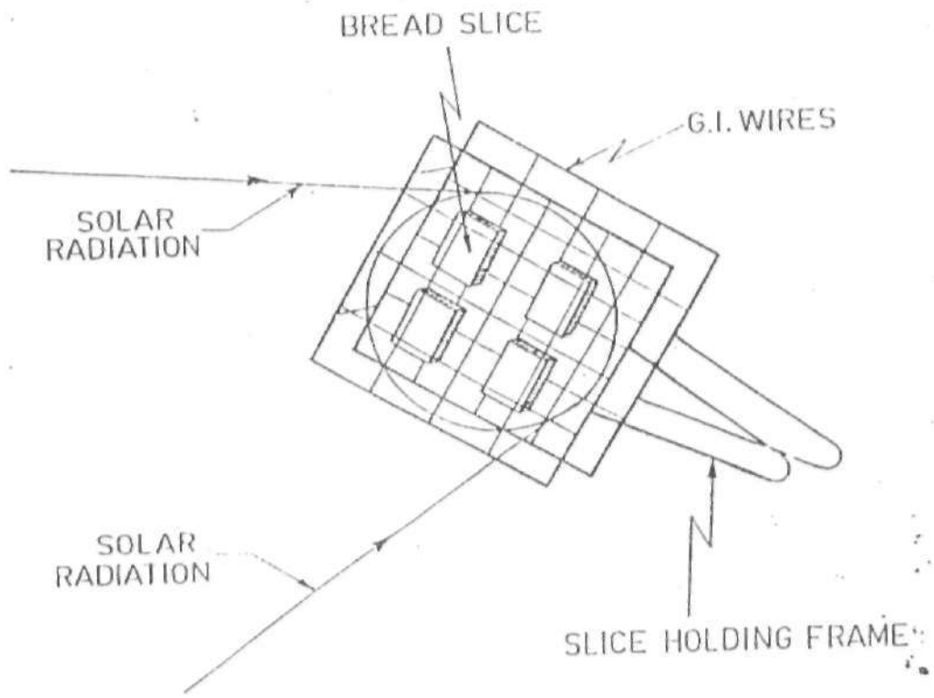


FIG. 3: MULTI SLICE TOASTER

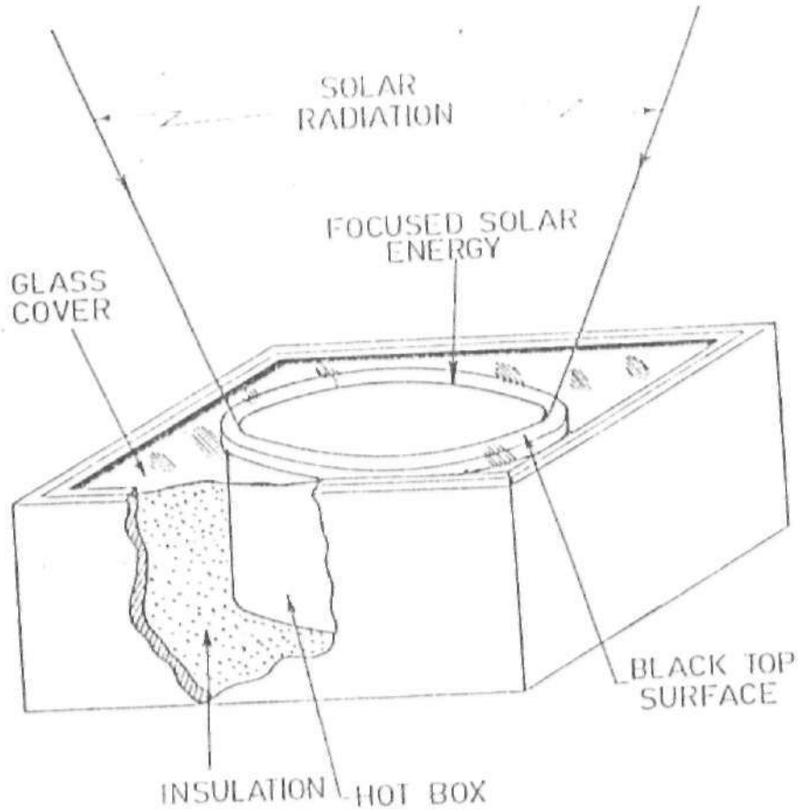


FIG. 4: HOT-CASE

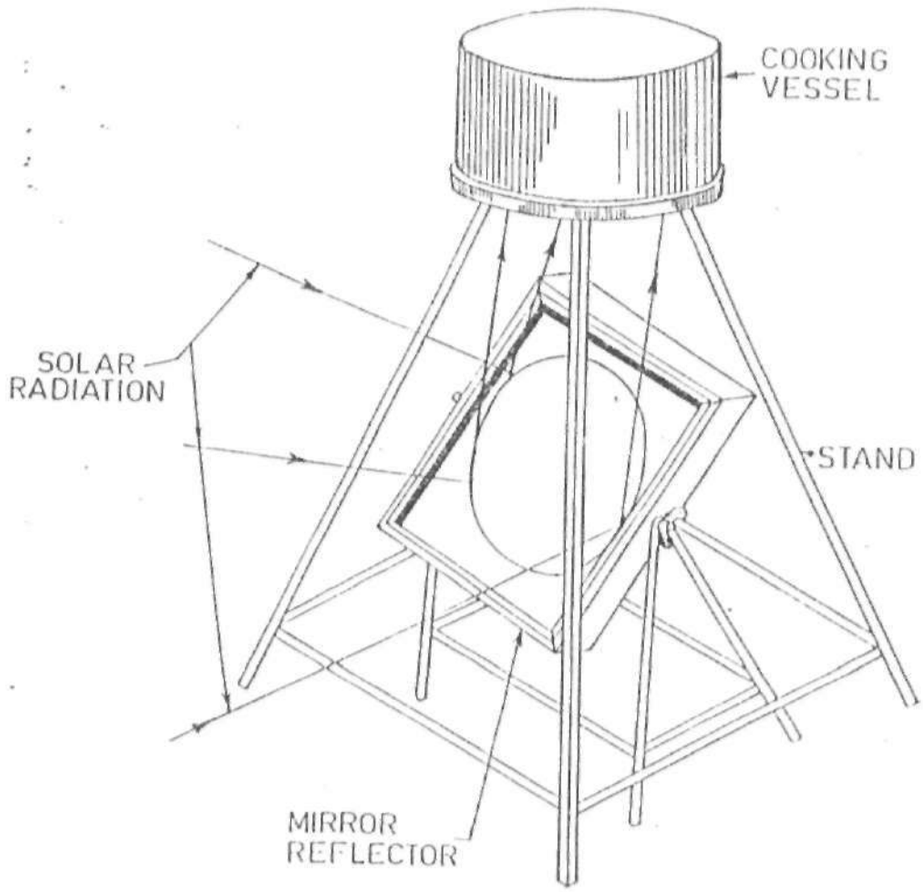


FIG. 5: COOKING STAND

CHAPTER FOUR

CASE STUDY

During the process of research and data collection, a researcher is expected to study existing similar situations or structures. It is also expected that after such study, one would be able to arrive at a logical conclusion, which will no doubt assist in the design approach.

Specific case studies were taken especially those that are relevant to the study area. There are two local case studies and one foreign case study. The local case study areas were visited while the foreign case study was conducted by consulting secondary source of information, literature research.

Case studies conducted includes:

i. Onersol, Solar Energy Research Centre, Niamey, Niger.

ii. Solar Energy Research Centre, Enugu.

iii. Solar Energy Research Centre, Sokoto

4.1 ONERSOL, SOLAR ENERGY RESEARCH CENTRE, NIAMEY

The Onersol complex, designed by a French Architect, Laszlo Mester Parajd is doubly significant in that it is intended to serve the objective of solar energy programme through project conception and experimentation towards practical application, but it is also a physical

structure inspired by traditional local Architecture and building materials. Thus, it was from the onset designed as a model of self-reliance in terms of style, materials, and energy consciousness.

The brief for the Onersol building contained provisions for research and development activities such as Laboratories, Administrative offices and Documentation, as well as Residential accommodation for temporary staff.

4.1.1 Design/Planning Concept

The French Architect created a building with four distinct parts joined by communicating internal courtyards with peripheral galleries, as can be seen in plate 4.1a.

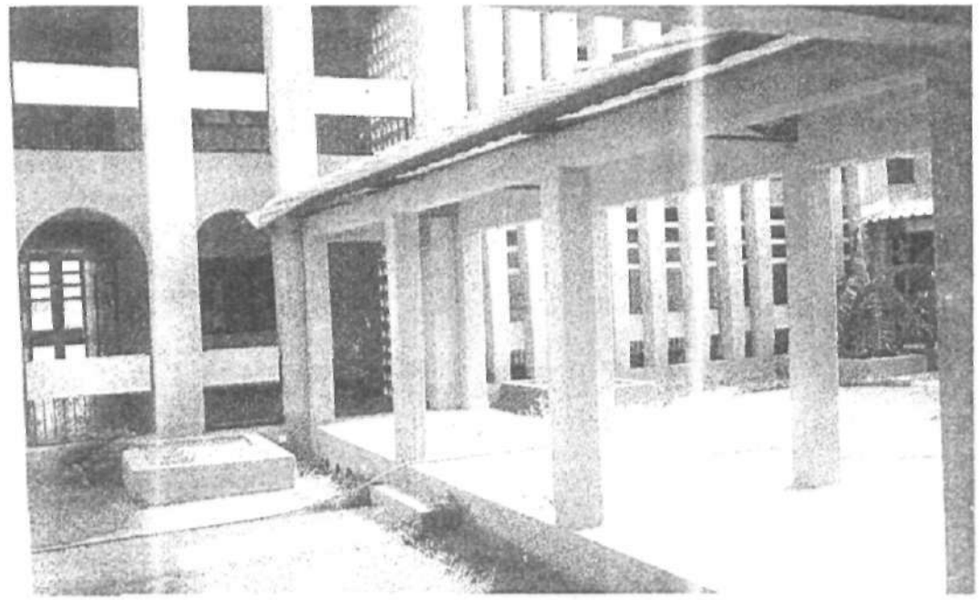


Plate 4.1a: Internal Courtyard

Entry for the public is through the central, single storey block containing reception, lounge and cafeteria; each of these adjoining spaces is covered with a dome, carried on columns, which demarcates the different areas. To the west of the entry, is a two storey residential block containing fifteen (15) bedrooms with bathrooms and organized around a courtyard. This can be seen in plate (4.1b) and (4.1c) below

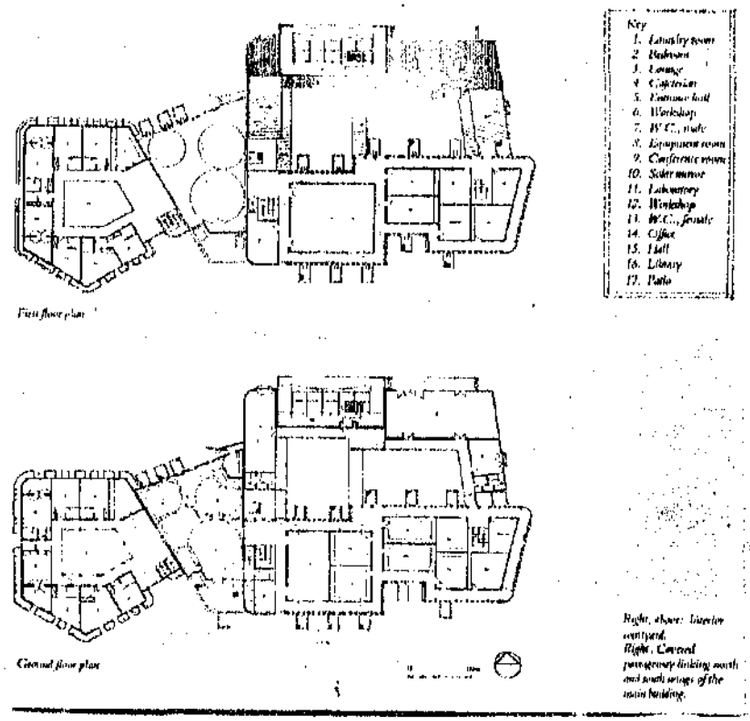


Plate 4.1b: Ground Floor & First Floor Plan

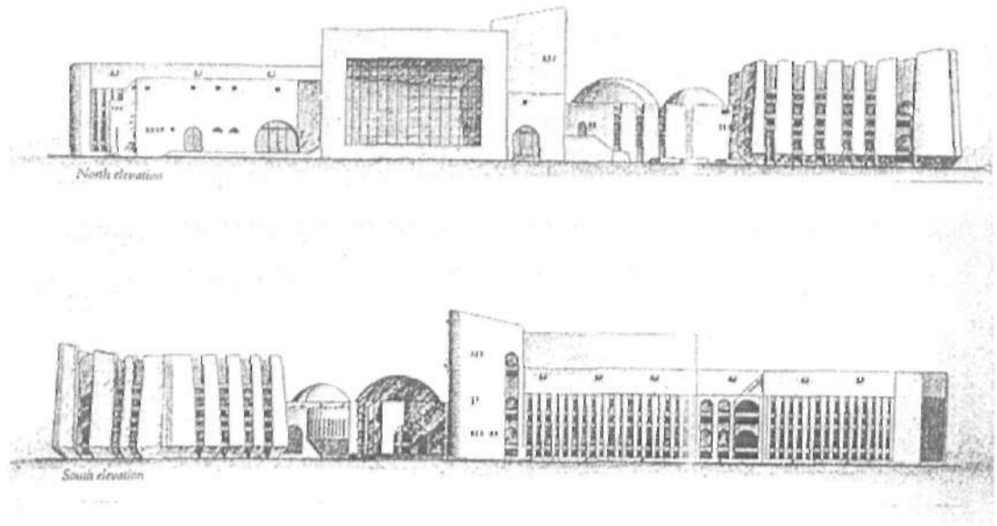


Plate 4.1c: Showing North & South Elevations

Laboratories, offices, library and meeting rooms are located in another two-storey wing to the southeast of the entrance. These spaces are situated at the centre of the wing with hallways and galleries around them for protection against the sun.

Natural cross-ventilation is provided through these into an enclosed courtyard, which separates this wing from the technical workshops and solar mirror in the northern, most section of the building. The total complex covers 3,500 square meters.

4.1.2 Materials And Finishes

The main strategy was to employ traditional materials and local labour, combining these with modern technology and expertise where necessary. The structure relies wherever possible upon load bearing walls of mud brick, stabilized with cements, however, concrete is employed for the foundations, metal trusses of local fabrication and other tension elements elsewhere, as well as aluminum for the roofing. Exteriors are covered with cement plaster tinted by pigments found locally.

4.1.3 Circulation And Services

Apart from the choice of a low-rise building containing functions arranged around inner courtyards, in keeping the local customs and methods of climate control, there is an interesting architectural feature on the west wall of the residential block. The structural bearing walls have hollow, chimney like elements for circulation of air. A continuous airflow through these helps to keep the interiors cool, while their spacing and thickness on the exterior façade provides protection for window openings

Although the building was designed with incorporation of a mechanical air-cooling system run on solar energy, this system was

not yet functioning as of May 1983. Efforts at the Onersol centre have been concentrated upon the development and production of prototype solar captors, water heaters, distillers, motor pumps and one electro solar power generator located in the centre of Niger.

4.1.4 Merits

i. Simple form with element of monumentality and aesthetically appealing elevations.

ii. The clear definition of the complex deserve some applause. Creating separation of all the functional wings.

iii. The ingress and egress have been well designed to facilitate some socio-cultural interaction.

iv. Employment of local building materials and finishes, as a model of self-reliance in terms of style, materials and energy consciousness.

Demerits

i. The composition is void of site landscaping.

ii. Inability to define a functional parking space for effective vehicular circulation around the centre

iii. Inadequate office spaces for the growing development of the centre

4.2 SOLAR ENERGY RESEARCH CENTRE, ENUGU

The activities of the Enugu solar energy research centre focus on renewable energy and covers research and development, public enlightenment and information dissemination as well as manpower training. Considerable progress in research and development in the field of renewable energy have been obtained, the last few years have also witnessed the execution of pilot demonstration project of renewable energy systems, which have direct bearing to the lives of Nigerians. Below are the plates of some of these projects.



Plate 4.2a: Solar Refrigerator

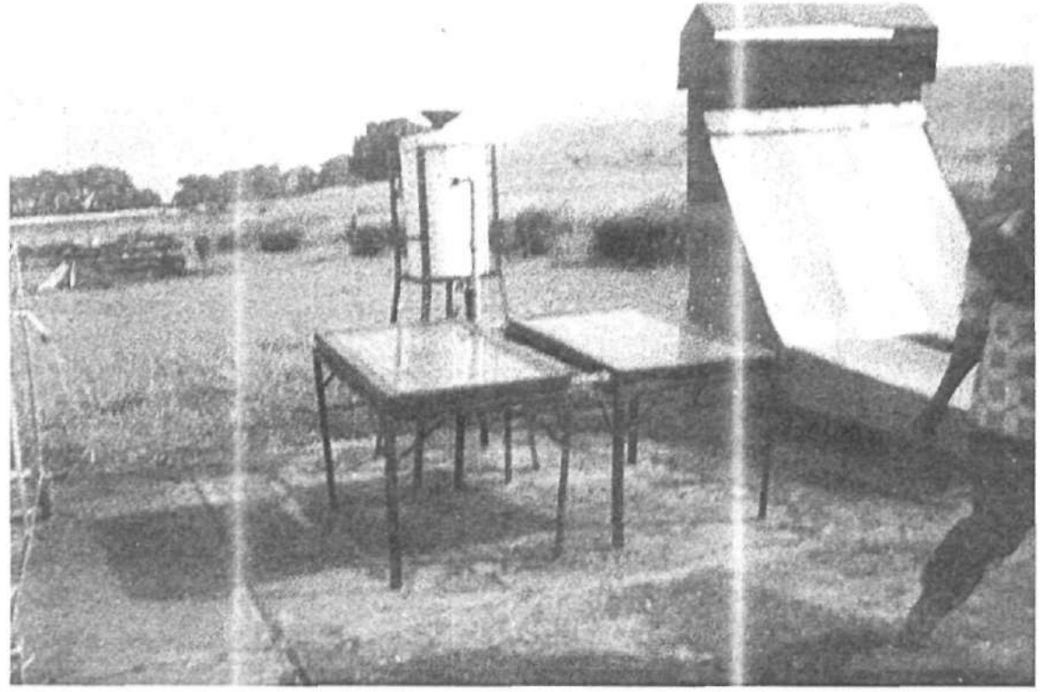


Plate 4.2b: Twin Solar Water Heater

4.2.1 Design/Planning Concept

The centre is a temporary site to house the activities of the energy research, which is a unit part of University of Nigeria's structure (complex).

Currently, the temporary site of the centre have the following: -

i. A single rectangular structure building housing office rooms for administrative and research personnel, a common room, computer room, general office, laboratories, electrical/mechanical workshop, library and conference rooms.

ii. A fenced testing and demonstration area where systems are mounted and studied.

The simplicity of the structure indicates that the complex was not primarily conceived or designed to house the solar energy research centre.

4.2.2 Materials/Finishing

The centre is constructed with simple hollow blocks, reinforced concrete columns, corrugated roofing sheets.

Finishes include cement plaster, glass and terrazzo floor finishes.

4.2.3 Circulation/Service

All functional spaces are accessible through a 1.5m wide passage with an open courtyard. The complex is accessed through an untarred road, as can be seen in plate 4.2c. All toilets are conveniently serviced.

Basically, the centre uses natural lighting and ventilation. The widows are recessed to avoid glare, these can also be seen in plate 4.2d.

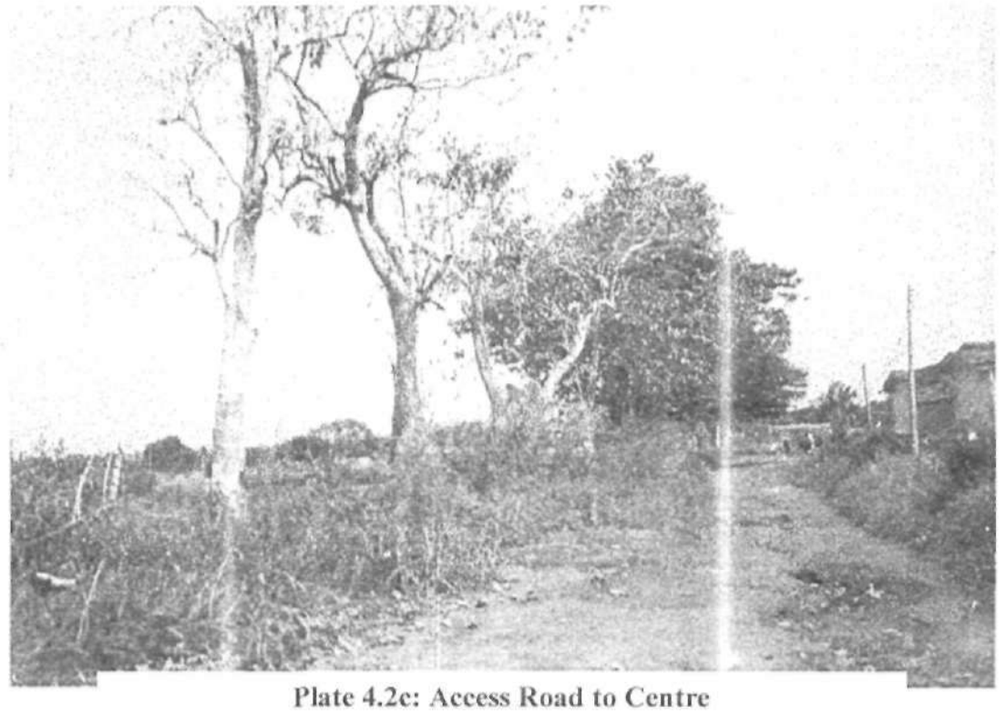


Plate 4.2c: Access Road to Centre

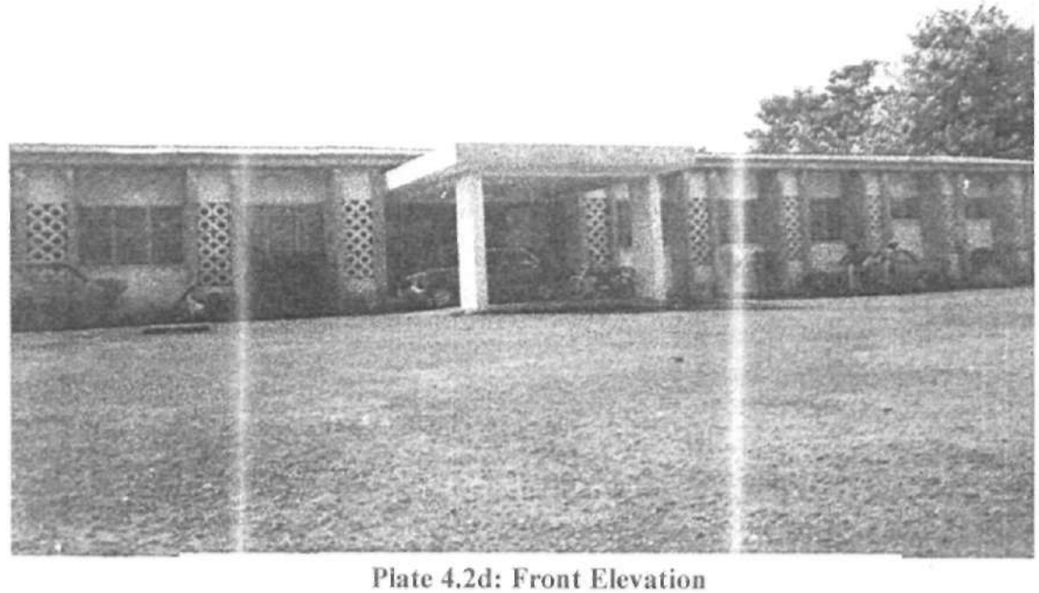


Plate 4.2d: Front Elevation

4.2.4 Merits

The centre is a very simple rectangular architectural structure with a complimenting simple façade.

Demerits

i. The centre lacks coherence and uniqueness in character

ii. Inadequate office spaces for the centre

iii. Lack of well defined pedestrian and vehicular circulation.

iv. Poor landscaping of the centre.

4.3 ENERGY RESEARCH CENTRE, SOKOTO

Research in Solar Energy has been taking place at Usman Danfodio University, Sokoto for more than ten years. In 1982, the senate of the University formally recognized the formation of an energy research unit that was an inter-disciplinary body comprising members of staff drawn from various Departments of the faculty of science.

Towards the end of 1982 the federal government took the decision to make University of Sokoto now Usman Danfodio University a centre for Solar Energy Research. The centre was to conduct research and development as well as manpower training in solar energy.

The establishment of the energy Commission of Nigeria in 1988, the Commission took over the funding and supervision of the Sokoto Energy Research Centre.

4.3.1 Design/Planning Concept

The complex is a simple rectangular pavilion of spread design concept. The complex was zoned into three parts, the administrative blocks, laboratories, and the demonstration field, these can be seen in plate 4.3a, 4.3b and 4.3c

The complex is a temporary site to house the activities of the centre, as it is a unit of Usman Danfodio University structures.

The structure was not primarily designed to meet the functional requirement of the centre.



Plate 4.3a: Administrative Block

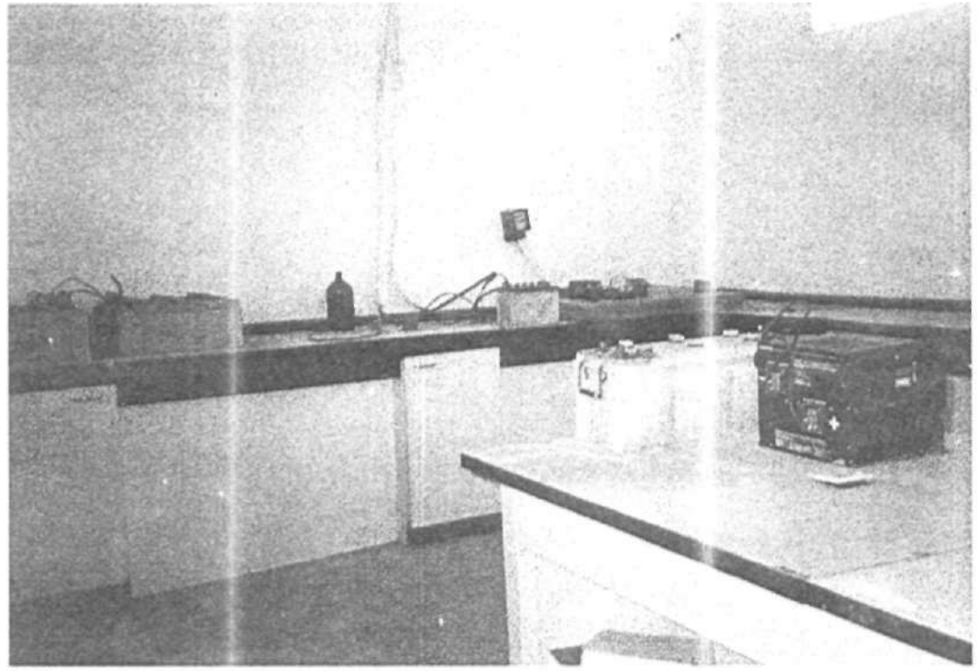


Plate 4.3b: Laboratory

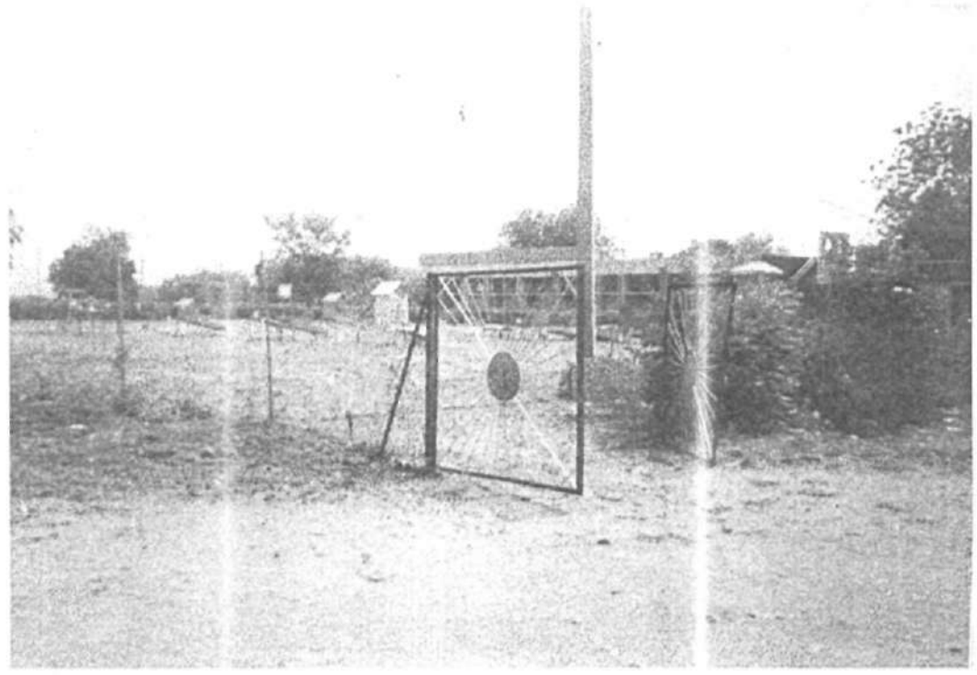


Plate 4.3c: Demonstration Area

4.3.2 Circulation/Services

All functional spaces are accessed through a concrete paved way linked to a passage of 1.2m wide. The vehicular circulation pattern is not well defined within the complex.

Toilets are conveniently provided with overhead storage tanks.

The centre mainly uses natural means of ventilation in supplementing Air Conditioner window units with other Solar Energy devices produced at the centre.

4.3.3 Materials/Finishing

The construction materials include reinforced concrete columns, forming a modular construction method, with hollow blocks and cement plaster. Finishes include glass, reinforced concrete columns and beams, terrazzo floor finish.

4.3.4 Merits

i. The entire complex is simple and blends into the environments.

ii. The separation of the conference areas and office areas from laboratories and workshop is commendable.

Demerits

i. Inadequate offices for the centre.

ii. Poor landscaping of the centre

iii. The composition lacks coherence without a unique character.

CHAPTER FIVE

STUDY AREA

5.1 SOKOTO CLIMATE

Sokoto lies within the hot and semi-desert climatic type. It has two clearly distinct seasons, the wet and the dry, with two interfacing minor seasons.

The dry season macroclimate is characterized by very hot dry air with afternoon temperatures that range between 30^0C and 40^0C and night time temperatures drop to between 14^0C and 20^0C, giving the characteristic wide diurnal range, typical of this type of climate.

The overall effect of this macroclimate is that the dry air, low humidity and low rainfall discourage plant life while the dry dusty ground reflects the strong sunlight, producing uncomfortable ground glare.

5.2 MAJOR SEASONS

Sokoto experiences two major and two minor seasonal changes that are closely related to cultural activities within the population.

5.2.1 Hunturu

The "Hunturu" season, from mid-November to mid-February, is the transition season between the wet and dry major seasons, during this

period the predominant social community activities are harvesting, marketing of produce, marriage ceremonies and the maintenance of buildings.

At this time of the year the daytime temperatures are hot and it is dry but at night it becomes cool. The dry dust laden "Harmattan" winds blow down from the north, creating a low-pressure condition, which results in low humidity both day and night.

5.2.2 Bazara

The period of mid-February to mid-May is known as the "Bazara" the major local activity is the preparation of land for cultivation. It is hot and dry during the day with generally cool nights. As the winds gradually shifts from an easterly to a southwesterly direction the relative humidity begins to increase.

5.2.3 Damina

The "Damina" or wet season, which lasts from Mid-May to Mid-August, is the time for intense activity in the rain feed agricultural economy. Both daytime and nighttime temperatures are generally hot, accompanied by high relative humidity and high pressure, reaching peak during mid-August. The prevailing winds come from southwesterly direction with secondary winds from the west. The low

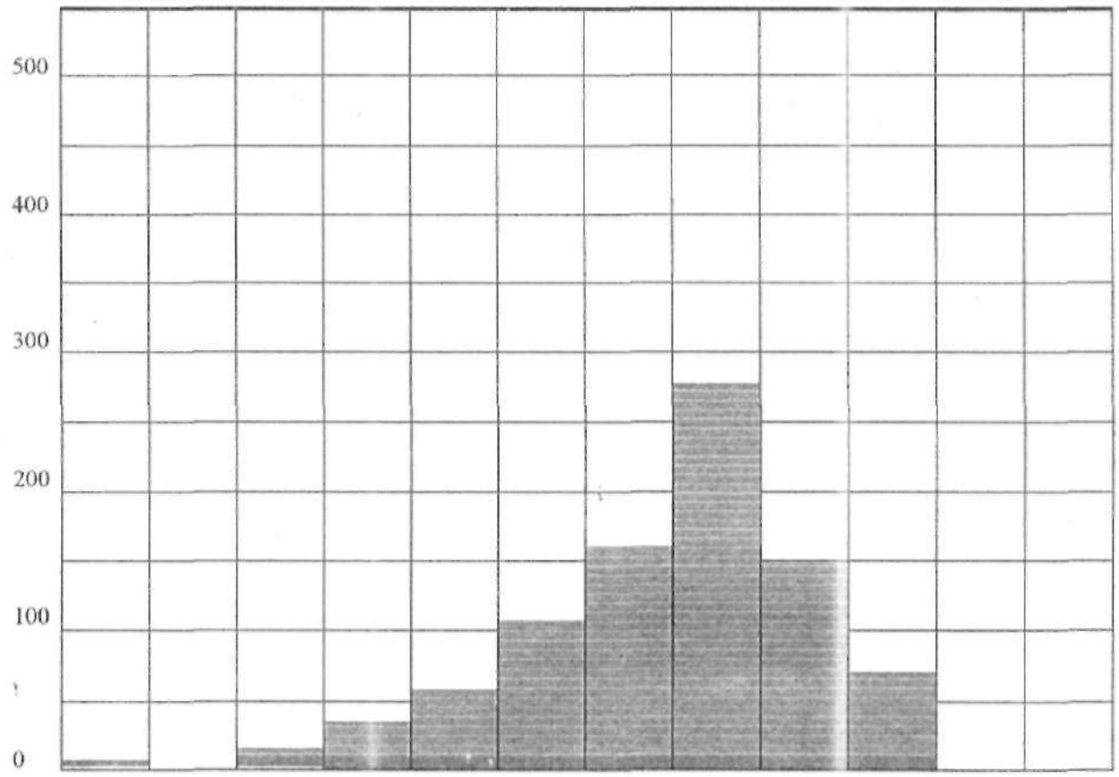
cloud cover and longer day light hours cause relatively high solar radiation. During this period of the rainy season most of the rainfall occurs over a comparatively short period of the 60 (sixty) or so rainy days per year about 78 (Seventy Eight) occur during August with intensities frequently in excess of 200mm/hr. The intensity of the rainfall, combined with rapid run-off, causes severe flood conditions.

5.2.4 Kaka

The period of Mid-August to Mid-November is known as "Kaka". The final stages of the wet season agriculture are completed during this period. The relative humidity begins to fall and the prevailing winds shift from a south westerly to an easterly direction. Solar radiation is moderate and from September to Mid-November the precipitation declines to a point where practically no rainfall is recorded.

5.3 RAINFALL

Sokoto has a comparatively low total annual rainfall with about 60% of it falling during the months of July, August and September. During this wet season storms and subsequent flooding may occur over limited areas.



Month:	J	F	M	A	M	J	J	A	S	O	N	D
N/mm	0.3	0.0	1.0	10.4	47.0	97.0	168.4	244.0	138.4	16.8	0.0	0.0

Table 5.3: Rainfall Data

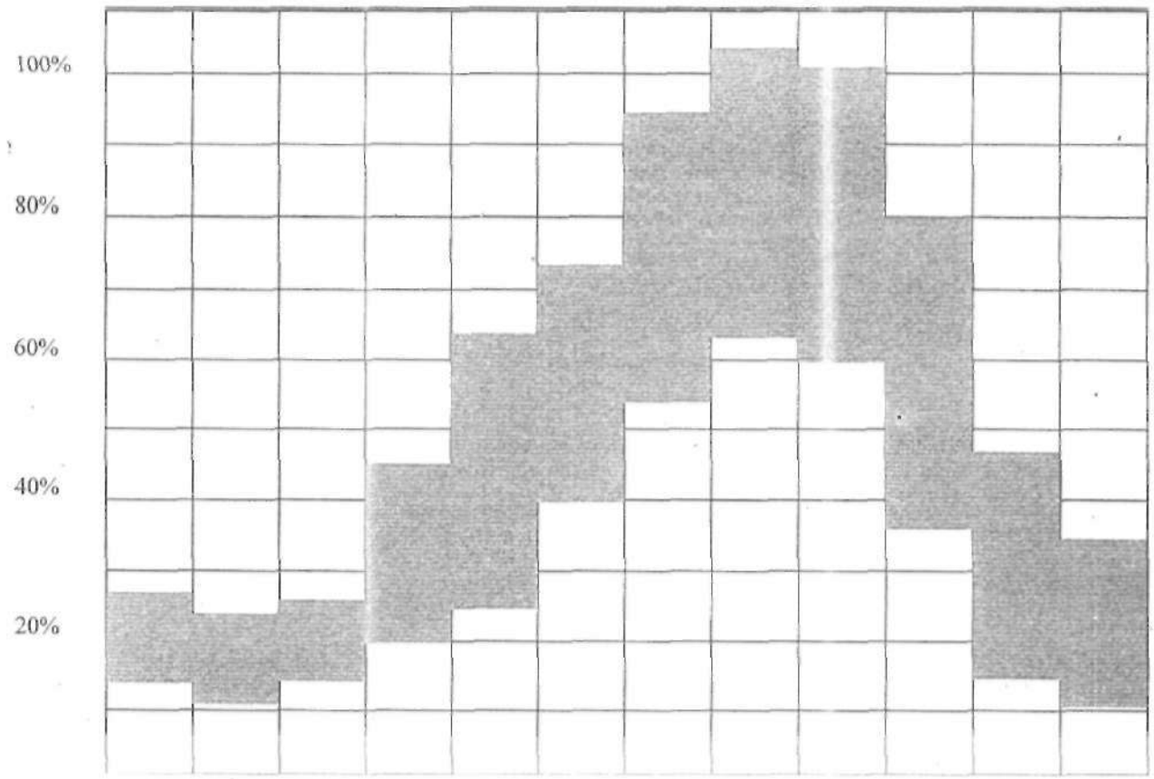
5.4 WIND DIRECTION

The winds vary locally with the most prominent being the North-east trade wind which is dry, cold and dusty "Harmattan" winds that blows down from the Sahara during the months of November to February.

While the other wind is the South-west trade wind which is moist and cool, which brings rainfall.

5.5 RELATIVE HUMIDITY

The human sensitivity to temperature is greatly affected by relative humidity associated with this dry season temperature condition the relative humidity scarcely reaches 50%. Such clear, cloudless skies do little to reduce the intensity of the solar radiation. During the wet season the humidity range increases to between 60% and 90%.



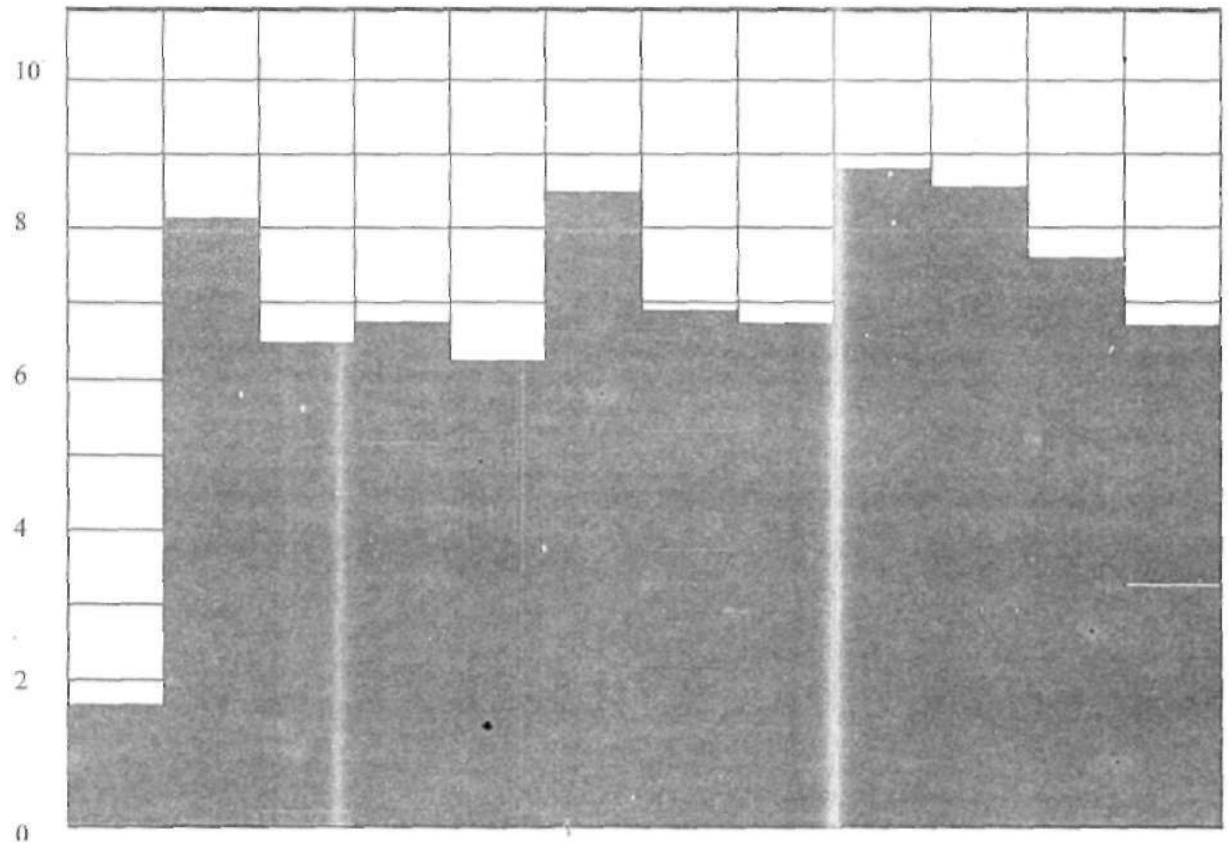
Month:	J	F	M	A	M	J	J	A	S	O	N	D
in/%	21.5	18.0	20.0	32.0	48.0	59.0	72.5	79.5	75.5	59.0	32.5	25.0

Table 5.5: Relative Humidity Data

5.6 SUNSHINE

Solar radiation is diffused by the dust in the atmosphere, causing poor visibility, which frequently results in interruptions in the air traffic schedules.

The solar radiation is generally intense because of the reduction of dust in the atmosphere and lack of cloud cover.



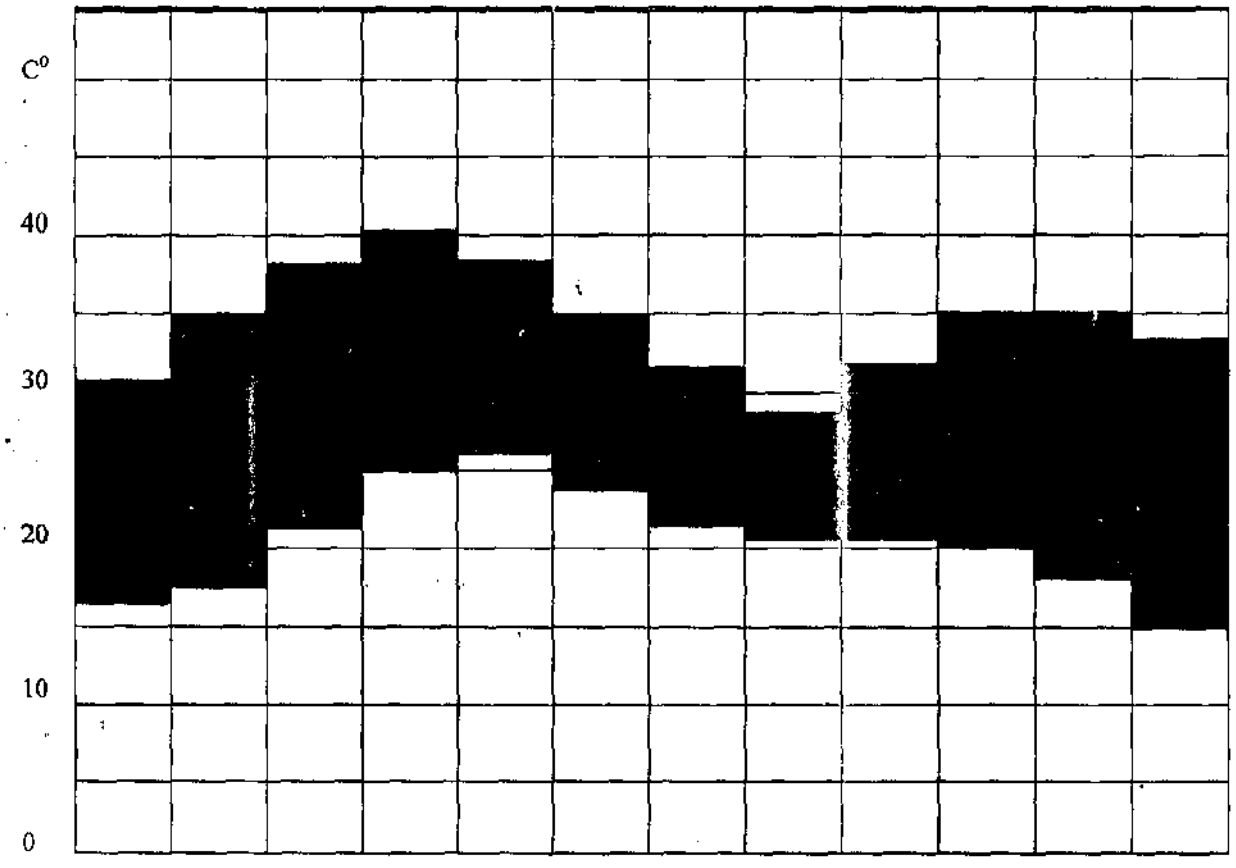
Month:	J	F	M	A	M	J	J	A	S	O	N	D
/Hrs	1.8	8.2	6.7	6.9	6.3	8.4	6.8	6.7	8.9	8.7	7.7	6.7

Table 5.6: Sunshine Data

5.7 AIR TEMPERATURE

In human terms net radiation is felt as air temperature. Approximate uniformity of temperature is experienced throughout the year.

The highest temperature occurs in the dry season when there is little cloud cover. Diurnal variations as high as 12^0C are known to occur during the rainy season.



Month:	J	F	M	A	M	J	J	A	S	O	N	D
MIX^{0}C	32.0	38.0	38.5	40.0	38.5	35.0	31.5	28.5	31.5	35.0	35.0	32.5
MIN^{0}C	15.5	17.5	21.5	25.0	26.5	23.5	22.0	21.5	21.5	20.0	17.5	15.0

Table 5.7: Air Temperature Data

5.8 IMPLICATIONS OF CLIMATE ON PLANNING

Climatic factors have a profound influence on planning and design decisions. They are critical to the understanding of creating a comfortable environment within which people can function efficiently.

Physical human comfort is a product of dry and wet bulb temperatures, air velocity and radiation heat exchange between the human body and the environment with these criteria in mind, some of the most important considerations involved in design are:

i. Building should be as compact as possible so that the various parts of a building create mutually beneficial shade.

ii. The exterior surface of the buildings should be minimized to reduce exposure to solar radiation. The basic geometry of the architecture and its urban configuration, particularly in high-density areas, can be designed to achieve this.

iii. An introverted or "Atrium" plan typology, with high peripheral walls and a small internal courtyard will reduce solar penetration and thereby improve the internal microclimate.

iv. Pedestrian walkways should be shaded with arcades or vegetation to protect people from the direct solar radiation.

v. Strategically located areas of dense vegetation within the planning environment will improve the microclimate in general, especially within residential areas. It is preferable to have a larger number of smaller vegetation areas as opposed to a few large open spaces.

vi. The provision of vegetation and water within the enclosed spaces will cool the air by evaporation. It will help keep dust under control and provide both visual and psychological relief.

5.9 SITE LOCATION

The site is located in Sokoto State, which was founded by Sultan Muhammad Bello, during his father's lifetime, Shehu Usman Danfodio, the home of Sultans, spiritual head of all Muslims in what is known as Western Sudan. The State, Sokoto shares boundary with Kebbi State, Zamfara State and Niger Republic.



Plate 5.9a: Map of Nigeria



Plate 5.9b: Map of Sokoto

5.10 VEGETATION

The site falls within the Sudan Savannah vegetation zone with three broadly identified types of vegetation, wooded alluvial valleys, tree savannah, grass and shrub savannah.

i. Wooded Alluvial Valleys

There is intensive cultivation activity of a variety of crops around the Kandoli Shela and Kantawa valleys. Crops such as sugar cane, Paw-paw, carrots, onions, tomatoes, and bananas are widely cultivated here. On the border of the valleys, Mango trees are the most dominant tree specie. Sub dominant trees include Neem trees (Azadirachta indica) and Acacia species. The Kandoli Shela runs throughout the year, and the beauty of the Fadama, with its fine trees, cool shaded paths and lush green appearance must be emphasized.



Fig. 5.10a: Wooded Alluvial Valleys

ii. Grass And Shrub Savannah

This is the characteristic vegetation of western hills and their associated rainfall run-off areas. It is noticeable that the intensity of Arable cultivation decreases in the area, although there appeared to be some signs of cultivation at some time in the past.



Plate 5.10b: Grass and Shrub Savannah

iii. Tree Savannah

The vegetation here consists of scattered trees and shrubs. The most dominant trees include Acacia Seyal or similar species while Hyphaene Thebaica (Dum palm) occurs in random groups.

Azadirachta Indica is also found scattered throughout this area. Other trees found around the area include a few isolated Adansonia Digita (Baobabs).

Generally, tree density increases in the areas closest to the Kandoli Shela valley. Arable farming is also practiced here, with the main crops being cassava and millet.



Fig. 5.10c: Tree Savannah

5.11 SITE SELECTION CRITERIA

The following factors lead to the choice of Sokoto as the location where the proposed Solar Energy Research Center is to be sited.

i. Sokoto has abundant Solar Energy supply about 9 hours of sunshine is possible on most days of the year.

ii. The site is large enough to accommodate facilities such as efficient modern laboratory, office buildings and other ancillaries for operational convenience.

iii. There are hotels and support facilities for conferences, which should ideally take place near the major demonstration site.

iv. It is located near other Solar Energy Research interested institutions like College of Science and Technology, the Polytechnic of Sokoto State, Birnin Kebbi and Ahmadu Bello University, Zaria.

5.11.1 Advantages Of The Site

The following are some of the advantages of the site that was chosen for the purpose of building a Solar Energy Research Centre.

i. The site is relatively flat.

ii. There are only very few trees on the site

iii. The site is connected by good road network

iv. The site has already been acquired

v. The site is isolated from traffic, noise within and outside the campus.

CHAPTER SIX

BRIEF DEVELOPMENT AND DESIGN PARAMETERS.

6.1 DESIGN BRIEF

PROJECT: PROJECT SOLAR ENERGY RESEARCH CENTRE, SOKOTO.

CLIENT: FEDERAL GOVERNMENT OF NIGERIA.

The centre will be provided with the following facilities for operational convenience, administration, research and training, service and maintenance, laboratories, workshops, computer room, auditorium, library, testing areas and housing for temporary staffers and students.

6.2 DESIGN PARAMETERS

6.2.1 Administration

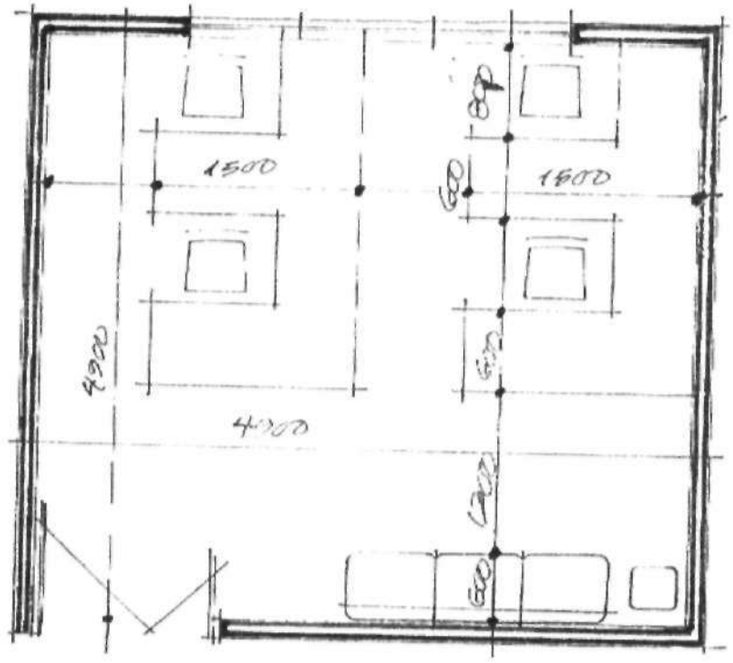
i. Main Entrance

ii. Offices for internal administration and coordination

iii. Provision for local and international conferences

iv. Provision for general public information on research results.

v. Some unallocated offices for unforeseen uses.



Number people -6-9

Typical Space Required per person -2.7-4m^2

Type of use:-
-Staff Working Area

Provision of Equipment:-
Pinboard, Computers, Telephone Extension

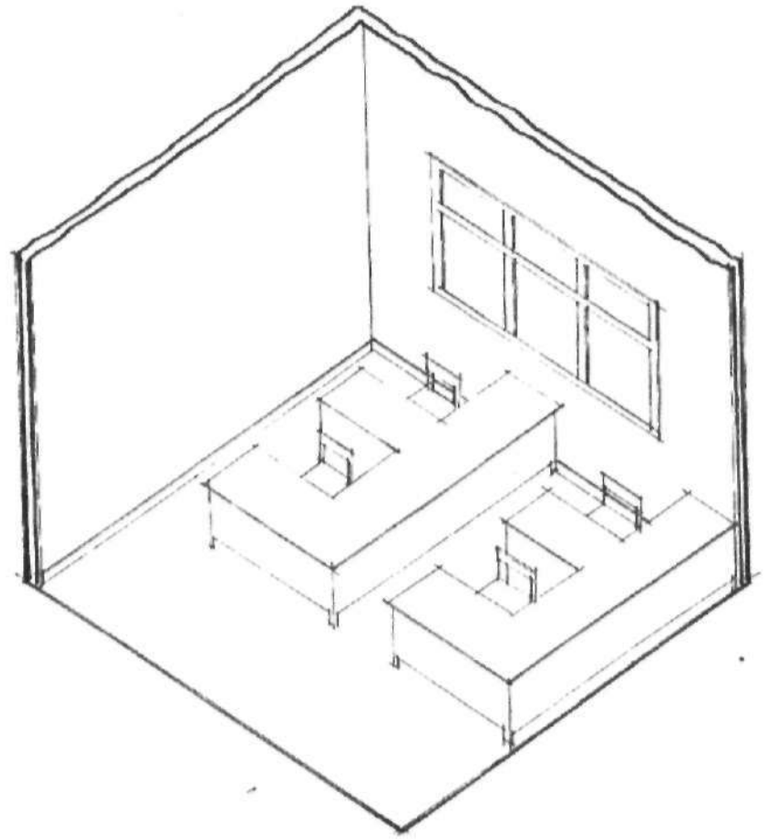


Fig 6.2.1: Open Ganged Work Station

6.2.2 Ancillary facilities

i. Staff Canteen

ii. Health Clinic

iii. Publication Unit

iv. Computer Unit.

6.2.3 Services, Operations and Maintenance

i. Offices

ii. Central Storage

iii. Workshop

6.2.4 Research and Training Facilities

i. General laboratories

ii. Offices for research staff

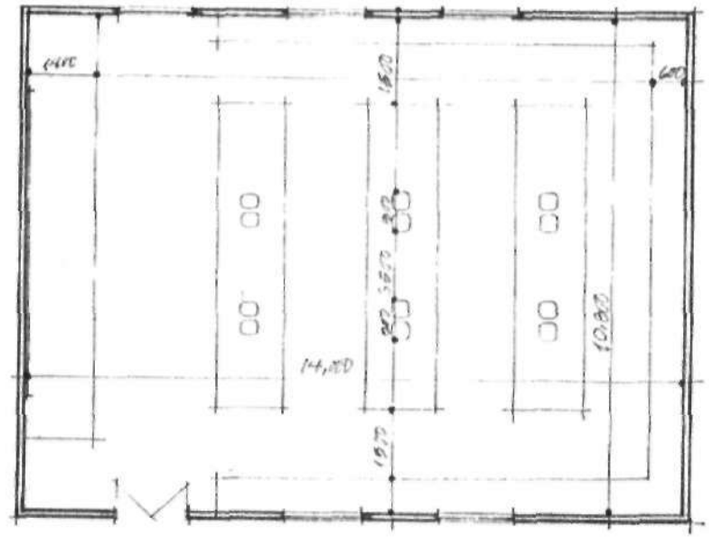
iii. Offices for training staff

iv. Administration for research unit

v. Administration for training unit

vi. Seminar room

vii. Library



Number of People: 10-12

Typical Space Required per Person
2.1 – 4.6m^2

Type of use:
Wet and Dry Solar Research

Provision of Equipment:-
Fume Cupboard, Batteries, Storage Cabinet.

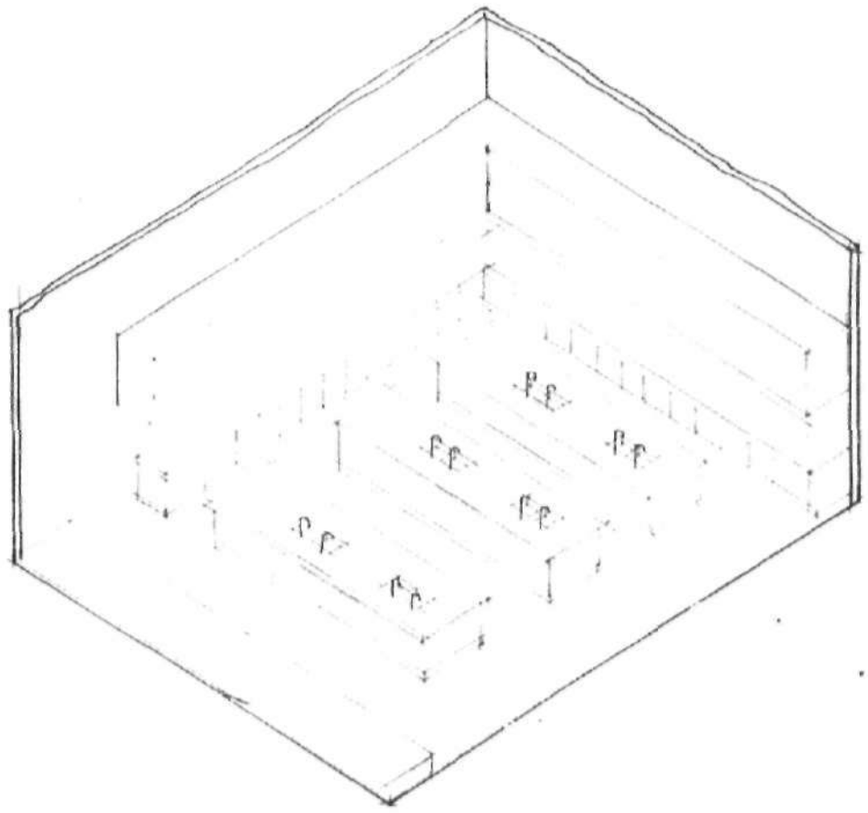


Fig. 6.2.4: Typical Laboratory

6.2.5 Meteorological Observation Plot

i. Demonstration Area

ii. Meteorological Observation platform

iii. Area for installation of wind mills

iv. Store

6.2.6 Housing

i. Staff housing

ii. Guest houses

6.2.7 Security

i. Gate house with guards at access point.

ii. Fence round the centre.

6.3 ADMINISTRATION UNIT

The administration unit consist of the following major departments; personnel technical health services and catering department.

i. Personnel Department

The personnel department is responsible for keeping the personnel records and managing the employee's benefits. This department is also concerned with the recruitment of staff, organising training for staff both within and outside the set up to improve on their standards.

ii. Technical Services Department

The technical services department undertakes the fabrication of some equipment used for researches; maintenance of furniture and other equipment used in the centre could be carried out in this department. Servicing of some research equipment could also take place here.

iii. Health Services Department

The health centre has the status of a clinic. Major cases should be referred to the hospital. Bed rest could be given to some weak staff that require rest for some hours.

iv. Catering Department

The Restaurant serves the whole of the centre. The services here should be undertaken by a contractor, adequate provision is given to the kitchen, store, servery and conveniences.

v. Finance Unit

There are four major departments that make up this unit, namely, Accounting, Budgeting, Purchasing and Central Store. Excessive expenditure by any department in the centre can be controlled through this unit.

vi. Information and Education Unit

The major departments contained in the unit are public affairs, word processing, library, consultation and Data bank.

vii. Public Affair Office

The office is responsible for preparation of public information and contacts with information media. It will prepare press relases, including photographic coverage of the centres events.

viii. Library

The library in this department provides information to both staff and the public under special arrangement. It can be used as a reference library for books and journals. It could also be used for general reading and study.

ix. Auditorium

The main function of the auditorium is for organising conferences and seminars. Occasionally, public lectures could be given in the auditorium. Provision would be made for projecting films if the need arises.

x. Computer Department

The importance of computer in research can not be overemphasized.

xi. Research and Training Unit

The research unit is provided with laboratories, offices for researchers, library and administration departments. Areas of research to be covered include:

i. Materials

ii. Photovoltaic Cells

iii. Thermal Conversion

iv. Bioconversion

v. Components and Systems

vi. Wind Energy

vii. Energy Conservation and Management

viii. Thermal Energy Storage

6.4 SCHEDULE OF ACCOMMODATION

i. Ground Floor

SPACE	TOTAL FLOOR AREA (M^2)
-Reception/Exhibition	295.0
-Waiting Room	48.0
-Photocopy	25.0
-Consultancy	24.0

-Waiting Room	25.0
-Record/Dispensary	24.0
-Injection Room	15.0
-Rest Room	24.0
-Toilets	36.0
-Drawing Studio	36.0
-Store	25.0
-Secretary to the Centre	25.0
-Secretary's office	25.0
-Telephone Room	25.0
-General Office	52.0
-Librarian	24.0
-Library	162.0
-Auditorium	358.0
-Toilets	56.0
-Restaurant	180.0
-Kitchen	42.0
-Store	15.0
-Photovoltaic/Electronic Lab.	180.0
-Reception	24.0

-Central Store	162.0
-Carpentary Workshop	162.0
-Technical Staff Office	30.0
-Toilets	28.0
-Biogas/Wood Stove Kitchen	48.0
-Classroom 1	104.0
-Classroom 2	104.0
-Seminar Room	108.0
-Toilets	80.0
-Reception	30.0
-Common Room	54.0
-Canteen	54.0
-Kitchen	36.0
-Servery	12.0
-Store	6.0
-Study	30.0
-Bedrooms (10)	300.0
-Laundry	27.0
-Store	27.0
Total	**3147.0**

ii. First Floor – Technical Unit Floor

SPACE	TOTAL FLOOR AREA (M^2)
-Budgeting Office	30.0
-Budgeting Officer	30.0
-Purchasing Office	30.0
-Purchasing Officer	30.0
-Store	46.0
-General Account Office	50.0
-Records	18.0
-Accountant	34.0
-Secretary	30.0
-Toilets	36.0
-Solar/Thermal Unit	30.0
-Photovoltaic Unit	25.0
-Meteorology/Wind Energy Unit	25.0
-Biomass Unit	24.0
-P.R.O	34.0
-Office	34.0
-Office	45.0
-General Office	45.0

-Records	16.0
-Personnel/Manager	32.0
-Secretary	30.0
-Chemical Lab.	180.0
-Office	30.0
-Solar Cooling Lab.	56.0
-Testing/Recording Office	42.0
-Meteorology Department	144.0
-Toilets	24.0
-Offices (9)	432.0
-Study	42.0
-Games Room	28.0
-T.V Room	60.0
-Laundry	30.0
-Toilets (6)	96.0
-Store	30.0
Rooms (12)	360.0
Total	**2444.0**

iii. Second Floor – Management Floor

Space	**Total Floor Area (M^2)**
-Director of Centre	100.0
-Toilet	6.0
-Secretary	32.0
-Waiting	32.0
-Conference	100.0
-Waiting	34.0
-Secretary	32.0
-Registrar	100.0
-Toilets	36.0
-Archive	36.0
-Computer/Control Unit	60.0
-Secretary	24.0
-Deputy Director	36.0
Total	**628.0**

iv. Grand Total

Floor	**Total Area (M^2)**
-Ground Floor Total	3147.0
-First Floor Total	2444.0
-Second Floor Total	628.0
Grand Total	**6219.0**

6.5 FUNCTIONAL RELATIONSHIP FLOW CHART

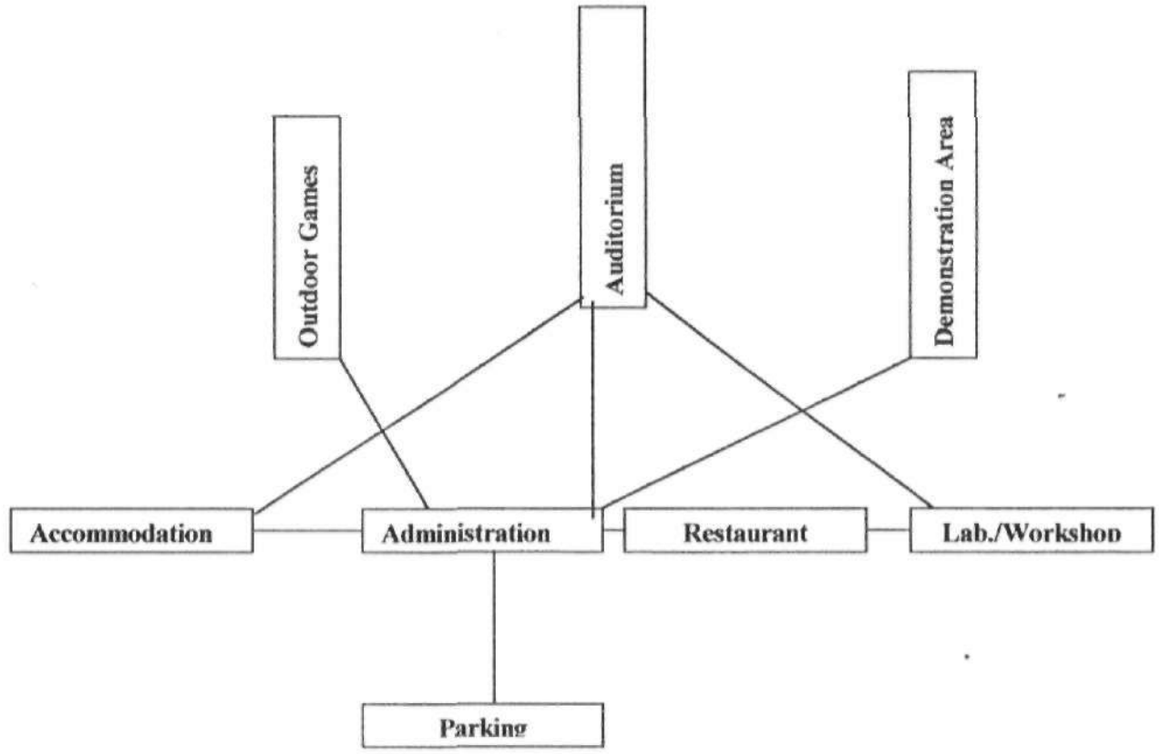


Fig. 6.5: Functional Relationship Flow Chart

6.6 ZONING

The entire complex has been divided into public, semi-public and private areas. Within the public areas falls the parking spaces, and administration. The restaurant, auditorium and accommodation fall under the semi-public area while the demonstration site, laboratories and workshops fall under the private area.

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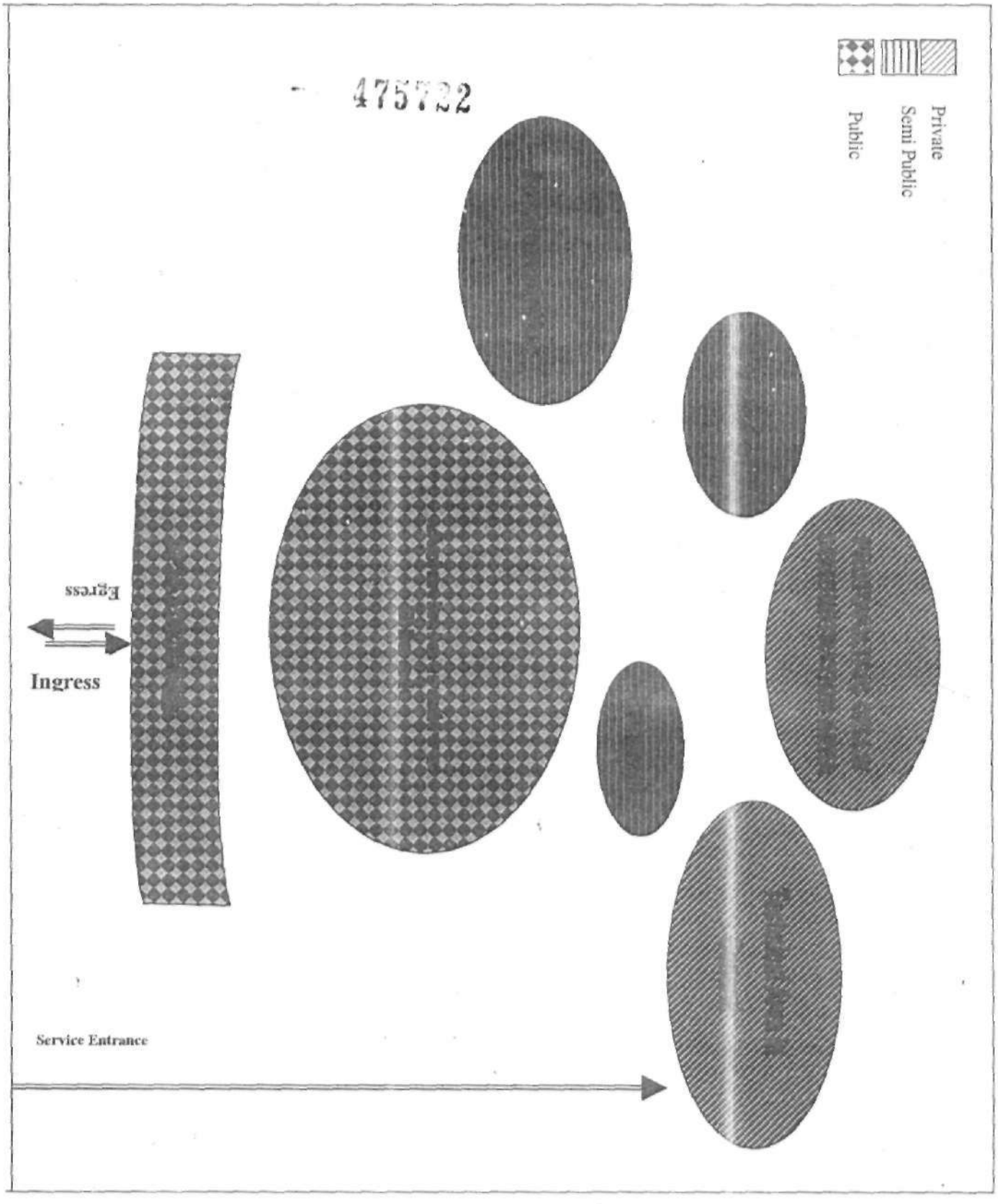
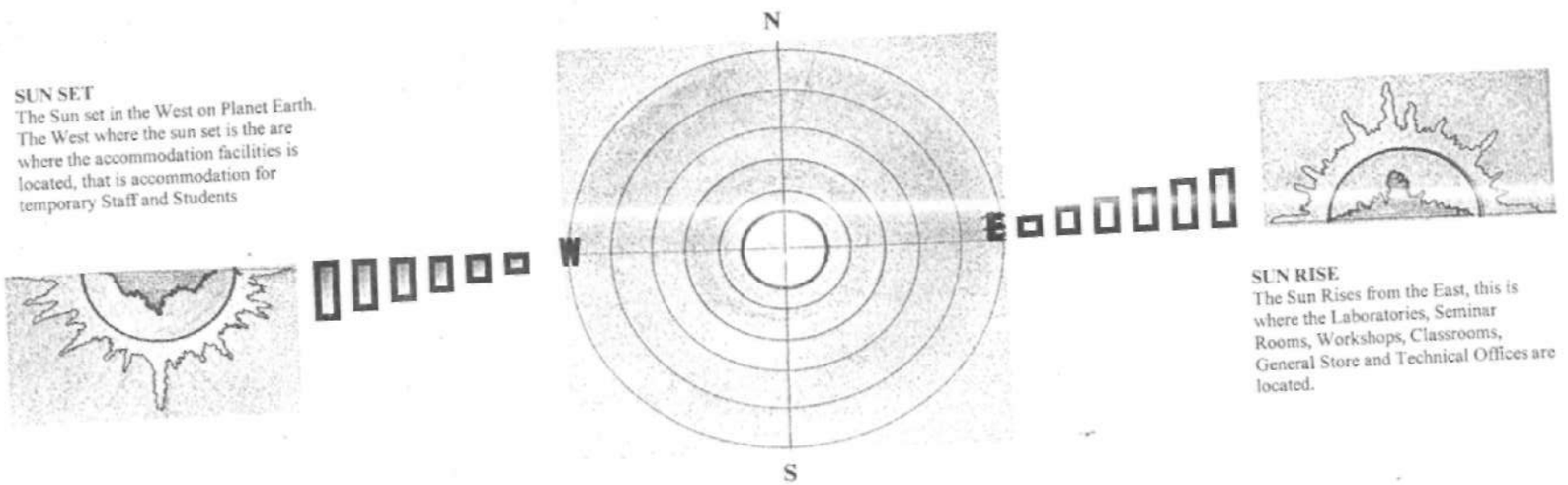


Fig. 6.6: Site Zoning

6.7 DESIGN CONCEPT

The concept of this design is the graphical representation of the Sun path over Planet Earth with the Sun rising from the East and setting in the West. The Laboratories, Seminar rooms, Workshop, Classrooms, General Store and Technical Offices are all located in the Sun rise diagram. The Accommodation facilities are located in the Sunset of the diagram. The Earth, which stands as the core of the Research Centre comprises of the Administrative Block, Auditorium, Auxiliary facilities such as Health Clinic, Restaurant, Computer Unit and Publication Unit. This can be seen in the diagram below



SUN SET
The Sun set in the West on Planet Earth. The West where the sun set is the are where the accommodation facilities is located, that is accommodation for temporary Staff and Students

SUN RISE
The Sun Rises from the East, this is where the Laboratories, Seminar Rooms, Workshops, Classrooms, General Store and Technical Offices are located.

EARTH
The Earth which stands as the core (Centre) of the Research Centre comprises of the Administrative Block, Auditorium, Auxiliary facilities such as Health clinic, Restaurant, Computer Unit and Publication Unit

Fig. 6.7 Design Concept

6.8 SITE CONCEPT

The site for the project is generally very dusty, there is also very heavy wind. The wind and dust, if not checked properly, will constitute a nuisance to the buildings and equipment installed on the site. In order to reduce the adverse effects of wind and dust on the site, trees have been planted densely along the boundries of the site. The trees at maturity will serve as wind breakers and also filter dust from winds blowing across the site.

The trees may pose a threat if planted very close to the building and may prevent the solar panels mounted on them from collecting maximum amount of solar radiation.

For security reasons, only two roads have been provided as entrances and exits to and from the site. Grasses and water bodies will also be provided to reduce the effect of dust.

6.9 DESIGN REPORT

The architecture of the structure utilizes a synthetic process. It is dependent on the exploitation of the technical qualities of its various component materials to create a homogeneous whole.

Choice of materials was based not only on their historical development but also on future potential.

Adobe bricks strengthened with cement like compounds utilize the natural cooling effects of mud with the advances in brick technology.

The location of the research centre where there is high solar radiation over long periods, poses an architectural problem. The abundant solar radiation makes it an ideal site location but thorough site analysis revealed a tendency towards hot discomfort.

Pilkington Flash glass infra stop Type 51 - 37 solar control glass of 7mm thickness, which was used on the East and west elevation. This provided adequate natural light transmittance but reduces solar heat gain by up to 80%

Fenestration above lintel level also minimize heat gain. The use of landscaped courtyards and thermal massing all contribute to maintaining the level of hot comfort.

Steel I section lattice frames are used for the roofs due to their strength and resistance to uplift from wind loads. This framework was also utilized with the

idea that solar panels may in future be incorporated into the building structure. The framework will then have been provided with adequate resistance to this new loading conditions.

CHAPTER SEVEN

CONCLUSION AND RECOMMENDATIONS

7.1 SUMMARY

A research topic such as this "Solar Energy Research Centre" should be given adequate attention having seen the enormous potentials of this rather new discipline in this ever changing world. Sokoto State has to its credit the generosity of the abundant solar radiation due to its geographical disposition. If this natural endowment is judiciously harnessed as suggested by the researcher in this project, a complete renaissance will be inevitable in the energy sector, since virtually everything that boarders around mankind and life evolve around this subject, then we can begin to consider a dawn of a new era in every facet of human endeavour.

7.2 CONCLUSION

The precepts laid down in this thesis work were arrived at from exhaustive research which if religiously followed, will not doubt act as a pointer to the new world that has up till his moment remained a mirage in most developing nations and Nigeria in particular.

7.3 RECOMMENDATIONS

Nigeria is one of the nations interested in alternative source of energy rather than over dependence on petroleum or fossil fuel which have gained the reputation of the main source of energy. Unfortunately it's lifespan may be only a few decades away.

Despite the fact that the level of awareness among the populace is rather low, effort should be made to educate the public on this abundant yet generally neglected source of power supply which can sustain the demands of the people. This could be achieved through conferences, workshops, seminars and the electronic media.

The building accommodates the facilities meant for operational convenience, the structural envelope or fabric should be original as much as possible, the use of local building materials should be employed as much as possible, a very healthy maintenance culture should be practiced.

If these factors are carefully considered, Nigeria will no doubt be justified for being regarded as the giant of Africa.

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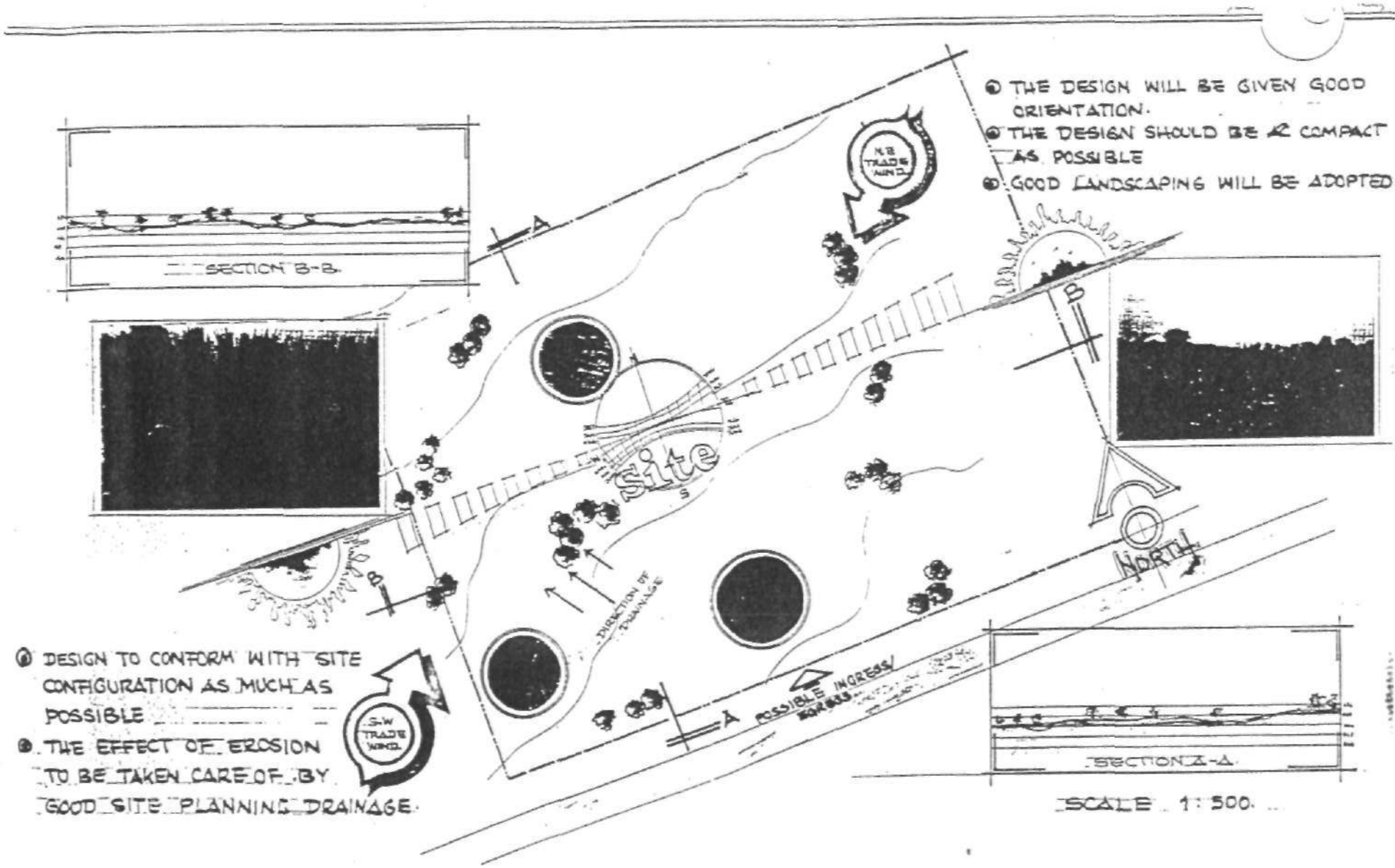
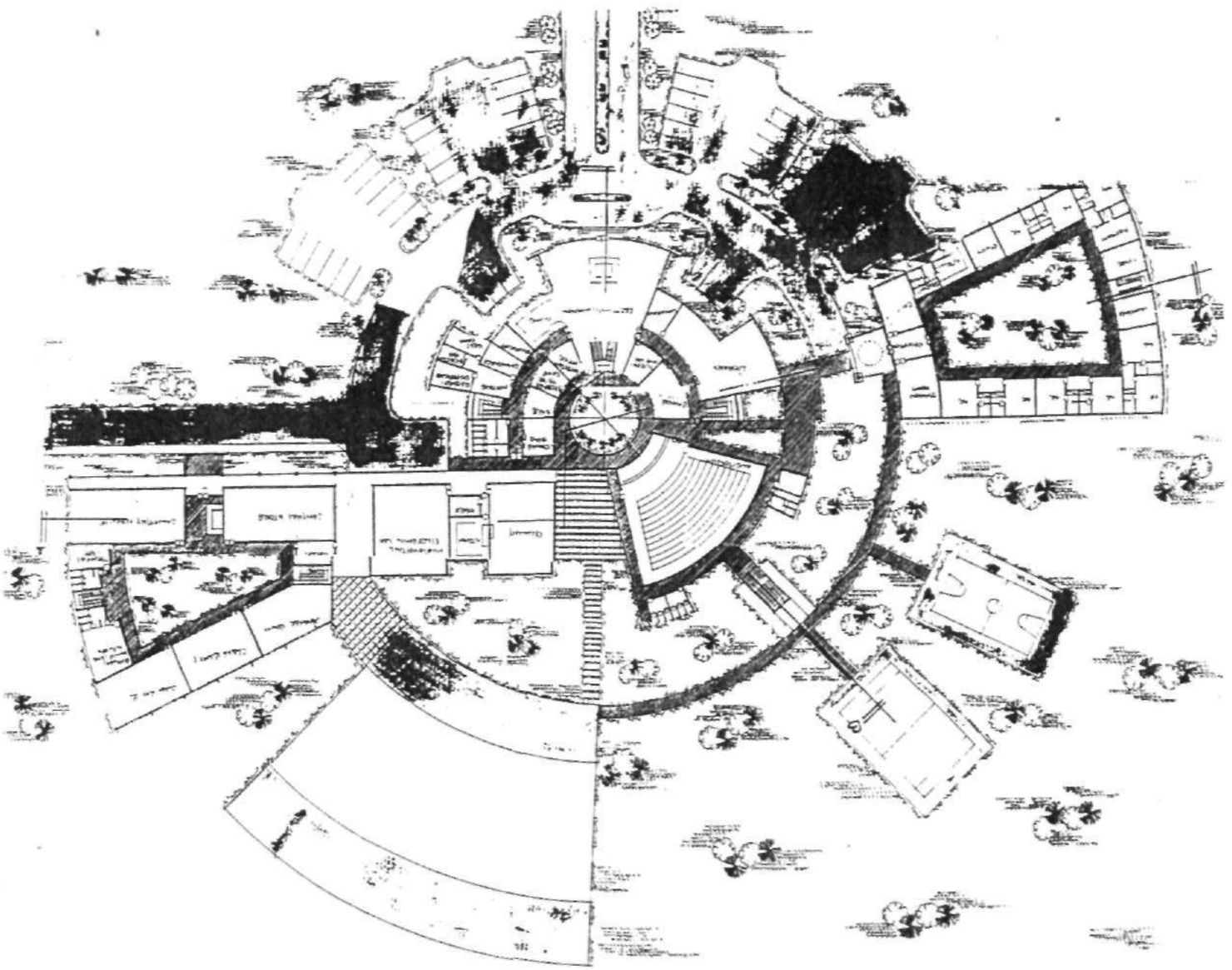
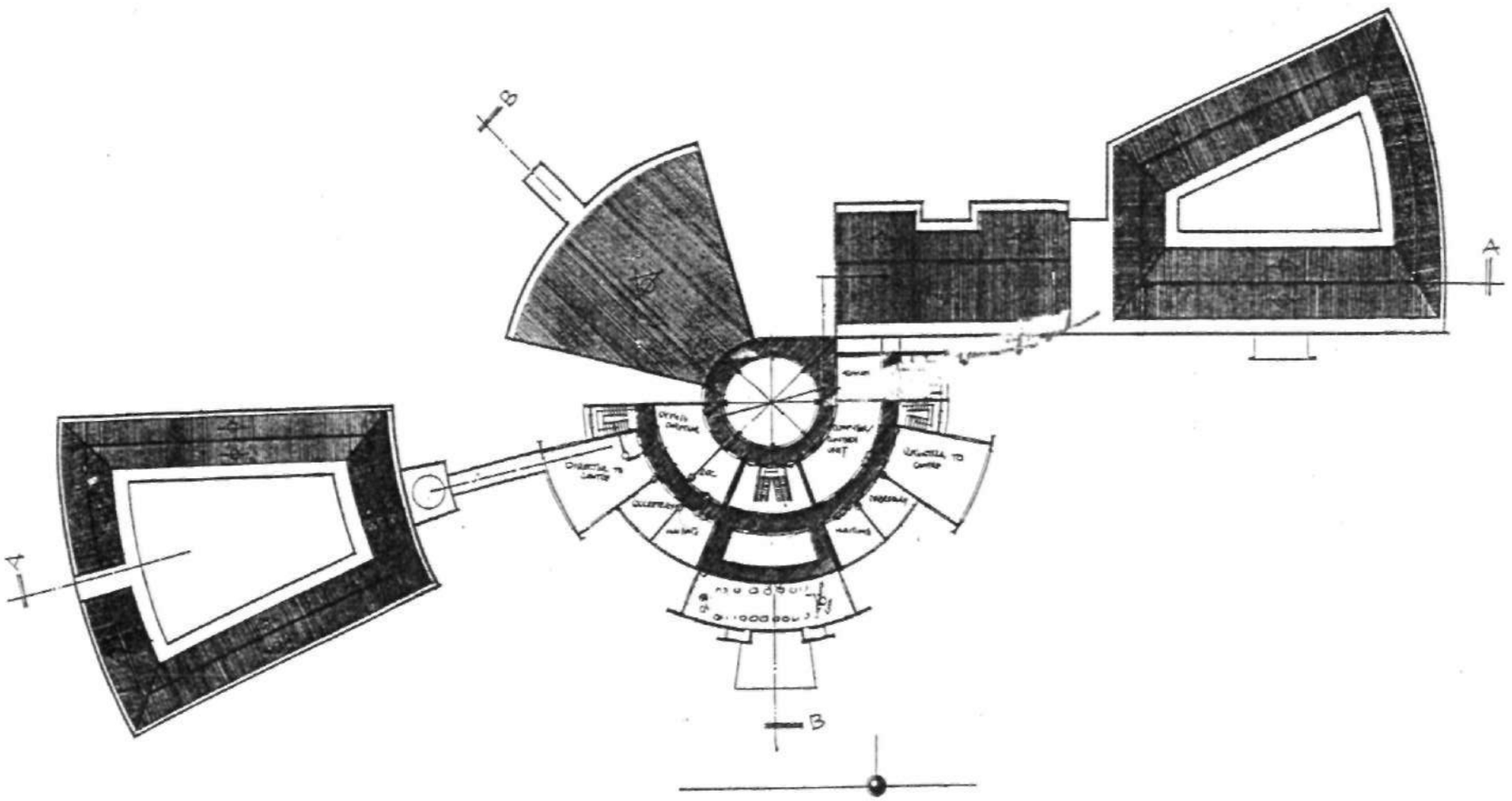


FIG. 5a. SITE ANALYSIS,

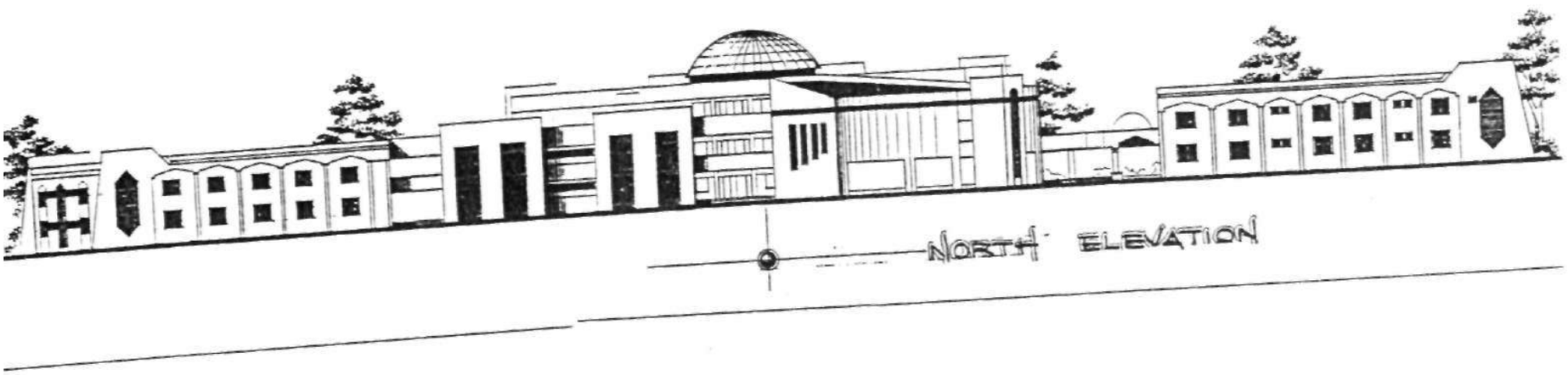
SITE PLAN





SECOND FLOOR PLAN,

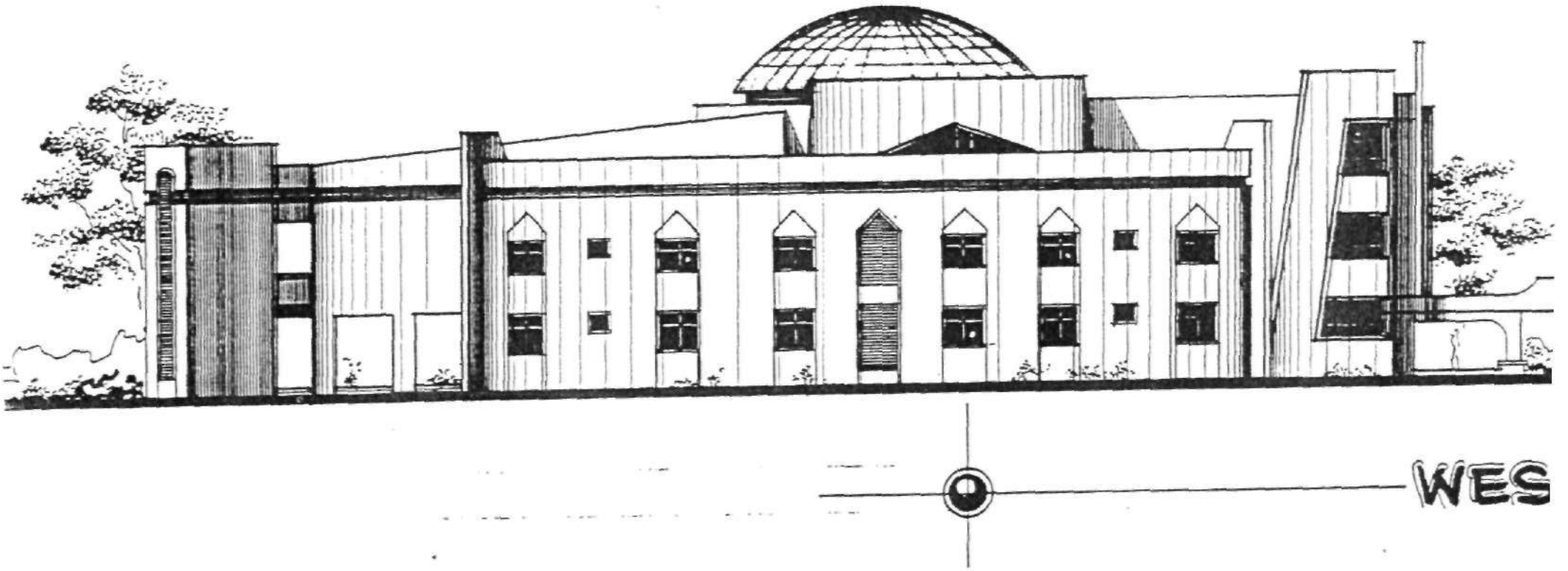
APPROACH ELEVATION



NORTH ELEVATION



EAST ELEVATION



WEST ELEVATION.