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FROM GRASS TO MEAT AND MILK: SITUATION AND PROSPECTS IN NIGERIA

Victor A. Oyenuga, FAS.

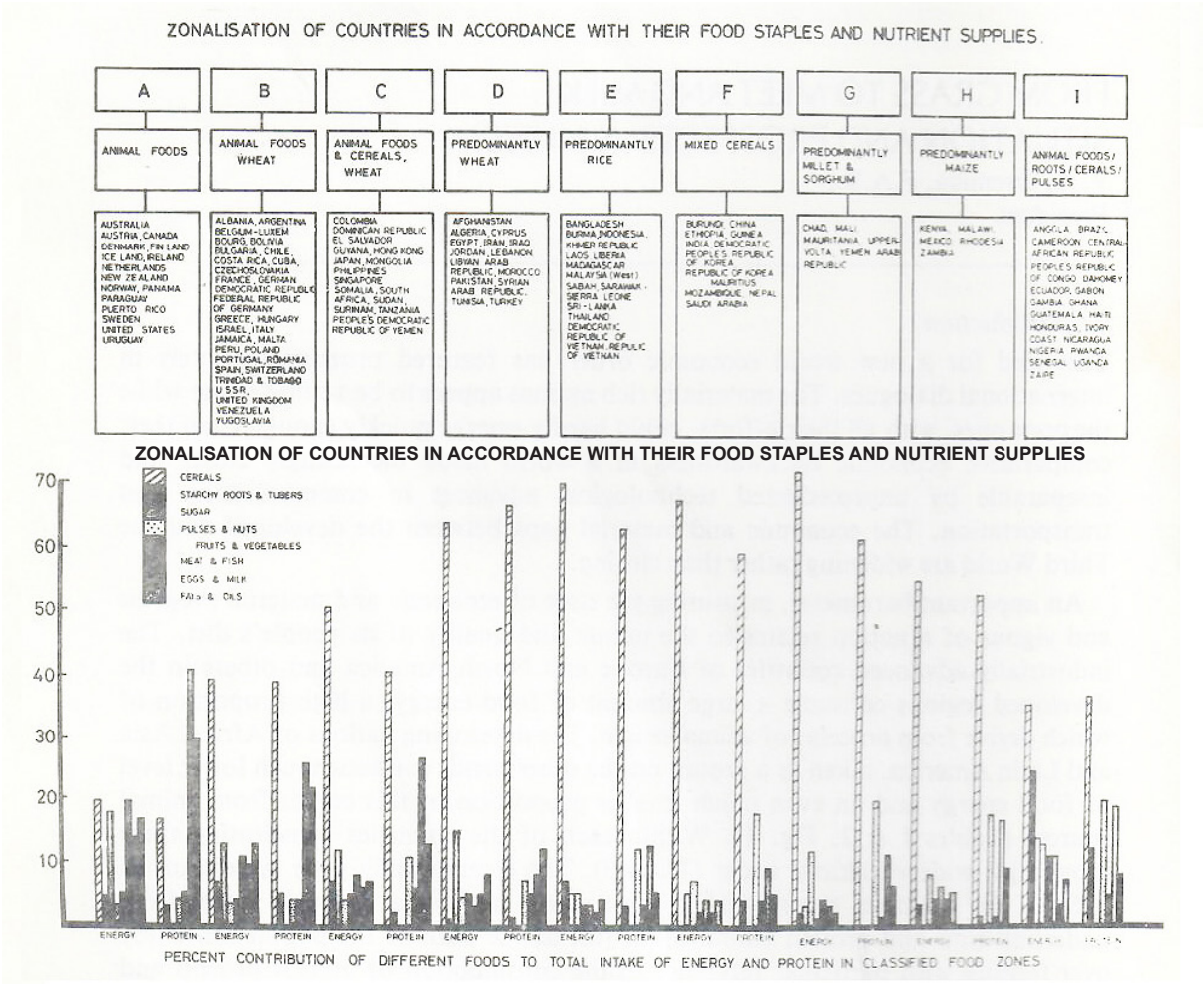
(First published in the Discourses of the Nigerian Academy of Science Vol 1No. 1 January 1978)

I. Introduction

The need for a new world economic order has featured prominently lately in international dialogues. The materially rich nations appear to be getting richer while the poor ones, with all their efforts, could hardly emerge quickly enough from their comparative economic backwardness in a world made increasingly closer and inseparable by unprecedented technological advances in communication and transportation. The economic and material gaps between the developed and the Third World are widening rather than closing.

An important barometer, measuring the state of economic and material progress and vigour of a nation relates to the nature and quality of its people's diet. The industrially-advanced countries of Europe and North America and others in the developed regions consume a large amount of food energy, a high proportion of which derive from proteins of animal origin. The developing nations of Africa, Asia, and Latin America, taken as a group, on the other hand, consume much lower level of food energy and an even much smaller proportion of this comes from animal sources (Tables 1 & 2. Fig. 1). Within each of the countries constituting these groupings, wide variations occur (Table 3). The economically poor Americans in the U.S.A., for example, as revealed in more recent nutritional surveys, suffer from undernutrition and protein malnutrition just as the bulk of the population enjoy over-feeding with particular reference to the consumption of animal protein and animal fat, an equally important form of malnutrition. In our country, a developing nation, the bulk of the population suffer from malnutrition, while an increasing minority get grossly over-fed. In the one case, malnutrition is a major cause of child mortality and low labour productivity; in the other, a cause of premature adult death among the over-fed minority in many developing nations and the over-fed majority in the Western nations. It is debatable as to which is more disruptive to society. Both forms of malnutrition are undesirable and should be eliminated.

Table 3 shows that some 67 million Africans or 25 per cent of Africa's 1970 population have intakes of food below the lower limit. Using the average 25 per cent limit as generally applicable to Nigeria, on a conservative estimate, this would amount to some 20 million persons.



ZONALISATION OF COUNTRIES IN ACCORDANCE WITH THEIR FOOD STAPLES AND NUTRIENT SUPPLIES

An individual with an intake included in this below limit group will be exposed to a high risk of an inevitable reduction in activity and adverse effect on growth, in the case of a child, or of a continuous loss of body weight in adults. There is, therefore, a very high probability that almost 462 million individuals in the world, 434 of whom live in the developing regions, 67 million in Africa and about 20 million (1977) in Nigeria have food available in a quantity insufficient to meet their needs.

II Why Animal Protein

There is general agreement among nutritional scientists on the need to raise the energy and protein levels of diets of the inhabitants of the so-called developing countries with a view, particularly, to eliminate the incidence of "kwashiorkor" and "marasmus." There is less agreement, however, on the nature of the major sources of protein and on the contributions animal products should make to the solution of the world's protein problems. Why talk about greater efficiency and productivity of animal production when "protein" can be produced several times and more efficiently from vegetables at a fraction of the cost of obtaining animal products? Besides, excess consumption of animal products, particularly animal fat, has been implicated in heart disease and in atherosclerosis. Technological and mechanical methods are now widely available for extracting proteins from leaves and seeds of plants and for spinning vegetables or for producing biosynthetic proteins of meat, milk, cheese, and butter which are made to feel, smell, taste, and texturized for chewing, like meat.

As a digression, therefore, it is probably pertinent to summarize some of the unique biochemical values of animal proteins and fats in human diet.

1. Animal flesh — beef, mutton, goat meat, pig meat, horse meat, poultry meat and their organs and offals, milk, eggs and fish and their processed forms — supply all the essential amino acids required by man in single, unaltered products and nearly in proportions required by man, since animal flesh is very similar in composition to human flesh. The differences which may occur usually tend to arise from handling, processing, and preparations such as cooking.

2. Animal products also contain substantial amounts of essential minerals, vitamins, and lipids in which vegetable proteins may be deficient.

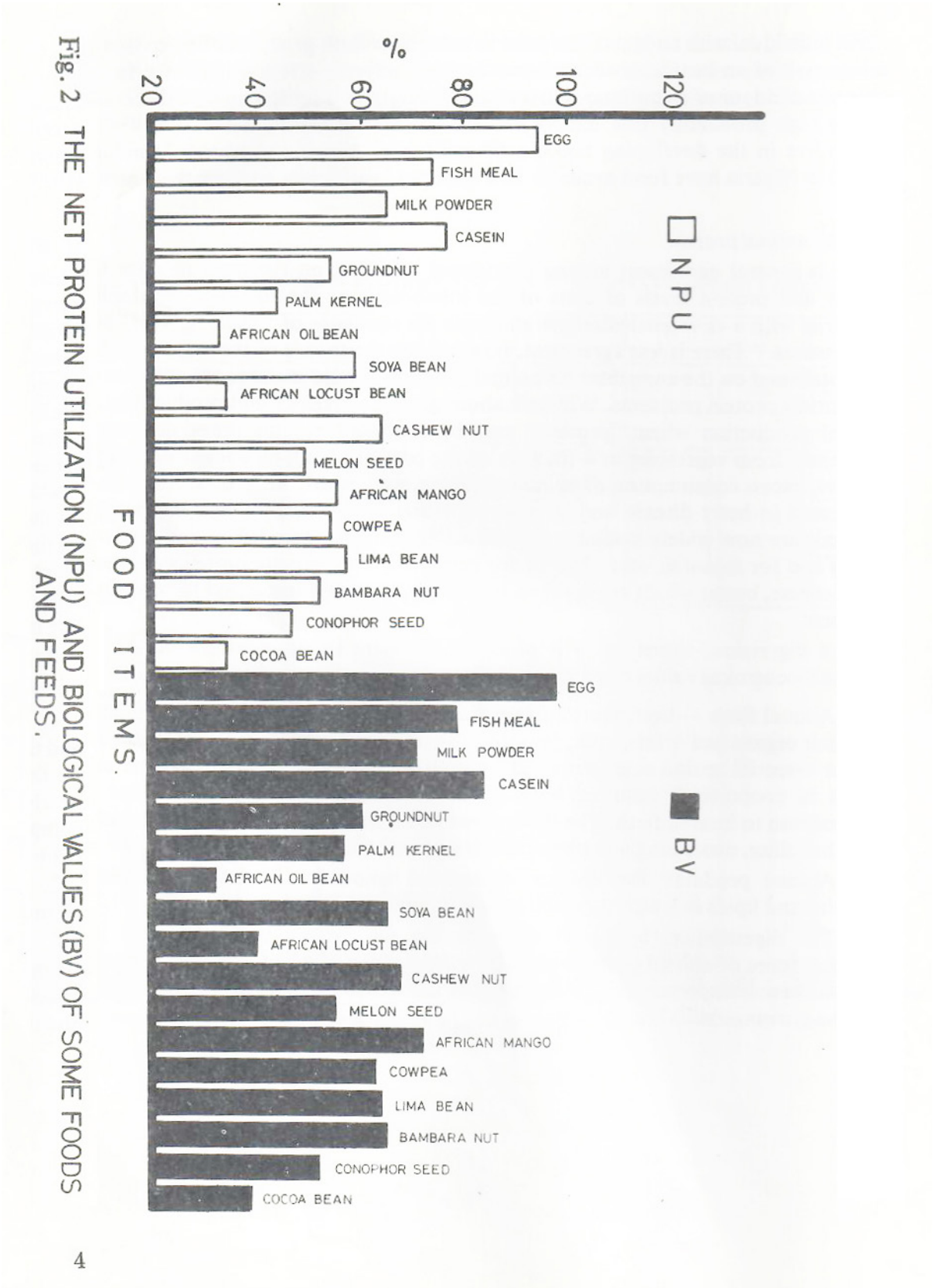


Fig. 2 THE NET PROTEIN UTILIZATION (NPU) AND BIOLOGICAL VALUES (BV) OF SOME FOODS AND FEEDS.

4

3. The digestibility, biological value, or the net protein utilization and the chemical score of animal proteins are higher than those of plant proteins, a matter of considerable importance in the nutrition of the weaned infant, the pre-school age and the growing child (Fig. 2).

4. With regard to animal fats, cholesterol, and others in relation to heart disease, it is necessary to remind ourselves that two different types of animal fats, exist:

(a) Storage fats — largely non-essential triglycerides, usually known as waistline fats;

(b) Structural fats — mainly phospholipids rich in essential fatty acids.

The waistline fats are saturated. The structural fats are highly unsaturated or poly-unsaturated. As explained below, the structural fats of animal products are also very different from vegetable fats in a nutritionally meaningful manner as to invalidate any claim that the "synthetic" meats from vegetable proteins have the same nutritional value as real meat from animal sources. The cell structural fats of animal products are biochemically different, more appropriately balanced, and more effectively utilized compared to vegetable fats.

As is well known, the essentially fatty acids which occur in plants are:

(i) Linoleic Acid: CH3-(CH2)4-CH = CH-CH2-CH = CH-<CH2)7-COOH (C18:2,n-6)

(ii) Linolenic Acid: CH3 - CH2 - CH = CH - CH2 - CH = CH-CH2-CH = CH-(CH2)7-COOH(CI8 : 3, n-3)

Linoleic acid is found essentially in plant seed and Linolenic acid in the leaf. These two fats, essential in the nutrition of animals, are incorporated primarily in plant phospholipids or structural fats. Under practical field or feeding conditions, herbivores eat both the seeds and leaves and thereby consume in their food these two essential fatty acids in the phospholipids. These poly-unsaturated fatty acids undergo metabolic processes in the mammalian liver to produce new, longer-chained complex varieties of poly-unsaturated acids for the mobile cell structures and membranes of the animal system (Chapman 1972). The elongation of the fatty acid chain occurs at the carboxyl (-COOH-) end of the molecule with the insertion of extra double bonds within the chain nearer to the carboxyl (-COOH-) group. Thus the 18:2, n—6 (linoleic) acid can be converted in the liver to 20:2, n—6; 20:4, n—6; 22:4, n—6; while the linolenic acid (18:3, n—3) can be elongated to 22:6, n—3 from C18:3, n—3 to 20:5, n—3 and 22:6, n—3. Two separate families of fatty acids are thereby obtained within the animal, based either on linoleic or on linolenic acids.

It will be seen therefore that there are two distinct groups of essential fatty acids:

(i) Vegetable fatty acids, essential in animal nutrition (C18:2, n—6 or linoleic acid and C18:3, n—3 or linolenic acid), and

(ii) Animal fatty acids (C20—22, with 4, 5 and 6 double bonds).

By using radioactive isotopes, it has been shown by Sinclair and Crawford (1972) that during the period of brain development, the long-chain fatty acids produced in the mammalian liver

are incorporated into the developing brain more than ten times faster than the parent plant poly-unsaturated vegetable fats. These incorporations occur during the early critical phase of cell multiplication. It has also been shown that diets deficient in essential lipids produce an irreversible reduction in brain size over a number of generations and irreversible impairment of the learning ability (Galli, White and Paoletti, 1970; Sinclair and Crawford, 1973 a & b). Protein malnutrition, therefore, can retard brain development in experimental animals and man (Steward, 1971; Cravioto, Pinero, Arroyo and Alcalde, 1969). Animal protein and its constituent fats are indispensable to the developing human brain. The brain is man's most outstanding development; its chief constituent is the structural fat which constitutes 60 per cent of brain solids. With increasing proportion of these long chain fatty acids in higher mammals there is a higher degree of development in the central and peripheral nervous system in which the long chain fatty acids are specifically found.

III Ruminant Livestock and the Production of Meat and Milk

The bulk of our animal protein comes from animals traditionally domesticated for food and economic purposes. They include the ruminants (cattle, sheep, goats, water buffalo and camels) and the non-ruminants and birds (pigs, rabbits, horses and poultry). The ruminants, with which this paper deals, constitute the bulk of the world's edible animal products available to man, accounting in 1974, with the edible offals, for nearly 50% of the total world meat production. In the same year (1974), Nigeria's meat production, according to Food and Agriculture Organization (F.A.O) (1974) amounted to 434,000 metric tons, made up as follows:

Beef and Veal (from cattle)	187,000
Mutton and Lambs	22,000
Goat Meat	63,000
Pig meat	29,000
Poultry meat	53,000
Others	80,000
Total	434,000
Cow's milk	1,092,000

Amount of animal products consumed in Nigeria compared with a few selected countries is shown in Table 4 and the estimated meat consumption levels in Africa in Fig. 3.

The Rumen

The importance of ruminants as sources of animal protein lies in the ability of these species to utilize plant materials, particularly pasture grass, otherwise unavailable as sources of nutrient to man, for food and convert same to meat, milk, hide, leather, wool, fibre, fuel and a wide variety of useful by-products. In some countries, work cattle are useful sources of power for farm work. Grass and pasture swards cannot be directly utilized by man and other non-ruminant animals because of their high fibrous and cellulose content. The ruminant digestive tract has four distinct compartments which serve as sites of food digestion.

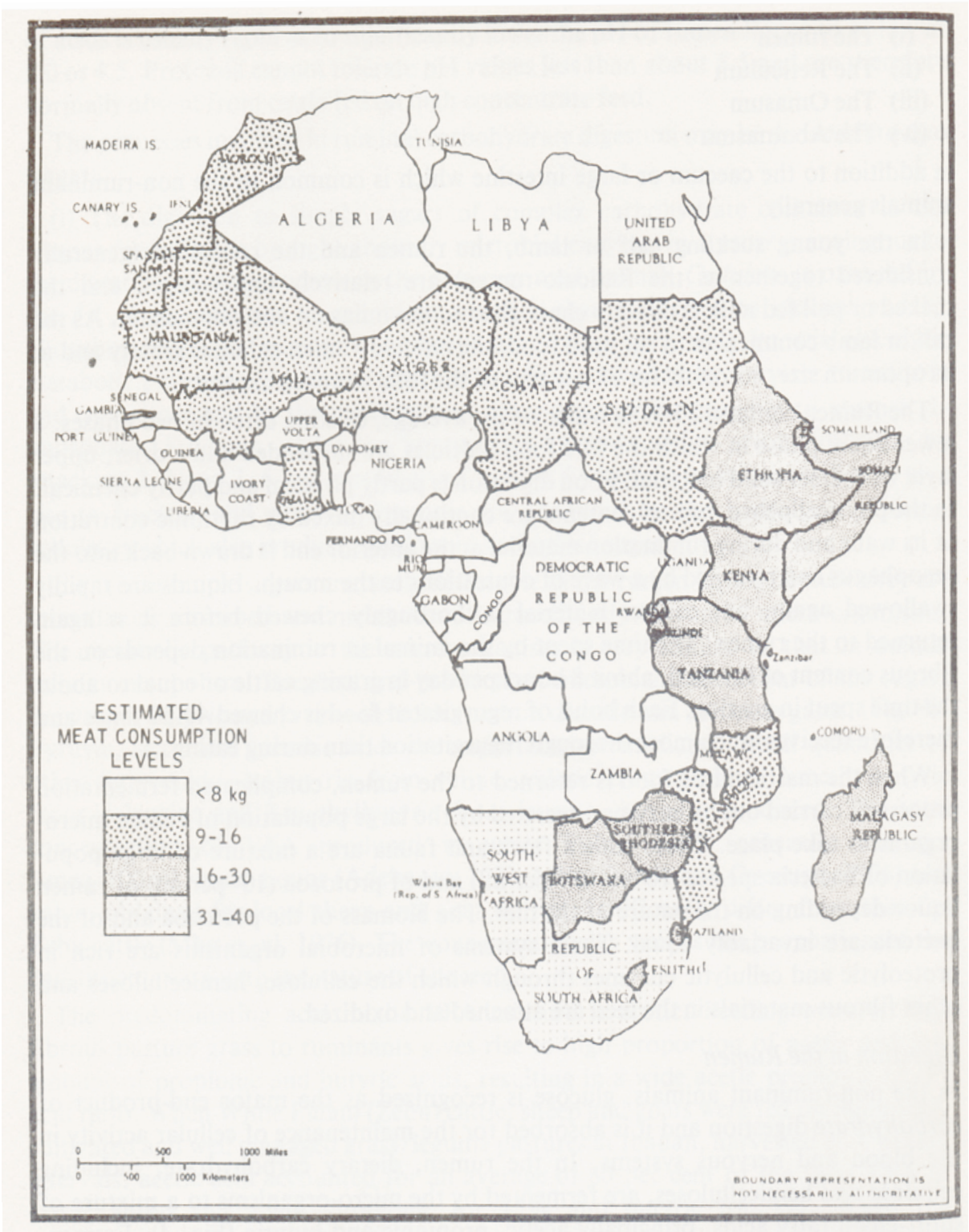


Figure 3: *Estimated levels of meat consumption [kilogram per person] in Africa.*

They are:
(i) The rumen
(ii) The reticulum
(iii) The omasum
(iv)The abomasum
in addition to the caecum or large intestine which is common to the non-ruminant animals generally.

In the young suckling calf or lamb, the rumen and the reticulum (generally considered together as the reticulo-rumen) are relatively undeveloped and the sucked or pail fed milk is directly channelled to the omasum and abomasum. As the calf or lamb commences to eat solid food, the reticulo-rumen enlarges greatly and at its optimum size, accounts for 85 per cent of the total stomach capacity.

The rumen contains 85-93% water on the average, existing often in two phases; a lower liquid phase in which the fine food particles are suspended and a drier, upper layer of coarser solid material. Food digestion is partly physical and partly chemical. In the physical phase, rumen contents are continually mixed by rhythmic contraction of its walls and, during rumination, material at the anterior end is drawn back into the oesophagus and returned by a wave of contractions to the mouth. Liquids are rapidly swallowed again, but coarser material is thoroughly chewed before it is again returned to the rumen. The time spent by the animal in rumination depends on the fibrous content of the feed, about 8 hours per day in grazing cattle or equal to about the time spent in grazing. Each bolus of regurgitated food is chewed 40-50 times and therefore receives much more thorough regurgitation than during eating.

When the masticulated food is returned to the rumen, complicated fermentation processes, carried out by enzymes, secreted by the large population of rumen microorganisms take place. These rumen flora and fauna are a mixture of large population of bacteria species (108 to 1012 per ml) and of protozoa (106 per ml) of rumen liquor depending on the nature of the diet. The biomass of the protozoa and of the bacteria is invariably equal. These systems of microbial organisms are rich in proteolytic and cellulytic enzymes through which the cellulose, hemicelluloses and other fibrous materials in the feed are attached and oxidized.

Digestion in the rumen

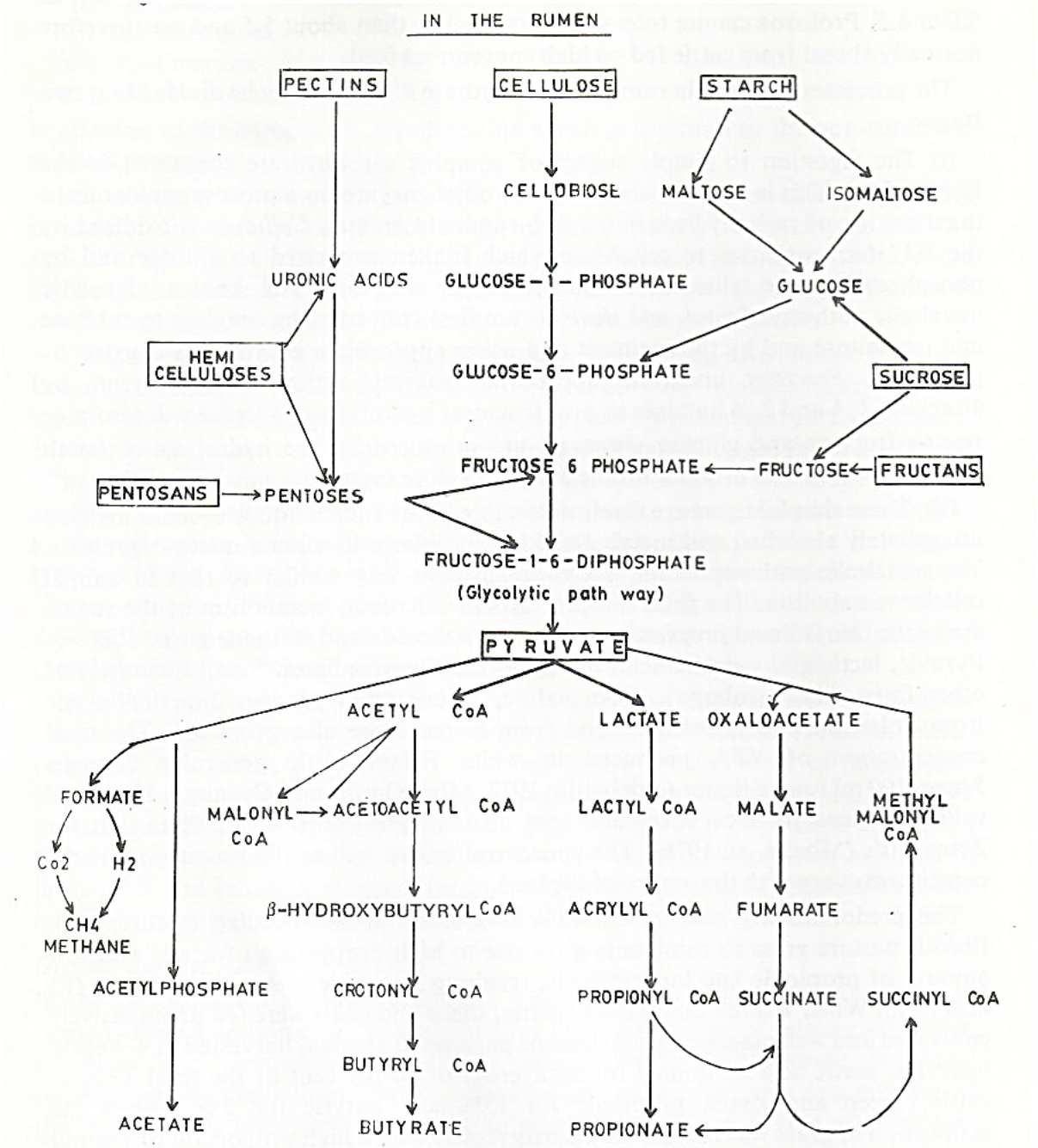
In the non-ruminant animals, glucose is recognized as the major end-product of carbohydrate digestion and it is absorbed for the maintenance of cellular activity in the blood and nervous systems. In the rumen, dietary carbohydrate, including cellulose and hemicelluloses, are fermented by the micro-organisms to a mixture of short-chain fatty acids, principally acetic, propionic, and butyric (Fig. 4). Fermentation of starch and sugars are normally complete in the rumen. Cellulose degradation is facilitated by adequate supply of nitrogen and decreased by the presence of soluble carbohydrate.

Theoretically, these acids produced during fermentation, are capable of lowering the pH of rumen liquor to 2.5-3.0. However, under normal conditions, the pH is maintained at 5.5-6.5 by means of the saliva from the mouth which buffers the ruminal pH level. In animals given predominantly concentrate diets, the production of acids is usually rapid as to significantly lower the pH of rumen liquor to as low as 5.0 or 4.5. Protozoa cannot tolerate pH values less than about 5.5 and are therefore normally absent from cattle fed on high concentrate feed.

The processes involved in ruminal carbohydrate digestion may be divided into two stages:
(i) The digestion to simple sugars of complex carbohydrate contained in the fibrous feed. This is brought about by microbial enzymes in a process analogous to the digestion of carbohydrate in the non-ruminant animal. Cellulose is oxidized by the (b~1, 4-glucosidases to cellobiose which is then converted to glucose and by phosphorylation to glucose -1- phosphate in the very well-known glycolytic metabolic pathway. Starch and dextrins are first converted by amylase to maltose and isomaltose and by the maltases and other appropriate enzymes to glucose-1-phosphate. Fructans, under the appropriate enzymic action are hydrolyzed, by attacking 2, 1 aI'!.d 2, 6 linkages to give fructose; hydrolysis _of sucrose will also give rise to fructose and glucose. Pentoses are produced by the hydrolysis of herni-celluloses which also produce uronic acid and xylose sugar.

(ii) These simple sugars are rarely detectable in the rumen liquor because they are immediately absorbed and metabolized intracellularly by rumen micro-organisms. The metabolic pathway in the micro-organism is very similar to that in animal cellular metabolism. The final end-products of microbial metabolism of the sugars are acetic, butyric and propionic acids; carbon dioxide and methane gases (Fig. 4). Pyruvic, lactic and succinic acids are important intermediates. Small quantities of other fatty acids-isobutyric from valine, valeric from proline, 2-methylbutyric from isoleucine and 3-methylbutyric from leucine-are also produced. The total concentration of Volatile Fatty Acids (VFA) produced in white Fulani cattle generally averages 5 meq/l00 ml rumen liquor (Adebanjo; 1972, Mba, Omole and Oyenuga, 1976) and values obtained for local sheep and goat do not significantly differ from that for Zebu cattle (Mba et. al. 1976). The concentrations as well as the proportion of the constituents vary with the nature of the feed.

The predominating acid in the VFA mixture is acetic. Feeding mature, high fibrous pasture grass to ruminants gives rise to high proportion of acetic and low amount of propionic and butyric acids, resulting in a wide acetic propionic (AlP) acid ratio. When White Fulani (Zebu) cattle, sheep, and goats were fed on intensively-cultivated and well-managed grass legume pastures at Ibadan, harvested at 4-weekly intervals, acetic acid accounted for an average of 80 per cent of the total VFA in cattle, sheep, and goats, propionic for 15070 and butyric for 5%. When the proportion of grass was reduced and partly replaced by a high proportion of groundnut cake, the proportion of acetic acid dropped to a minimum of 5.8.5 molar per cent while those of propionic and butyric acids rose respectively to 21% and 14% in cattle, giving rise to a close AlP of 2.8. Urea, a non-protein nitrogenous compound, substituted well and economically for



CONVERSION OF CARBOHYDRATES TO VOLATILE FATTY ACIDS IN THE RUMEN.

Fig 4 CONVERSION OF CARBOHYDRATES TO VOLATILE FATTY ACIDS

groundnut cake for this purpose (Mba et. al., 1976).

The digestion and metabolism of protein in the rumen is also by far more complicated than in the non-ruminant. The peptides, amino acids, and ammonia which are the end-products of microbial protein fermentation in the rumen all serve as sources of nitrogen to rumen micro-organisms for building up their cells during proliferation in the rumen. The micro-organism cells themselves become available for digestion in the lower gut (Fig. 5) and they constitute a major source of protein for the ruminant. The ability of the rumen flora to utilize ammonia and other non-protein nitrogenous substances (NPN) for cell synthesis is a key feature of nitrogen me-

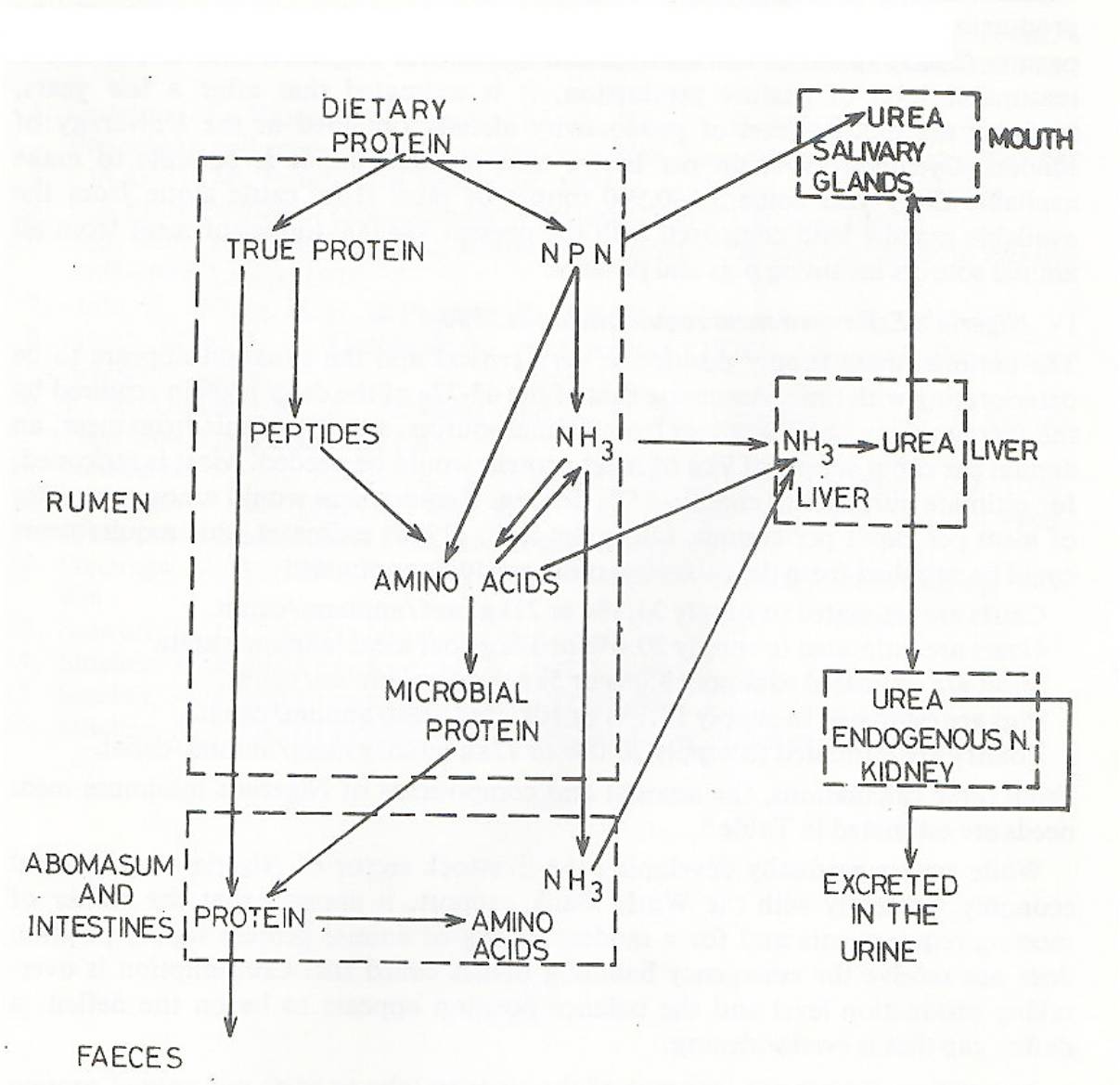


Fig. 5 DIGESTION AND METABOLISM OF NITROGEN IN THE RUMEN.

tabolism in the ruminant. A sizeable proportion of protein fed to ruminants can be supplied in the form of NPN like urea, biuret, NH3 and other nitrogenous compounds. It is now a common practice to supply a substantial part of ruminants' diet with urea in commercial dairy or beef cattle management. Urea is rapidly hydrolysed by bacterial urease to NH3. Feeding of urea required simultaneous supply of an energy source such as cereals which in practice, should be fed when urea is used in ruminant nutrition. However, some of the feed proteins escape bacterial fermentation and pass directly without oxidation to the abomasum. It has been found that, depending on its performance, the ruminant is able to meet between 60 and 80 per cent of its protein requirements from microbial protein.

I have gone into some details of this biological protein and energy manufacturing factory of the ruminant animal because of the potentials these animals offer for meat and milk supply for the nation. In a country with low level agricultural output and productivity and considerable expanse of unutilized grazing lands, it does not appear realistic to hope to depend primarily on concentrate feed for livestock production. Some 20,720,000 hectares of land exist as permanent meadows and pasture (FAO, 1974). If the bulk of this portion of Nigeria's land is put into a reasonable level of pasture production, it is estimated that after a few years, applying the modest level of productivity already obtained at the University of Ibadan (Oyenuga, 1975) on per hectre meat production, it is possible to make available every year some 3,480,960 tonnes of meat from cattle alone from the available grazing land compared with the present 434,000 .tonnes of meat from all animal sources including pigs and poultry.

IV Nigeria's Estimated Meat Requirements in 1980

The national meat supply position is very critical and the situation appears to be deteriorating with time. Assuming that of the 65-72g of the daily protein required by the average Nigerian, 35g comes from animal sources, and 25g of this from meat, an annual per capita supply of 9kg of meat protein would be needed. Meat is reckoned, for estimate purposes to contain 15% protein. Requirement would amount to 60kg of meat per capita per annum. Using the FAO (1966) estimates, these requirements could be supplied from the following meat producing animals:

Cattle are estimated to supply 34.3% or 21kg beef/annum/capita.
Goats are estimated to supply 20.6% or 12kg goat meat/annum/capita.
Sheep are estimated to supply 8.0% or 5kg mutton/annum/capita.
Pigs are estimated to supply 17.1 % or 10kg pig meat/annum/capita.
Poultry are estimated to supply 20.0% or 12kg poultry meat/annum/capita.

From these calculations, the amount and composition of Nigeria's minimum meat needs are estimated in Table 5.

While we are gradually developing the livestock sector of Nigeria's agricultural economy, presently with the World Bank support, it appears that the matter of meeting requirements and for a modest raising of animal protein supply position does not receive the emergency handling that is called for. Consumption is overtaking production level and the balance position appears to

be on the deficit, a deficit gap that is even widening.

As a nation, we are not ignorant of the steps to take to raise our animal protein production. Several suggestions and recommendations are available (F.A.O., 1966; Fed. Min. of Agriculture, 1974; Oyenuga, 1974). I will, therefore, not waste your time to add to the formidable list. What we need is the will to plan and execute the plans, the determination and the general dedication to face realistically solutions of national economic problems. When, as a people, we are truly ready, we shall tackle our problems and develop our immense natural resources of which agriculture with livestock production constitute an important sector.

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Table.l

Country	Energy (Real)		Energy as requirement		Protein (g)		Protein Energy Ratio •	
Developed	1961	1970	1961	1970	1961	1970	1961	1970
Australia	3140	3050	98	98	89.1	101.1	11.3	13.1
Canada	3010	3190	113	120	91.6	97.8	12.1	12.2
German Demo.	2730	3400	104	130	67.0	83.6	9.8 10.7	9.8 10.9
Republic German	3120	3230	117	121	84.0	88.4	12.2 10.6	12.3 10.1
Fed. Rep. Japan	2340	2470	100	106	71.9	76.2		
Netherlands	3250	3290	121	122	86.3	83.8		
New Zealand	3510	3330	133	126	108.4	107.3	12.3	12.8
USSR	3000	3280	117	128	87.0	101.0	11.6	12.3
United Kingdom	3180	3140	126	125	91.2	90.2	11.4	11.4 11.9
United States	3120	3270	118	124	92.4	97.3	11.8	
Mean for Developed Countries	3040	3165	1147	120	86.9	92.7	11.4	11.9
Developing								
Angola	1910	1910	81	81	39.9	39.9	8.3	8.3
Brazil	2430	2600	102	109	60.7	63.8	9.9	9.8
China	2010	2370	85	100	54.3	63.2	10.8	10.6
Colombia	2180	2250	94	97	49.8	50.8	9.1	9.0
Egypt	2220	2360	88	94	66.0	66.1	11.8	11.2
India	2100	2060	95	93	55.2	52.6	10.5	10.2
Kenya	2380	2350	103	101	75.2	70.9	12.6	12.0
Mexico	2500	2560	107	110	65.0	65.1	10.4	10.1
Nigeria	2440	2290	103	97	65.5	59.9	10.7	10.4
Phillipines	1880	1920	83	85	43.8	44.5	9.3	9.2
Mean for Developing Countries	2205	2267	94.1	96.7	57.9	57.9	10.3	10.1

Table 2 Contribution of different food sources to Energy and protein consumption o some Developed and Developing Countries.

Food Sources	Developed Countries (Group A)		Developing Countries (Group 1)	
	Energy	Protein	Energy	Protein
Cereals	20	17	36	37
Starchy roots and tubes	4	3	25	12
Pulses and nuts	3	4	8	20
Fruits and vegetables	5	5	6	4
Meat and fish	20	41	6	19
Eggs and milk	14	30	3	8
Sugar	17	—	9	—
Fats and oils	17	—	7	
	100	100	100	100
Animal Protein contributed	34	71	9	27

Group A Countries		Group 1 Countries	
Australia	New Zealand	Angola	Guatemala
Austria	Norway	Brazil	Haiti
Canada	Panama	Cameroon	Honduras
Denmark	Paragua	Central African Republic	Ivory Coast
Finland	Puerto Rico	People's Republic of Congo	Nicaragua
Iceland	Sweden	Dahomey	Nigeria
Ireland	United States	Ecuador	Senegal
Netherlands	Urugay	Gabon	Togo
		Gambia	Uganda
		Ghana	Zaire

Table 3: *Estimated number and proportion of people with insufficient protein/energy supply by Regions in an Average year (1979)*

Regions	*Population [million]*	*Proportion below lower limit [%]*	*Number below lower limit [million]*
World	2,830	16	462
Developed	1,070	3	28
Developing	1,760	25	434
Far East(1)	1,020	30	301
Africa	280	25	67
Near East	170	18	30
Latin America	280	13	36

(1) Excluding China.

Table 4: Consumption of animal products in certain selected countries in 1974 (kg/caput/year)

	Meat	*Milk*	*Eggs*
U. S. A.	198.5	255.5	19.0
Fed. Rep. of Germany	123.0	350.5	14.7
Hungary	146.4	239.3	18.3
Argentina	225.0	253.1	8.2
Nigeria	5.1	4.6	1.7

Table 5 *Amount and composition of Nigeria's minimum meat requirements in 1980*

Type	*Amount (mt)*	*% of total*
Beef	1,680,000	34.3
Goat meat	960,000	20.6
Mutton	400,000	8.0
Pig meat	800,000	17.1
Poultry meat	960,000	20.0
Total	4,800,000	100.0

AN APPRAISAL OF NIGERIA'S DEVELOPMENT OF NUCLEAR SCIENCE AND TECHNOLOGY

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ABSTRACT

Having noted the aims for the development of nuclear science and technology in Nigeria as already expressed by two responsible sources: the Nigeria Atomic Energy Commission Decree 1976, and the Natural Sciences Research Council of Nigeria, the paper examines whether those aims are best or most-cheaply provided through nuclear technology by assessing the energy resources of Nigeria: coal, crude oil, natural gas, and hydropower. On finding that all Nigeria's resources may well be committed in the next 20 to 30 years, the development of renewable energy resources; solar energy, biomass, and wind is recommended in preference to nuclear energy whose problems are immense and long lasting. Selected problems of nuclear power reactors are then reviewed before discussing how best to develop nuclear science and technology in Nigeria by presenting the views of a committee of the Natural Sciences Research Council of Nigeria.

1. INTRODUCTION

When the Council of the Nigerian Academy of Science suggested that I should talk on the "Economics and the Politics of Nigeria's Development of Nuclear Technology" I accepted, but was not enamoured with the inclusion of the words "economics and politics" in the title, for I can lay no claim to Economics and Politics: neither by study nor by practice. I have therefore taken the liberty to modify the title of this talk to the more amenable topic of "An Appraisal of Nigeria's Development of Nuclear Science and Technology."

We know nuclear science as the science of the atomic nucleus but what is nuclear technology? There is no agreement on the definition of technology and even the very conception of technology is controversial. We shall therefore for the moment be content with an operational definition suitable for our purpose. We may simply take technology as the systematic techniques for making or doing things. In this case, nuclear technology becomes the systematic techniques of making or doing things based on or pertaining to the atomic nucleus.

2. WHAT IS THE RELEVANCE OF NUCLEAR SCIENCE AND TECHNOLOGY TO NIGERIA?

To be on firmer grounds, we shall here be guided by the relevance of nuclear science and technology to Nigeria as already assessed and expressed by responsible sources in Nigeria. The Nigeria Atomic Energy Commission Decree 1976 states that, "the Commission shall have power

(a) to prospect for and mine radioactive minerals;
(b) to construct and maintain nuclear installations for the purpose of generating electricity;
(c) to produce, use and dispose of atomic energy and carry out research into matters connected with the peaceful uses of atomic energy;
(d) to manufacture or otherwise produce, buy or otherwise acquire, treat, store, transport and dispose of any radioactive substances;
(e) to make arrangements with universities and other institutions or persons in Nigeria for the conduct of research into matters connected with atomic energy or radioactive sub stances and to make grants to universities or other institutions or persons engaged in the production or use of atomic energy or radioactive substances or in research into matters connected with atomic energy or radioactive substances;
(f) to educate and train persons in matters connected with atomic energy and radioactive substances;
(g) to advise the Federal Military Government on questions relating to atomic energy."

Prior to the above Decree of August 1976, the Natural Sciences Research Council of Nigeria set up a Committee which conducted a study in January 1976, and recommended the establishment of a National Institute for Nuclear Sciences. The report which was later accepted by the Council, recommended that the programme of the Institute should include the following:

(i) Training and development of manpower for nuclear power;
(ii) Development of electronics technology in connection with control and regulations;
(iii) Development of materials for harnessing solar energy for electricity generation;
(iv) Exploration of the country for nuclear materials;
(v) Irradiation of woods, fibres, concrete mixtures, etc., with a view to improving their qualities for industrial purposes;
(vi) Development of better strains of seeds for agricultural purposes;
(vii) Production and processing of isotopes for medical, agricultural, scientific, and other applications;
(viii) Development of non-destructive testing methods and devices;
(ix) Neutron activation analysis of various samples, imported and local for quality control;
(x) Development of the application of neutron activation analysis to explora¬tion and mining;
(xi) Application of irradiation to the solution of the fundamental national problem of wastage of harvested crops;
(xii) Application of radiation to medical diagnosis and therapy;
(xiii) Documentation of nuclear science and technology research but especially nuclear power studies; and

(xiv) Organization of high level study groups, seminars, symposia, conferences and occasional activities to popularize knowledge of nuclear science and technology."

The above two prescriptions are in sufficient agreement to assure us of the paths and goals so far openly anticipated for Nigeria's development of nuclear science and technology. We must however, also take note of the occasional sweeping reference to nuclear weapons on the radio.

3. IS NUCLEAR TECHNOLOGY THE BEST OR CHEAPEST MEANS OF ACQUIRING THE DESIRED PRODUCTS AND SERVICES?

3.1 Introduction

In our limited time and space it is extremely difficult to rationalize every product or service that may accrue from Nigeria's development of nuclear technology. Moreover, if a major product justifies the development of the technology, the secondary and tertiary products and services should immediately follow. We shall therefore deal with section 3 under three main headings: nuclear technology for energy; nuclear technology for analysis and treatment; and development of manpower for nuclear technology.

3.2 Nuclear Technology for Energy

In March 1973 Nigeria's demand for electric power was projected as in Table 1. (Ilumoka 1973). This should be compared with the NEPA (1977) projections of national sales, production and maximum demand of electric power for the period 1970/71—1985/86 given in Table 2. In Table 3, we show NEPA plans to cope with this explosive demand by phasing in preferred undertakings and phasing out less desirable ones.

In addition to hydropower, Nigeria uses the following fuels for generating electricity: Coal, A.G.O. (automotive gas oil), R.F.O. (residual fuel oil), and natural gas. Their specific fuel cost in kobo per Kilowatt hour (kwh) is given in Table 4. Of course, this is not the last word on the relative cost of electricity from various sources because it does not include the capital and maintenance costs.

For example, Mackay (1973), a Canadian consultant of NEPA, summarized the choice before us then as follows:

"Coal, oil, or natural gas can be used to fuel thermal plants and Nigeria has large reserves of all the three. However, while coal may eventually be used on a large scale, oil and natural gas are the logical fuels to use in the immediate future because: they are in large scale production, and no large capital investment or new organization will be required to supply fuel for electricity generation.

Natural gas, produced in association with oil is being flared in large quantities. Even after the development of plans for large-scale exports of Liquified Natural Gas (LNG) there will still be large quantities available for other purposes; this will be available for power generation for the

Table 1 National Sales, Production and Maximum Demand of Electricity for 1960/61-1981/82 {Ilumoka 1973).

Year 1 April to 31 March	Sales MWH	Production or Requirement MWH	Maximum Demand MW	MD. Annual Growth %
1960/61	360,000	448,300		
1961/62	438,000	549,000		
1962/63	524,000	659,400	128	
1963/64	641,000	797,700	146	14.1
1964/65	752,000	925,400	175	19.9
1965/66	847,000	1,064,200	195	11.4
1966/67	955,000	1,177,100	229	17.4
1967/68	718,000	889,200	174	24.0
1968/69	793,000	1,001,500	190	9.2
1969/70	914,000	1,158,000	206	8.4
1970/71	1,148,000	1,388,400	269	30.6
1971/72	1,468,000	1,680,900	332	23.4
1972/73		2,060,000	388	16.9
1973/74		2,470,000	462	19.1
1974/75		2,948,000	548	18.6
1975/76		3,515,000	650	18.6
1976/77		4,182,000	773	18.9
1977/78		4,973,000	917	18.6
1978/79		5,906,000	1084	18.2
1979/80		7,016,000	1285	18.5
1980/81		8,330,000	1528	18.9
1981/82			1811	18.5

Table 2 *National Sales Production and Maximum Demand 1970/71 — 1985/86 (NEPA 1977)*

Year 1 April to March 31	Sales(Mwh)	Production (Mw.)	M.D. (Mw.)	M.D. Annual Growth %
1970/71	1,148,015		253	—
1971/72	1,467,738	1,681,507	330	30.4
1972/73	1,751,800	2,210,603	390	18.2
1973/74	2,038,446	2,608,227	445	14.1
1974/75	2,343,176	2,907,379	527	18.4
1975/76	2,715,184	3,465,121	629	19.4
1976/77	3,374,804	4,298,670	758	20.5
1977/78	4,303,137	5,509,504	979	29.1
1978/79	5,292,098	6,764,143	1201	22.6
1979/80	6,162,387	7,891,716	1392	15.9
1980/81	7,905,139	9,987,780	1760	26.4
1981/82	9,920,523	12,410,028	2189	24.4
1982/83	12,233,170	15,197,744	2683	22.5
1983/84	13,401,230	16,703,402	2929	9.2
1984/85	14,740,717	18,432,192	3211	9.3
1985/86	16,276,342	20,416,576	3532	10.0

Table 3 *National Grid Energy Availability and Demand in Gigawatthours (NEPA 1977).*

Station	Plant Factor	76/77	77/78	78/79	79/80	80/81	81/82	82/83	83/84	84/85	85/86
Kainji	.32	2217	2217	2217	2217	2217	2217	2015	*	*	*
Ijora	.50	263	263	263	263	263	—	—	—	—	—
Delta	.60	1035	1035	1035	1035	1035	846	846	657	657	657
Afam	.60	788	788	788	788	788	788	736	683	499	499
Oji	.60	—	—	—	—	—	—	—	—	—	—
Sapele	.70	—	—	355	2132	3851	4266	4266	4266	4266	4266
Diesels	.10	17	23	25	25	25	—	—	—	—	—
Shiroro	.45**	—	—	—	—	—	2102	2360	2360	2360	2360
Jebba	.45**	—	—	—	—	—	105	2074	4089	4089	4089
New Gas Turbines	.6	—	—	—	—	3153	3153	3153	3153	3153	3153
Lokoja	.45**	—	—	—	—	—	—	—	3189	6833	7687
Total Grid Available Energy		4320	4328	4683	6460	11332	13477	15450	18397	21857	22711
Total Grid Demand Energy		4199	5491	6743	7892	9988	12410	15198	16703	18432	20417
Energy Balance		+121	−1163	−2059	−1432	+1344	+1067	+252	+1694	+3425	+2294

*Kainji output integrated with Jebba.
**80% availability assumed on hydraulic plant until primary energy capability reached.

Table 4 ***Specific Electricity Fuel Cost in Kobo per K WH (NEPA 1977).***

Fuel	Location	Fuel Cost in Kobo/KWH	Target Availability (MW)	Energy GWH
Coal	Oji River	1.190	15	43.8
A. G. 0.	Calabar	2.868	8.4	1.7
A. G. 0.	Kaduna B	2.525	4	1.45
A. G. 0.	Ijora A & C	3.094	36	65.5
R. F. 0.	Kaduna C	0.484	7	9.4
R. F. 0.	Ijora B	0.739	85	197.3
Natural Gas	Afam	0.303	155	803.65
Natural Gas	Delta	0.229	192	1055
Hydro	Kainji	0.000	520	3345

cost of collecting and transmitting it to the power stations, which will be low for stations sited in or near the gas fields. Gas or oil-fired generating plants are lower in capital and maintenance costs than coal-fired plants.The coal fields are farther from the load centres than the oil-fields, and transport of coal or electricity from them to the load centres would be more difficult and expensive.

Large investments in mining and the associated infrastructure would be required to meet the requirement of a major generating programme. For instance, 100 MW unit at 60% annual capacity factor would use 720 tons of coal per day or 264,000 tons per year. Production and transportation of coal to fire four or five such units would be a heavy task."

The fuel cost per kwh is nevertheless useful. A casual look at Table 4 easily elicits the question: but why did NEPA engage in the use of oil to generate electricity in the first instance? The answer is obvious from Table 5 which shows that as a result of the fuel crisis of 1973-74 the price of oil has gone up by a factor of 4, an event which NEPA may not have predicted and which seriously marred the above prescription of Mackay (1973) in less than nine months.

We now examine our reserves as far as possible. The coal reserves of Nigeria, (Table 6), are fairly well known, (De Swardt and Casey 1961, U.N. 1976b), and comprises 353 million long tons at Enugu, Inyi, Ezimo, Orukpa, Okaba, Ogboyoga and Oti, and 90 million metric tons of lignite at Asaba mainly.

The most recent crude oil reserve in 12 wells in Nigeria given as 3,150 million barrels on January 1, 1976 by Petroleum Encyclopedia 1976 is incomplete and earlier reserves will be discussed later. What seems to be immediately important is to focus attention on the enormous quantities

Table 5

Posted Price of Nigerian Crude Oil at 34° A.P.I. Gravity in U.S.A. $ per barrel. There will be the usual price escallation or de-escallation of U.S.A. $0.003 for each one tenth degree A.P.I. above or below the stated gravity for each grade of oil subject to a maximum of 40° A.P.I. and a minimum of 30° A.P.I. The rate of $0.0015 will apply for any crude oil whose gravity falls below 30° A.P.I. Posted prices do not include harbour or terminal dues of U.S.A. $0.02 per barrel. (Department of Petroleum Resources 1976)

	1969	1970	1971	1972	1973	1974	1975
January	2.17	2.17	2.42	3.176	3.561	14.691	14.691
February	2.17	2.17	2.42	3.176	3.561	14.691	14.691
March	2.17	2.17	2.42	3.176	3.561	14.691	14.691
April	2.17	2.17	3.212	3.1560	3.806	14.691	12.0630
May	2.17	2.17	3.212	3.424	3.806	14.691	12.0630
June	2.17	2.17	3.212	3.424	4.0030	14.691	12.0630
July	2.17	2.17	3.195	3.409	4.1350	14.691	12.0630
August	2.17	2.17	3.195	3.409	4.2910	14.691	12.0630
September	2.17	2.17	3.195	3.409	4.2910	14.691	12.0630
October	2.17	2.42	3.178	3.409	4.287	14.691	13.0710
November	2.17	2.42	3.178	3.409	8.4040	14.691	13.0710
December	2.17	2.42	3.178	3.409	8.3390	14.691	13.0710

Table 6 *Coal Reserves of Nigeria in Million Long Tons. (De Swardt and Casey 1961).*

Location	Economical to Mine		Uneconomical to Mine 1958
	Indicated	Inferred	Indicated
West of Enugu	26	8	16
Enugu N. W. of Iva Mine	16	4	24
Inyi	10	—	—
Ezimo	29	17	—
Orukpa	50	7	—
Okaba	54	19	3
Ogboyoga	82	25	4
Oti	—	6	—
Total	267	86	47
	353		47

There are also some 90 million metric tons of lignite or brown coal mostly around Asaba (U.N. 1976b).

Table 7 *Quantities of Nigerian Crude Oil and Associated Gas for 1970-1975. (Numbers in bracket seem to me to lack internal consistency). Department of Petroleum Resources 1976.*

	Crude Oil Production	Crude Oil Export	Gas/Oil Ratio	Gas Sold	Gas Used as Fuel	Gas Flared	Total Gas Produced
	10^6 bbls	10^6 bbls	m^3/bbl	10^6m^3	10^3m^3	10^6m^3	10^6m^3
1970	395.834	383.455	20.383	62.392	48.611	7957.445	8068.448
1971	558.879	542.545	23.214	111.749	72.454	12789.797	12973.982
1972	665.283	650.980	41.711	159.458	114.597	27475.524	27749.579
1973	(719.375)	(723.314)	30.367	(105.832)	(199.497)	21539.715)	(21845.044)
1974	823.316	795.710	33.070	427.395	146.903	26652.340	27226.638
1975	660.144	627.639	28.261	324.391	131.341	18200.598	18656.330

of natural gas produced in association with oil which is annually being flared. The painful message of Table 7 is that about 98% of our natural gas production is just being burnt for nothing. The 20,000 million cubic metres of gas or so we flare annually can produce 30,206 GWH. of electricity at NEPA rate. This is 5.5 times the present national demand for electric energy and 1.5 times the projected demand for 1985/86. We may therefore observe in passing that a crying need exists for gas-based industries that will curtail this colossal waste.

NEPA appears to be working hard to assess and utilize our hydropower potential. A survey by their consultants has identified a total of 32 possible sites for hydro units in Nigeria (NEPA 1977). Of these, the cheapest being seriously pursued are (Ilumoka 1977):

Lokoja	1950 MW
Makurdi	600 MW
Ikom	400 MW
Shiroro	600 MW
Jebba	545 MW

Our hydropower potential is not accurately known but Onwumechili (1973) stated that global estimates indicate that our hydropower potential is only about half that of China, half that of Brazil and only a thirteenth that of Congo.

On the other hand, as at January 1973, the world's resources of uranium, the fuel for nuclear power is given in Table 8. From this we see that Nigeria does not possess any reasonable amount of uranium unless detailed exploration turns in unexpected pleasant surprises. It should also be mentioned that USA has supplied most of the commercial separative work to date. To sep-

Table 8 *Estimated World Resources of Uranium as at January 1973 (Cameron 1974).*

Country	Price Range < $[1] 10/lb U_3O_8		Price Range $ 10—15/lb U_3O_8	
	Reasonably Assured Resources	Estimated Additional Resources	Reasonably Assured Resources	Estimated Additional Resources
	10^3 tonnes	10^3 tonnes	10^3 tonnes	10^3 tonnes
Agentina	9.2	14	7.7	23
Austrialia	71	78.5	29.5	29
Brazil	—	2.5[2]	0.7	—
Canada	185	190	122	219
Central African Republic	8	8	—	—
Denmark (Greenland)	5.6	10	—	—
Finland	—	—	1.3	—
France	34.2	19.3	10	20
Gabon	20	5	—	5
India	—	—	(2.3)	(0.8)
Italy	1.2	—	—	—
Japan	2.8	—	4.2	—
Mexico	1.0	—	0.9	—
Niger	40	20	10	10
Portugal (Europe)	7.4	5.9	—	10
Angola	—	—	—	13
South Africa	202	8	62	26
Spain	8.5	—	7.7	—
Sweden	—	—	270	40
Turkey	2.2	—	0.5	—
USA	259	583[3]	141	231
Yougoslavia	6	10	—	—
Zaire	1.7	1	—	—
TOTAL (rounded	865	911	670	627

[1] $ Value of March 1973: 1$ = 0.829 EMA u/a = 0.829 SDR (Special Drawing Rights)
This $ value corresponds to $42.22 per fine ounce of gold.
[2] Plus 70,000 tonnes U by-product from phosphates.
[3] Plus 70,000 tonnes U by-product from phosphate and copper production.
*From Joint NEA/IAEA Working Party Report
"Uranium Resources, Production and Demand," August 1973.

arate one kg of natural uranium into U-238 and U-235 with 0.20% U-235 tails assay, USA had charged as follows:

$26.00 per kg before 1970 $28.70 in 1970 $32.00 in 1971

$36.00 to $38.00 in 1973 (depending on type of contract), and URENCO had demanded as much as $48.00 per kg unit in 1973-74. To buy the usual material for making fuel elements of uranium enriched from 2.2% to 2.6% U-235, the USA would charge the cost of natural uranium plus the cost of enrichment at rate 3% higher than for a mere separative work contract (Roberts 1974).

Having generally reviewed the demand for electric energy and the available resources for generating electricity, we must now attempt to answer the question: Does power requirement justify Nigeria's development of nuclear technology?

During the Second National Symposium on Science and Technology in National Development (March 12th - 16th, 1973) a Committee of 19 participants on Energy Resources, Electricity Generation, and Demand, was set up to consider the papers read on Energy Resources and Electricity Supply in Nigeria and make recommendations. The Committee recommended among other things: that Nigeria should seriously work on the development of alternative energy resources especially nuclear and solar energy; that in particular, Nigeria should work towards the installation of at least one nuclear power plant within 25 years from then; that Nigeria should minimize the use of oil for generating electricity and shift emphasis to the use of natural gas. These recommendations have now been reflected in NCST (1975).

Table 9 *Economics of nuclear and oil-fired plants as a function of plant size* (*Lane. 1974*).

PLANT SIZE MW(e)	100	150	200	300	400
Unit Cost, $KW[a]					
PWR	812	675	588	485	425
Oil-Fired	311	284	262	227	207
Differential	501	391	326	258	218
Operating & Maintenance, $KW (month)[a]					
PWR	1.26	0.91	0.71	0.52	0.42
Oil-Fired	0.61	0.45	0.36	0.28	0.24
Differential	0.65	0.46	0.35	0.24	0.18
Nuclear Fuel Cycle[b]					
mills/kWh	1.93	1.91	1.89	1.84	1.79
Oil-Fired Plant Heat Rate					
kcals/kWh	2290	2270	2263	2259	2253
Break Even Oil Prices[b]					
$/10^6 kcals	410	337	293	245	216
$/MBtu	103	85	74	62	55
$/barrel	6.12	5.03	4.37	3.66	3.22

Basis

a. Average of the 14 Market Survey Countries.

b. These are the levels of oil prices at which nuclear electricity is already competitive. The calculations are based on 8% interest rate, 30 years plant life, 80% plant factor. It will be seen that even for a relatively small plant. size of a 100 MW(e), nuclear power becomes advantageous for oil prices above $6.12 per barrel.

The present discourse attempts to review the situation. From Table 9 (Lane 1974), we see the oil prices at which nuclear electricity becomes competitive with electricity from oil-fired plants as a function of plant capacity. Nuclear power becomes cheaper at oil prices of $7.00 or more per barrel, and therefore, Table 5 shows that nuclear energy may have become cheaper than electricity generated with oil in Nigeria since November 1973. However, Table 4 suggests that in Nigeria electricity from oil may cost up to 2.4 times electricity from coal, 10 times electricity from natural gas, and many more times the cost of electricity from hydropower. We must therefore conclude that judging from unit cost alone, while nuclear power in Nigeria may be cheaper than electricity from oil, it is still more costly than electricity from coal, natural gas and hydropower, and is therefore not justifiable. Even the above comparison between oil and nuclear electricity based on 1973 price may not have remained valid in view of the following statement from Nader and Abotts (1977):

"The one area in which nuclear power supposedly would clearly be superior was fuel costs. But that advantage is rapidly being eroded, as has been shown by David Snow's report for Mitchell, Hutchins, Inc. Snow found that from 1973 to 1976 uranium prices rose from $6 per pound to $50 per pound, and could be expected to rise to $100 per pound by about 1978. The total costs of nuclear plant paying $100 per pound, Snow estimated, would just break even with an oil plant paying $12 per barrel of oil."

But have we got enough reserves of those other cheaper sources of power?

(a) The total capacity of our hydropower at Kainji, Lokoja, Ikom, Makurdi, Shiroro and Jeba is 4,895 MW or 5.0 times the 1977/78 Maximum Demand (MD). Presumably, the remaining 26 of the total 32 sites identified will have a total capacity of another 10.0 times the 1977/78 MD.

(b) Presently, we are flaring about 20,000 million cubic metre of natural gas annually. If all this gas is used for electricity generation it can sustain a capacity of 5,639 MW which is about 5.76 times the M.D. for 1977/78.

Thus, a feel of the capacity that will stretch our hydro and natural gas resources is about 21 times the 1977/78 M.D. of 979 MW. Given the compound rate of growth of our maximum demand, this 21 fold increase leads to the following number of years for our maximum demand to equal the combined capacity of our fully stretched hydro and natural gas resources.

Maximum Demand Annual Growth %	Years to Stretch Hydro and Nat. Gas
20	17
15	22
10	32
5	62

This generating capacity of 21 times the 1977/78 Maximum Power Demand is 20,559 MW.

The associated gas will run out with our oil reserves in about 20 years (Table 10). In Table 11 we assess the remaining life of our natural gas reserves. The reserves are taken from U.N. (1976b) but since their definition of gas production is not useful for our purpose of estimating remaining life, we take production figures from the Department of Petroleum Resources (1976ab). We see that our natural gas reserves are likely to last about twice as long as our crude oil reserves because of gas fields not associated with oil. For the purposes of this study we may take it that our hydro and gas resources will continue to sustain a generating capacity of about 20,559 MW long after they would have been stretched to that figure.

Table 10: ***Crude Oil Reserves of Nigeria in Million Metric Tons (1958-1965from Schatzl 1969c converted and 1969-1974from U.N. 1976b).***

Year	Reserves	Annual Production	Remaining Life in Years
1958 1959	3 11	0.260	12
1960 1961	21 42	0.542	20
1962 1963	56 70	0.850	25
1964 1965	139	2.270	18
	415	3.327	17
		3.772	19
		5.952	23
		13.538	31
1969 1970	675	26.951	25
1971 1972	575	54.203	11
1973 1974	1351	76.377	18
	1729	90.918	19
	2495	101.765	26
	2655	111.578	24

Table 11: ***Natural Gas Reserves of Nigeria in*** 10^9 ***cubic metres.***

Year	Reserve 10^9 m^3	Annual Production 10^9 m^3	Remaining Life in Years
1970 1971	153	8.068	20
1972 1973	283	12.974	22
1974	1161	27.75a	42
	1370	21.845	63
	1423	27.227	52

We are therefore left to discuss how best to provide for the additional increases in MD over and above 20,559 MW. From the point of view of present costs above, attention should then be turned to the use of coal. The remaining life of our coal reserves at actual production rates from 1958 to 1974 are given in Table 12. We see that our coal could last for 1,000 years if production is continued at the 1974 very low rate which is unlikely because of the imminent iron and steel industry.

Furthermore, oil wells may be drying up by then but the serious consequences of any decision to provide all additional electric power demand with coal alone can be gleaned from Tables 13 and 14. Before studying them, let us inquire into whether the amount of power we are discussing how to provide in 20 to 40 years from now will in fact be required. By then the population of Nigeria is likely to have exceeded 100 million but we work with that convenient figure. Electric power of 100 GW works out at 1,000 Watts per capita, and 34 GW at 340 Watts per capita. Table 15 of 1974 electric power consumption in selected countries shows that the situation being discussed is not unrealistic. In fact it is not much better than the level per capita already reached by Zambia in 1974.

From Tables 13 and 14 we see the following situation by the time Nigeria develops a generating capacity of 34 GW.

	Constant Annual Growth of M.D.			
	20%	15%	10%	5%
Years to reach 34 GW from now	20	25.5	37	72
Remaining life of coal then (Years)	8	9	8	5

Table 12 Remaining Life in Years of the Coal Reserves of Nigeria in Million Metric Tons. {The production is taken from U.N. \976d).

Year	Reserves	Annual Production	Remaining Life in Years
19ES	359	0.940	382
1959	358	0.754	475
1960	357	0.571	626
1961	357	0.607	588
1962	356	0.634	562
1963	355	0.577	616
1964	355	0.699	508
1965	354	0.740	479
1966	353	0.640	552
1967	353	0.203	1738
1968	353	—	—
1969	353	0.016	22040
1970	353	0.059	5977
1971	353	0.194	1817
1972	352	0.341	1033
1973	352	0.326	1080
1974	352	0^304	1157

Table 13 Electric power in MWthat has to be generated with given quantity oj coal in million metric tons per year depending on assumed annual growth rate of maximum demand for electric power after stretching the hydro and natural gas resources of Nigeria to produce 20,559 MW.

Year After 20559 MW	5% Growth		10% Growth		15% Growth		20% Growth	
	Power	Coal	Power	Coal	Power	. Coal	Power	Coal
1	1028	2.757	2056	5.514	3084	8.271 ■	4112	11.028
2	2107	5.651	4317	11.578	6630	17.782	9046	24.261
3	3241	8.692	6805	18.251	10709	28.722	14967	40.141
4	4431	11.884	9541	25.589	15399	41.300	22072	59.197
5	5680	15.234	12551	33.662	20792	55.764	3p598	82.064
6	6992	18.723	15863	42.545	26995	72.401	40830	109.506
7	8370	22.448	19505	52.312	34128	91.531		
8	9816	26.327	23511	63.057.				
9	11335	30.400	27918	74.876				
10	12929	34.676						

Table 14: Remaining life in years of the coal reserve of Nigeria in million metric tons consequent on NEPA alone consuming coal and generating with coal only to provide for assumed annual rates of growth M.D. for electric power after stretching the hydro and natural gas resources of Nigeria to produce 20,559 MW.

Year After 20559 MW	5% Growth		10% Growth		15% Growth		20% Growth	
	Coal Reserve	Rem Life	Coal Reserve	Rem Life	Coal Reserve	Rem Life	Coal Reserve	Rem Life
1	332	120	341	62	344	42	346	31
2	329	58	335	29	336	19	335	14
3	323	37	323	18	318	11	311	8
4	314	26	305	12	289	7	271	5
5	302	20	279	8	248	4	212	3
6	287	15	254	6	197	3	130	1
7	268	12	211	4	126	1		
8	246	9	159	3				
9	220	7	96	1				
10	190	5						

Table 15: The electrical energy installed capacity per capita for selected countries in 1974 (Based on U.N. 1976b).

Country	Population in Thousands	Electric Energy Capacity MW	Electric Energy per capital Watts
Egypt	36417	4100	113
Singapore	2219	1109	502
Zambia	4751	1031	217
South Africa	24920	13435	539
Canada	22479	56864	2530
Venezuela	11632	4305	370
Argentina	25050	9260	370
Iran	32139	4200	131
Hong Kong	4249	2275	535
New Zealand	3027	4449	1470
Belgium	8678	8980	1035
United Kingdom	55968	79560	1422
Poland	33691	19130	568
Switzerland	6443	11400	1769

The cutoff of 34 GW is chosen since it would be pointless to build an additional coal-fired plant that will not be fuelled for at least 10 years.

Any conclusion from this study depends on the chosen annual rate of growth of maximum demand. What is a reasonable growth rate to bear in mind? Mackay (1973) wrote:

"The present forecast is that the system peak demand, including export to Niger, will increase to 1,607 MW in February-March 1983. This represents an increase of 360% or a compound annual rate of 16.5%."

Thus in 1973 NEPA confidently planned for 1972/73 to 1981/82 with an average growth rate of 18.48% (Table 1). By 1977 the actual experience of the M.D. had forced NEPA to re-plan for 1972/73 to 1981/82 with an increased annual average growth rate of 20.9% (Table 2).

Past experience may be summarized with the following two excerpts from the experts:

"Load growth has historically been rapid, in the range of 15-22% per annum, and limited to that only by the lack of generating capacity and other supply facilities. The growth rate in existing areas can be expected to decline as the system grows, and suppressed demand is satisfied, but the absolute value will continue to increase" (Mackay 1973).

"Apart from the period of Civil War in the Country, the annual rate of growth of energy (kwh) sales had averaged oyer 20% per annum in the last 18 years. . . . This rate is certainly one of the highest in the world and means that the electrical load practically doubles every four years" (Ilumoka 1973).

In view of all this, we should settle for a rate of 15-20% since we are examining a period of the order of 20 years.

We may now summarize our study of the energy resources as follows: With the 15 to 20% compound annual growth of electrical power demand in Nigeria, if all the presently known hydropower, natural gas, and coal reserves of Nigeria are requisitioned in that sequence almost wholly for the generation of electricity, they would be nearly fully committed in about 20 to 30 years from now when the electrical power demand is expected to be about 34 GW. By then the oil reserves would have been depleted to such an extent that oil may not rescue the situation unless new reserves are discovered.

The presumptuous features of this study are:

(a) We have assumed that all our gas may be used for generating electricity but it will never be possible to do so because part will be used for gas-based industries that are bound to come soon and it will never be feasible to collect all the natural gas from all the oil wells.

(b) The rate of crude oil production in future is likely to fall below the production in 1972 to 1975 which gave the high volume (20,000 million m3) of associated gas being flared which we assumed will be available all the time.

(c) We have assumed that in 17 to 22 years all our coal may be requisitioned for generating electricity but this will never be possible because the present big consumers like Nigerian Railway Corporation, Cement Factories, etc. will continue to use coal. In fact even at the peak use of coal by Electricity Corporation of Nigeria in 1962/63, only about 30% or 176,000 long tons of the coal consumed in Nigeria was used for generation of electricity.

(d) Other coal based industries have been planned but above all the iron and steel industry about to start should consume large quantities of coal.

(e) Even if all the above constraints are removed, it may not be feasible to handle annually the 36.049 million metric tons of coal required to generate the 13,441 MW in excess of 20,559 MW from hydro and gas. Mackay (1973) worried about the production and transportation of coal to generate 400 MW but we are discussing the generation of 13,441 MW with coal! This coal required annually is over 100 times the total coal produced in Nigeria in 1974!

(f) Even if all the constraints are removed and the production and transportation of 36.049 million tonnes of coal per annum is feasible, the total coal reserves may not keep the plants going for up to 10 years from then (Tables 13 and 14). The possible redeeming features are:

(i) There remains the possibility that the 26 unexploited hydro sites may support more than the 9,790 MW estimated in this study. However, Mackay's (1973) assessment is as follows: "There are many other potential hydro-electric sites, but so far as is known they are all relatively small. It is possible that many of them may eventually be developed, in conjunction with irrigation and flood control or for area supply. However their total contribution to the grid requirements, while it may be economic, will be small and dif fuse." In view of this, our estimation should be adequate and may in fact be over gener ous allowance.

(ii) Tables 10 and 11 show that our estimated reserves of crude oil and natural gas were increasing from 1970 to 1974 as new fields were being discovered. It is therefore to be expected that these reserves will further increase.

(iii) De Swardt and Casey (1961) guess-estimated that per chance there may be 1,000 million long tons of workable coal in the areas investigated. Furthermore, the 90 million metric tons of poor quality lignite may be worked in a desperate situation. Finally, the 47 million long tons considered uneconomical to mine in 1958 may become feasible as technology improves.

The accuracy of our conclusion from the study depends on the extent to which the possible redeeming features offset the presumptuous features of the study. I venture to guess that the crunch on the actual demand for electric power will occur even earlier than predicted but it will be suppressed and concealed from statistics by lack of capability, resources, facilities and finance. The request for electricity may begin to sit on the queue longer than the request for tele-phone. It should however be appreciated that a major suppression will hamper the development of industries and infrastructures.

We conclude that power demand and the lack of adequate local energy resources to cope with it justifies the development of alternative energy resources or the importation of either conventional energy resources or energy itself.

My prescription is that top priority should be given to the development of renewable energy resources in the following order—solar energy, biomass, wind, and tides. Secondly, although the importation of the resources for nuclear energy may appear cheaper than the importation of the materials for conventional energy, the problems of nuclear energy are so immense and so long lasting that the odds are not clearly in its favour. Thirdly, serious consideration should be given to a cooperative development of nuclear energy in Niger where there is sufficient uranium reserve and we buy energy from Niger to whom we sell energy now,

3.3 Nuclear Technology for Analysis and Treatment

We recall that we are trying to examine whether the openly declared Nigerian objectives for the development of nuclear technology can be reasonably achieved by other means. The aspects of these objectives concerning the analysis, diagnosis and treatment of humans and materials can easily be achieved without much involvement in nuclear technology. The equipment, management and analysis of data are fairly straight-forward and in fact most of the techniques are already in use in Nigeria today such as X-ray technology, various uses of isotopes, and irradiation. The difference is that the establishment of a major nuclear facility in Nigeria could lead to local production of some of the materials being imported for such work today.

3.4 Development of Manpower for Nuclear Science and Technology

There is every need for the development of manpower for nuclear science and technology. Modern technology is a direct product of science. A country should keep the study of science alive in order to keep meaningfully abreast with what is happening in the world of science and technology, and thus be able to decide at the appropriate time what technology to develop. To do this adequately, a minimum level of investment, establishments, and equipment in the area of nuclear science and technology is imperative.

Because of its problems, one can only recommend nuclear power as a last resort. However, our analyses above show that Nigeria should resort to some alternative source of electrical* energy in the next 20 to 30 years. The only other source of that is already a going concern for large supplies of electrical energy is nuclear power. What happens if the other sources are not fully developed in the next 15 years? We must therefore prepare for the introduction of nuclear power. How soon?

From Kenward (1976) we take the list of some typical overall project times, giving the delay between giving the go-ahead to a project, and the production of energy resources as prepared by the US National Academy of Engineering.

Coal-fired power plant	5- 8 years
Surface coal mine	2- 4
Underground coal mine	3 -5
Uranium exploration and mine	7-10
Nuclear power plant	9-10
Hydroelectric dam	5- 8
Production of oil and gas from new fields	3-10
Production of oil and gas from old fields	1-3

We should therefore begin to train manpower and set up establishments for nuclear science and technology without delay.

4. PROBLEMS OF NUCLEAR SCIENCE AND TECHNOLOGY

4.1 Introduction

Nuclear technology is relatively new. It was in 1934 that a Hungarian physicist, Leo Szilard filed the specification for a patent on how nuclear chain reaction could be developed. In 1942 the U.S. Manhattan Project achieved the first controlled nuclear chain reaction. The U.S. Atomic Energy Commission was then formed in 1946 to develop peaceful uses of atomic energy but it took another 20 years or so to make the first nuclear power reactors commercially competitive.

Now that nuclear power is contributing about 4% of the world's energy consumption and is expected to contribute as much as 15% by 1990 (Petroleum Encyclopedia 1976) its impact on society can no longer be neglected. Unfortunately, nuclear technology does not lend itself to practice in the open laboratory and nuclear science is so expensive that man's knowledge of the science has not kept pace with the level of energy man wishes to harness from the atom nor is he very sure of the implications of his actions for the future of man. The normal process of science is that its theories and laws are revised as scientific knowledge grows. Unfortunately, this can often be very disastrous in nuclear science and technology where the slightest mistake can have fatal and very long lasting effects. Largely because of this fear of the unknown nuclear power has recently become rather controversial.

4.2 Radiation Effects

Exposure to nuclear radiation is dangerous both in the short run and long run. It could lie latent and surface later as well as develop genetic effects. Thus, it is imperative to formulate regulations setting limits to the radiation to which man may be safely exposed. The following measures quantify radiation and its effects:

(a) One curie is a unit of radioactivity corresponding to 3.7 x 1010 nuclear trans-formations per second.

(b) One rad is a unit of absorbed radiation dose from the radiation exposure that corre sponds to an energy deposition of 0.01 joule per kg of material.

(c) For X-rays, or 7-rays one roentgen is the radiant energy which under standard conditions of temperature and pressure, produces in 1 cm3 of dry air, a total ionization

of one electrostatic unit of charge (adding both positive and negative charges).

(d) One rem (roentgen-equivalent-man) is that dose of absorbed ionizing radiation of what ever kind which has the same biological effect as one roentgen of 7-radiation or hard X-rays.

The immediate problem is that a limit considered safe today may tomorrow be discovered to be unsafe after all the irreparable harm had been done. For example, the maximum allowed dose limit in addition to the background radiation we are all subjected to was for a long time fixed at 170 mrem/y. When in 1969 Gofman and Tamplin (Penner and Howe 1976) alerted the Institute of Electrical and Electronic Engineers that this dosage could cause 20 times more deaths through cancer and leukemia, a big controversy arose. After re-investigations it was finally confirmed that for the population of the U.S. 170 mrem/year could cause 3,000 to 15,000 cancer deaths annually with similarly increased hazards in other directions. The maximum permissible dose has now been reduced to a mere 5 mrem per year since 1972.

The pity of it is that even though X-rays, 7-rays, radio-isotopes and other sources are currently being used in Nigeria, the country has no body regulating, inspecting, nor controlling the exposure to these radiations.

4.3 Operational Safety of Nuclear Fission Reactor

Now, there is a big controversy on how safe the nuclear reactors are. The reactor industry and the experts in allied institutions use statistics and probability to prove that the chance for a major reactor accident is much less than the chances of mishap in other normal human engagements like, riding motor vehicles, fires, drowning, firearms, air travel, railways, hurricanes, operating fossil-fuelled power plants etc. We may call this side the establishment. On the opposite side are the citizen action organizations, the environmental conservationists and experts not connected with institutions allied to reactor industry. We may call this side the humanitarians.

We now illustrate their positions with some quotations: SigvardEklund (1974), the Director General of the International Atomic Energy Agency wrote:

"Nuclear safety has been under heavy discussion the last few years in spite of the fact that the nuclear industry as a whole has an unprecedented record of being safety-minded with a minimum of casualties as a result. At a recent visit to the Savannah River plant in U.S., I was told that the number of accidents was 1/40 of corresponding chemical industry operations. The International Atomic Energy Agency issues a list every year of land-based nuclear power and research reactors in its 104 member states, and also an annual report on operational experience with nuclear power stations. In 1972 the cummulative reactor/years of operating experience rose to 1,004. It is most remarkable that during those 1,000 reactor/ years of operating experience, there has not been a single incident involving accidental release of harmful amounts of radioactivity from a power reactor to its surroundings. . . . Nuclear power represents a solution which is friendly to the environment but there are also some problems associated with extensive use of nuclear power. It is definitely wrong to claim that they all have been solved, but they

are manageable at present and later, at the end of the century, techniques will be found which can be applied to the problems which will then be of another magnitude. . . . Nuclear power provides a means of bridging the energy gap until new sources of power are developed and does not, if carefully planned and con¬trolled, face mankind with unacceptable environmental consequences."

Penner and Howe (1976), Energy Centre, University of California, San Diego wrote:

"At presently operative control levels for nuclear reactors, a safely operating reactor appears to constitute a lesser hazard than any other currently available and economically competitive energy source. The operative constraint 'as low as possible' for radiation output should be interpreted to mean that all reasonable effort will be exerted to reduce supplementary radiation levels from nuclear reactors to still smaller values provided other economic and social costs do not become prohibitively high. . . . We must not forget that all energy use implies environmental degradation and health dangers. It is therefore improper to single out a particular energy source and discuss its hazards out of context. Within context we must learn to think of total hazard and benefit per unit energy produced".

Hammond (1876) emphasizes the price of not having nuclear power by quoting calculations from a 1975 article in The Economist of London. Cost estimates are expressed in terms of a new currency, the COPEC-year (C-y) which equals the total surplus cash accumulated by members of the Organization of Petroleum Exporting Countries (OPEC) at the 1975 export rate. One C-y = $60 x 109. Similarly, one COPEC-day = C-d = $164 x 106 and one COPEC-hour = 1 C-h = $6.8 x 10? The rate at which the assets of the world could be bought if all oil income were used exclusively for this purpose is illustrated in the summary reproduced in Table 16. Fortunately, the needs of the people living in the OPEC have thus far precluded the exclusive use of foreign currency acquisitions for the purposes assumed in Table 16. However, the compilation should serve to emphasize the thesis that cost-benefit factors must be carefully weighed in making decisions on energy-resource developments and applications."

Table 16 A 1975 estimate of the economic power of OPEC, expressed as time required to purchase the world's major assets [Penner and Howe 1976].

Asset	Time required for purchase by OPEC if all oil income were applied for the purchase of assets
all companies listed on the world's major stock exchange	15.6 y
the entire personal wealth of Britains	15.5 y
an annuity of $232 per week for all Arab males	12.8 y
all listed stocks on the New York stock Exchange	9.2 y
all of Britain's industrial assets	6.0 y
all U. S. foreign investments	1 8 y
IBM Corporation	143 d
Exxon Corporation	79 d
Bank America Corporation	10 d

Thus we see clearly that even the establishment supports nuclear power only as a last resort until a better alternative source of energy is developed. For the humanitarian side we quote from Nader and Abbotts (1977).

"Indicative of the technical controversy is the fact that on August 6, 1975, over 2,300 scientists sent a statement to Congress and the President warning that the dangers of a rapidly expanding nuclear power programme were 'altogether too great and urging a 'drastic reduction' in the construction of nuclear plants. A similar proclamation in September 1975 addressed the special problems of plutonium, the element to which the atomic industry's future is unavoidably tied, and expressed technical and humanitarian concerns. In this statement, a prestigious panel of distinguished citizens including 15 Nobel laureates and 26 members of the National Academy of Sciences, concluded that the use of plutonium as reactor fuel is 'morally indefensible and technically objectionable' . . . and the amount of radioactivity in an operating reactor core can be prodigious. In fact, the radioactive inventory in a large nuclear power plant can represent 1,000 times more radioactivity than was unleashed by the Hiroshima bomb. . . . The most feared nuclear accident sequence is the Loss of a Coolant Accident (LOCA). . . . This in turn could lead to the consequences predicted by WASH—740, or worse... .

"The Price-Anderson Act establishes a three-tiered system of limited liability for nuclear plant accidents. Each operating nuclear plant is required to obtain the maximum available private liability insurance, which at present is $140 million. If an accident were to occur, the second tier would be provided by 'retrospective premiums' of $5 million, which would be assessed each operating nuclear power plant. If the first two tiers of payment total less than $560 million, then the federal government would assume responsibility for the difference. In any case, the total nuclear accident liability is limited to either $560 million or the sum of the First two tiers, whichever is larger. Either liability limit is clearly inadequate to cover the damage of a WASH-740 type accident. (Even with 1,000 reactors operating, the retrospective premium would provide only $5 billion, less than the WASH-740 accident property damage alone). ... If the probability of a reactor accident really is so low, why will the industry not accept full liability for such an 'incredible' accident? If the industry statements were, in fact, true, then the industry would be risking very little by accepting liability for an accident that, practically speaking, will not occur."

In my view the crux of the matter is that probability ultimately relies on Jacob Bernouli's principle that if m successes occur in N trials, the probability that the next trial will be a success is m/N. Thus the gambler that succeeds in the first attempt, is entitled to expect that success is certain but we know he does not necessarily succeed in subsequent attempts. On the other hand, the probability of success is zero until the first success is recorded. Unfortunately, the first LOCA promises to be so bad that the humanitarians are unwilling to let the matter rest on probability. In fact, probabilities are meaningful only when the number of events is sufficiently large. In this regard, we recall that commercial nuclear power plants are scarcely more than 20 years old and produce only about 4% of the world's energy consumed. In particular, there are so far

extremely few of them in countries where the level of technology and infrastructures enhance the non-Bernouli but realistic probability of catastrophic accident.

4.4 Illustrations of Problems of the Nuclear Reactor

The LOCA is perhaps the most feared reactor danger. It became almost a nightmare after the failure of the emergency core cooling system (ECCS), designed to stop it, when tested in a scaled down model. In 1957 the Brookhaven Report labelled WASH-740 stated that in the worse case of LOCA, 3,400 people would be killed immediately and another 43,000 would suffer serious injury while $7 billion property damage will occur in an area of 150,000 square miles around the reactor. An attempt to update this by a Steering Committee in 1964 estimated 45,000 deaths, 100,000 injuries and $17 billion or more property damage. Finally in 1975 the more optimistic and probability based Rasmussen Report from his Reactor Safety Study panel predicted 3,300 early deaths, 45,000 early injuries and $14 billion property damage. To these could be added "45,000 cancers in the 10 to 40 years following the accident and genetic diseases for 5 generations" (Nader and Abbotts 1977).

As far as possible we now take examples in sequence through the reactor industry operations.

"By 1944, several studies had established that 50 to 75% of the (uranium) miners in the Schneeberg (Germany) and Joachinstal (Czechoslavakia) mines died of lung cancer, and that the death were related to high radon gas concentrations in the mines" (Nader and Abbotts 1977).

Uranium mining also often leads to the radioactive pollution of rivers and drinking water.

Very large tonnage of tailings from uranium mills were regarded as safe and used for construction fills until as late as 1971. Many houses in Grand Junction, (Colorado) were found to be dangerously radioactive and the U.S. Congress spent $10.5 million in 1975 removing the fillings.

"One of the ironies of the supposedly 'clean' nuclear power is that each 1,000 MWe nuclear plant requires the equivalent of a 45 MWe coal plant—which annually burns 135,000 tons of coal—to supply its enrichment needs alone. In addition to the electricity it consumes, each plant complex also occupies about 1,500 acres of land, which is about 2.3 square miles" (Nader and Abbotts 1977).

Nuclear reactors produce so much waste heat that its management poses a problem. A number of costly methods are available to dissipate the heat but we describe the one that gives an idea of the quantity involved. The heated water may be returned to an ocean, a stream, a lake or an artificial reservoir. The efficiency of this system depends on the air-water interface—usually one to 2 acres per MW of generating capacity so that a typical 1,000 MWe plant may require an artificial pond as large as 2,000 acres. When discharged into natural bodies of water, the heat changes the biological life in water in a very large area in the environs.

After its useful life of about 30 years, a reactor has to be decommissioned. A small plant of

22 MWe in Minnesota cost $6 million to dismantle and it is estimated that decommissioning the regular size of about 1,000 MWe would cost $18 to $60 million, depending on the method adopted. It has been estimated that decommissioning one plant in Britain may cost as much as it cost to commission.

One of the fascinating things about nuclear fuel is that it could be renewable and self-sustaining. Plutonium-239 is one of the products of uranium nuclear plants. Plutonium itself could be used as fuel in breeder reactors that will produce more fuel than they consume. Plutonium is nevertheless feared because (a) it is very toxic, (b) it has a very long half life of 24,000 years, and (c) it can easily be used to make bombs.

However, the International Atomic Energy Agency maintains an inspectorate that regularly visits nuclear facilities in countries that are signatories to the nuclear non-proliferation treaty. They audit accounts to ensure that as far as possible no fissionable material is diverted to a non-peaceful use. Such regular inspections will extend to Nigeria since we have signed the non-proliferation treaty.

Spent nuclear fuels are re-processed to recover chiefly uranium and plutonium for two main reasons: firstly to use them as future fuels but more importantly to reduce the problem of waste management of long lived activity.

One of the most difficult problems of the nuclear industry is nuclear waste management. Whether you store the waste in the form of liquid like the British or you solidify them to reduce the volume like the Americans, the real problem is that they remain highly radioactive and toxic for very many years. The following Fig. 1 from Penner and Howe (1976) shows that even after one million years the activity can still be as high as 1,000 curies or 37 million million (137 x 1012) transformations per second. In fact the toxicity, Fig. 2, has its peak after one million years because transuranic daughters are more toxic than their parents. This situation is difficult to comprehend. It means that if Jesus Christ, 2,000 years ago, had used electricity from a 1,000 MWe light water reactor which was later decommissioned in his time, in spite of all the care to remove uranium and plutonium from it, the waste from the reactor in whatever form it is today will still be too "hot" (10,000 curies) to be disposed off anyhow. This poses many problems:

(a) The specialized encasements however durable would need to have been changed many times.

(b) The books containing information on burial location may have been out of print, and even its language may become obsolete and difficult to decipher by now.

(c) Some geological upheavals may occur and expose it before it can be disposed off anyhow.

But we talk of one million years which is 500 times longer than since the birth of Christ. Some propose international management of radioactive waste while others simply hope that at some era, some suitable powerful technology will be developed to decontaminate the wastes.

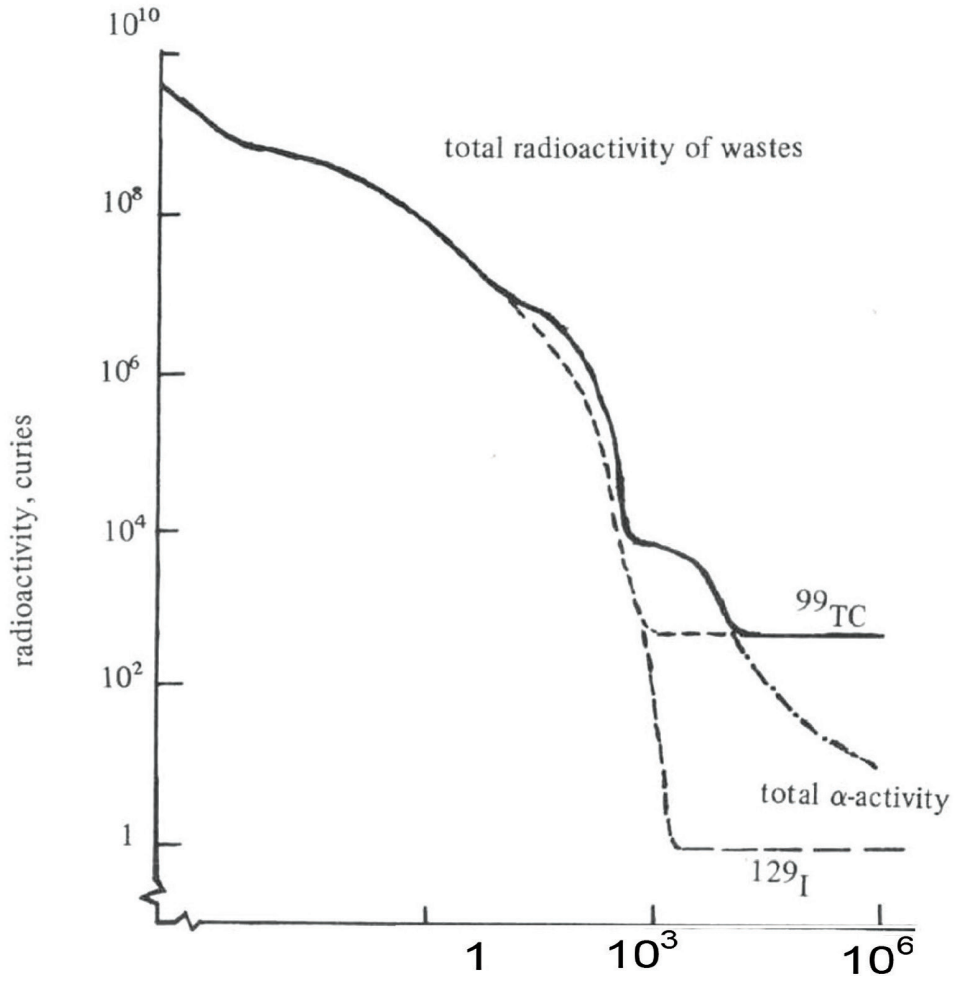

Fig. 1

The approximate radioactivity of high level wastes, from which 99.5% of the Pu has been removed, is shown as a function of time after reprocessing of the fuel taken each year from a \i JO3 Mw€ LWR. The average residence time in the reactor is about 3 y. The solid line shows the total radioactivity. Emissions from fission products dominate for ~ 100 y. After ~ 600 y, the toxicity of a -emissions from actinides exceeds that of the fission products. The dashed line (—J shows that]3 -decays of 137 Qs and 9® Sr dominate to ~ 800 yt after which low-energy fis from 99Tc (t\;= 2.12 x 105y) are the primary radioactivity. The shortest dashed line (—) represents the final decay or rare earth elements. The longest dashed line (—) corresponds to 1291 (tj= 1.7 x 107y). The long-and-short-dash line (-.-) represents the as for long-lived actinides and their daughters. Adapted from T H. Pigford and K. P.\Angf (1975).

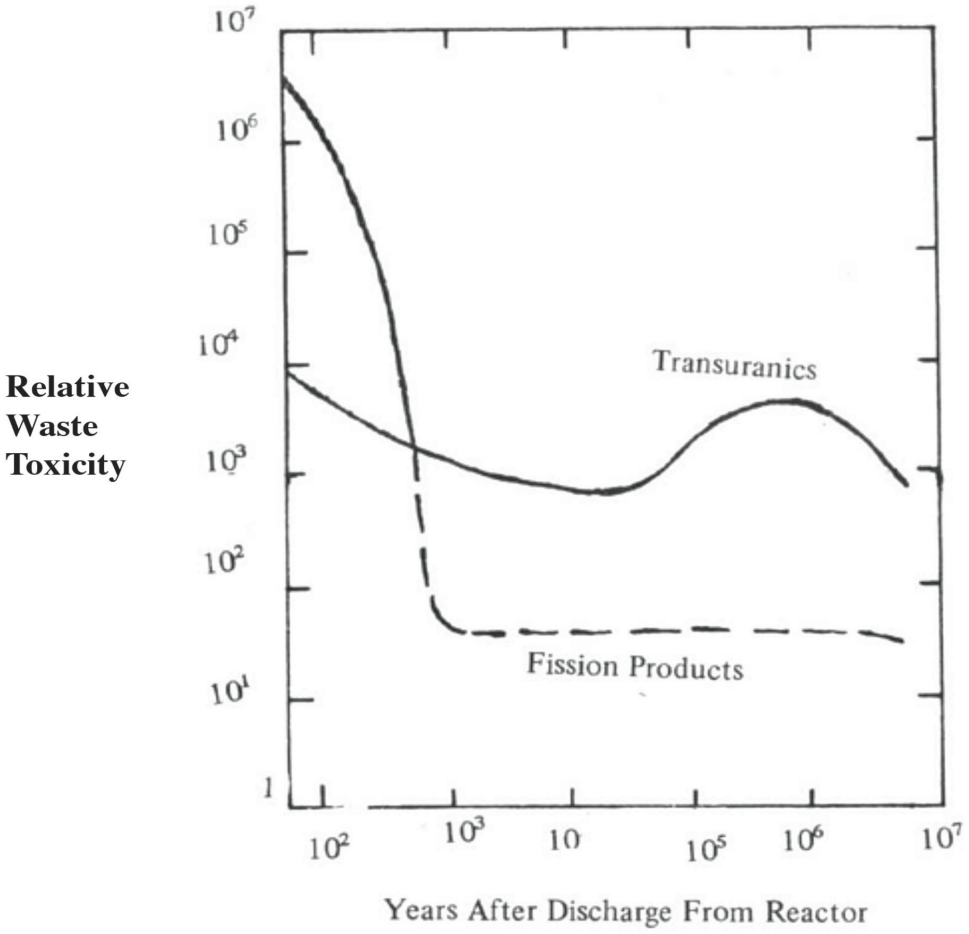

Fig. 2

Toxicity of radioactive waste as a function of time after discharge from the fission reactor. (After Union of Concerned Scientists 1973).

What is very worrying is that problems of nuclear science and technology are bound to assume greater magnitude in developing countries where infrastructures are minimal, nuclear technology is in its infancy, simpler equipment do not work for lack of spare parts for proper servicing and repair, power fails, taps are dry and communication may be by car through traffic jams. Finally, a country that cannot help itself with any aspect of the nuclear fuel processing and re-processing nor provide spare parts for the nuclear machinery locally, even if it has large foreign exchange to play with, is simply organizing a kind of bait for its vital interests by installing nuclear power plants. It should be avoided if at all and for as long as possible.

5. HOW BEST CAN WE DEVELOP NUCLEAR SCIENCE AND TECHNOLOGY FOR OUR GOALS?

5.1 Introduction

The experts from developed nations who participated in the IAEA Advisory Group Meeting on Problems of Nuclear Physics in Developing Countries held in Accra-Ghana, 30th June to 4th July 1975 were unable to recommend the development of any major nuclear facilities like a reactor or an accelerator in developing countries because:

(a) They considered that the developing countries should better use their meagre foreign exchange for developing infrastructures.
(b) They considered that very little good physics can now be done with the small size facilities that are likely to be afforded.
(c) They felt that the general level of industrial activity and development in the country should reach a reasonable height before a nuclear facility can be technically sustained.
(d) They felt that scientific and technological manpower should be sufficiently high in quantity and quality to cope with the complex technology involved.

Instead, those experts encouraged us to consider regional centres, for example, one institute for the whole of West Africa, so as to achieve the "critical mass' in terms of scientific manpower, finance, resources and other facilities needed for meaningful nuclear undertaking. When in our chagrin we countered that India had made it, one of the experts thought it was because India has so many thousands of scientists that at least a few are bound to be of the right calibre.

When I probed one of the experts in private conversation, he told me in confidence that in his view, there should be a division of labour: while the developed nations buy raw materials from the developing nations, the latter should buy products of technology from the former. I therefore do not believe the statement in Encyclopaedia Britannica (1974):

"The fact that the underdeveloped countries want to import technology from the developed countries and the fact that the developed countries see the export of their technology as in their own self-interest would seem to provide a congenial base for collaboration."

In fact the author does not believe that technology can either be "imported" or "transferred." In my view, technology can only be "developed" or "acquired" by actually practising the techniques whether one adopts the opinion that technology should be developed from the grass roots or the proposal that the latest technological ideas should be acquired.

5.2 Approach to Development of Nuclear Science and Technology

Believing that technology can only come from a "do-it-yourself" philosophy and that we need to have all necessary technology at some stage, I agree we should start now as modestly as we can even with nuclear science and technology. With what do we start?

Three nuclear facilities immediately come to the mind: training and research reactor, particle accelerator or neutron generator. Nearly all the areas of relevance and need mentioned in Section 2 above can be studied by experiments in-pile and out-of-pile around a nuclear research reactor. Hardly any other nuclear research equipment can be used for so many different purposes as a research reactor. Even those that permit of a limited range of applications may not be simultaneously used for those purposes as is the case with nuclear reactor. Yet, these less versatile nuclear research equipments are also less flexible than the nuclear reactor because they are not amenable to easy modifications like a training reactor. Hardly any other nuclear facility can expose the trainee to so wide a range of nuclear phenomena, and so it had become customary to train future workers on different types of reactors and other nuclear facilities for sometime around a research and or training reactor

Consequently, the Committee set up by the Natural Sciences Research Council of Nigeria on the matter in June 1975 recommended and the Council approved that Nigeria should establish a National Institute for Nuclear Sciences whose central facility should be a small training and research reactor of not more than 2 MW

But in view of all that has been said above, we must be realistic, and so the .Committee made the following points and recommendations:

"The point was made that in Nigeria ... the wide ranging nature of nuclear sciences and technology may raise debate as to who should sponsor the National Institute for Nuclear Sciences. It was however clear to the committee that while specialised reactors could be established for specialised purposes, like electricity generation, industrial applications, etc., these would come much later. The initial effort in the area of Nuclear Sciences and Technology is clearly one of education and development of manpower.

"The National Institute for Nuclear Sciences is a big and costly establishment of which only one can be afforded at this stage of development in Nigeria. The first Institute for Nuclear Sciences in Nigeria with a major facility, like research reactor, should be organizationally independent of the institutions of higher learning. Its enormous facilities should be available on equal terms to all the personnel qualified to use them who may be scattered all over the country, for only in this

way can these facilities be used to maximum advantage. Close relationships should, however, be developed between the Institute for Nuclear Sciences and institutions of higher learning, but it should not be attached to anyone of them. As additional institutes or major facilities become available in Nigeria it may become more reasonable to attach the later institutes or facilities to institutions of higher learning or industrial institutions. . . . "As soon as a firm decision is taken to go ahead with the project some core staff should be assembled who, with the help of other experts around, should decide finally on the reactor to be ordered.

"A programme should be prepared for the retraining of the core staff and other future scientific staff for the institute recruited before the installation of the reactor. At least some of the staff should undertake their retraining in the firm supplying the reactor so as to participate in the design and construction of the reactor and appreciate its problems. "Once a definite commitment to the establishment of the institute is made, there will be need for a continuous flow of people taking basic degrees in nuclear sciences and engineering.

"Since a major reason for engaging in such a project is the development of technology that is expected to arise from this big scientific challenge, the research/training reactor to be ordered must not be of a very high power. This should force the scientists, engineers and technologists of the institute to begin early to think of improvements and redesigns; in particular the National Institute for Nuclear Sciences should decide quite early to build its own reactor. Only in this way can the expected returns in the acquisition of technology be assured."

Table 17 gives the scientific manpower in the various categories (total 44) recommended by the Committee for a National Institute for Nuclear Sciences. The author has been collecting names and addresses of scientists in Nigeria having reasonable acquaintance with and therefore more easily re-trainable in nuclear sciences and technology. The Table shows that perhaps it is only in Physics that we are likely to find enough manpower by starving the universities and re-training their Physics staff. The author is taking this opportunity to appeal to Fellows to write down now names of scientists in Nigeria they know in the area of nuclear science and technology together with their disciplines and towns they live in and submit in order to make the list more comprehensive and reliable.

Table 17: Scientific manpower in Nigeria having reasonable acquaintance with nuclear science and technology.

Discipline	Estimate of need by NSRCN Committee	Provisional collection by author
Agriculture	5	0
Biology	2	1
Chemistry	10	4
Engineering	7	2
Geology	6	4
Medicine	3	1
Physics	11	28

6.. CONCLUSIONS

In conclusion we now itemize some of the points made in the above lecture:

1. With the 15 to 20% compound annual growth of electrical power demand in Nigeria, if all the presently known hydropower, natural gas and coal reserves of Nigeria were requisitioned in that sequence almost wholly for the generation of electricity, they would be nearly fully committed in the next 20 to 30 years when the electrical power demand is expected to be about 34 GW. By then, the oil reserves may well have been depleted to such an extent that oil may not rescue the situation unless new reserves are discovered. The accuracy of this statement depends on the extent to which the possible redeeming features offset certain assumptions made in the study.
2. Priority should be given to the development of renewable energy resources in the order; solar energy, biomass, wind and possibly tides.
3. Although the importation of the resources for nuclear energy may appear cheaper than the importation of the materials for conventional energy or the importation of energy itself, the problems of nuclear energy are so immense and so long lasting that the odds are not clearly in its favour. In fact the costs of starting and ending a nuclear plant are almost equally heavy and anxious expenditure on its waste materials may continue for many generations.
4. As a matter of urgency, the Nigeria Atomic Energy Commission should arrange for the regulation, control and inspection of exposure to ionizing radiation in Nigeria.
5. The global picture is that continuation with nuclear power is being tolerated only as a means of bridging the energy gap until new sources of power are developed. As of now, there is hardly any alternative for a world that has organized along the lines of heavy

dependence on technological power. Nigeria is moving towards the same position of having no alternative.

6. A country that cannot help itself with any aspect of the nuclear fuel processing and re-processing nor provide spare parts for the nuclear machinery locally, even if it has large foreign exchange to play with, will be ill-advised to install nuclear power plants.
7. On the issue of installation of nuclear power plants, serious consideration should be given to a cooperative effort with Niger or even ECOWAS and based in Niger where there is sufficient uranium reserve, and then, we buy energy from Niger to whom we sell energy now.
8. Technology can neither be "imported" nor "transferred" but just has to be "developed" or "acquired" by practice. Even where the technology already exists it takes about 10 years to develop a uranium mine and about another 10 years to commission a nuclear power plant. Nigeria should therefore start now, to develop nuclear science and technology in a modest way.
9. The recommendations of the Natural Sciences Research Council of Nigeria on how best to develop Nuclear Science and Technology are commended for consideration.

Thank you.

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ATTITUDINAL AND BEHAVIOURAL ASPECTS OF EPIDEMIOLOGY AND CONTROL OF PARASITIC DISEASES IN TROPICAL AFRICA

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INTRODUCTION

In my lecture to the College of Medical Sciences at the University of Benin last month (Ukoli, 1986), I made bold to propose that the prevalence of parasitic diseases (as well as other communicable diseases) should be included among the indicators for monitoring and evaluating progress made towards achieving health for all by the year 2000 in the less developed countries (LDCs) prescribed by the World Health Organization. In everyone of those indicators, Nigeria falls far short of expectation. Thus, as shown by Omene, the expenditure on health in Nigeria is way below the recommended 5% of the gross national product; the resources available are not equitably distributed and primary health care is not available to the entire population; owing to the poor nutritional status of the people, the incidence of low birth weight (LBW) in infants is still very high, double the recommended 10%; infant mortality at 150/1000 is still way above the prescribed limit of 50/1000, and life expectancy at birth is less than 50 years instead of rising above 60 years. When we add to this catalogue of woes the fact that the prevalence of all the most virulent parasitic diseases is still very high, and we have made very little progress towards eradicating, or in case this is not feasible, controlling or preventing them, the conclusion is inescapable that the attainment of the slogan "health for all by the year 2000" is a pipe-dream as far as Nigeria is concerned (Ukoli, 1986).

High prevalence of parasitic diseases, along with poverty, ignorance, and hunger are indisputable indices of under development. But just as explicit is the fact that these LDCs lack the material, manpower, and technological resources to grapple with and overcome these problems. Where such resources are available, they lack the capacity to mobilize them effectively or the will to formulate rational policies and the drive to ensure their successful implementation. Consequently in the case of parasitic diseases, rather than succeeding in minimizing their impact, the LDCs in tropical Africa are experiencing an increase in their prevalence and severity which thereby continue to constitute the greatest threat to the health and socio-economic status of the people (Ukoli, 1984).

But even more intriguing is the fact that control of these diseases is within our reach; in fact all that is needed to be known for the successful application of the various control measures is already common knowledge. Thus the salient features of the parasites and their intermediate hosts and vectors which enhance the spread of the diseases and whose manipulation will procure control have been known for decades, and have been successfully exploited in eradicating the diseases in the advanced countries. Admittedly, changes in the socio-economic status of the people in these countries, which find expression in improved sanitation, better nutrition, and increased awareness of the aetiology of the diseases, have contributed significantly towards their eradication and control. In tropical Africa, parasitologists have made significant contributions, through research, to knowledge about our environment and its parasitic fauna and their hosts. However, such research does not appear to have resulted in the development of fresh insights into the problems nor has it provided a new thrust for the generation of novel and original ideas for control. It is as if all our efforts have ended up merely characterizing our local conditions and at best corroborating, verifying, and reinforcing the already available knowledge forming the basis of well-established control strategies (Ukoli, 1988). Moreover, many studies conducted on problems of disease, whether they achieve breakthroughs or not, are likely to remain mere academic exercises with little practical or policy impact, for the simple reason that we are yet to evolve effective ways of managing and utilizing research findings.

CONTROL OPTIONS FOR PARASITIC DISEASES

What then constitutes the modern approach to the management of parasitic infections, which involves the application of already available knowledge? The answer is the adoption of one or a combination of the following options:

1. Treatment, mainly through chemotherapy.
2. Protection from infection and re-infection, mainly through chemoprophylaxis and immunization, and
3. Prevention of infection either by,

(i) controlling human behaviour or (ii) controlling the intermediate host or vector.

Although all three options have been tried in various parts of Africa at one time or the other, yet they have not produced the desired results. Why?

In the first place, the prospect of eradicating an infectious disease by immunization or vaccination, though always an attractive one (c.f. the recent global victory over small pox), seems in the case of parasitic diseases to belong to the future (Ukoli, 1986). Although great strides have been made in research into this problem in recent years, the sad fact is that no effective vaccine has yet been developed against any of the major parasitic diseases. The use of drugs for disease prevention is still a dream with most parasitic diseases, indeed only malaria has so far succumbed to chemoprophylaxis.

The most effective procedure seems to be by chemotherapy, although it is obvious that, with

most parasitic diseases, it only offers temporary relief. There seems to be little point in treating the symptoms of the disease, which is but the tip of the iceberg, only for the patient to be exposed to reinfection when he returns to his normal surrounding and way of life. Management of the disease by chemotherapy alone, without removing the cause of the problem or preventing the possibility of reinfection is nothing more than an exercise in futility. In any case, the prohibitive cost of these drugs places them out of the reach of those who need them most - the poor peasants who are the victims of the ravages of these diseases, and for whom a single treatment would represent a sizeable proportion of a meagre monthly income.

That leaves us with the third option i.e. prevention of infection. Here the locus in tropical Africa has been to develop control measures against the intermediate hosts and vectors. However, although the scientific and technological know-how is available, the control schemes that have been devised, or the programmes mounted have been maintained at such a rudimentary level that successes already achieved have been difficult to sustain. Admittedly, this has been due largely to financial, administrative, manpower and technical constraints, but unfortunately excuses do not keep the infections at bay! The various approaches to the control of intermediate hosts and vectors fall into broad groups, chemical and non-chemical (or biological) methods.

Non-chemical methods involve the ecological modification of their habitats, the use of competitors, predators; parasites and pathogens to reduce their populations, and various types of genetic manipulation designed to displace the wild susceptible strains. I have made a critical review of the prospects and problems of these approaches in my book on *'Parasitology in Tropical Africa'* (Ukoli, 1984). Unfortunately, however, though based on sound scientific principle, some of which have successfully undergone laboratory tests and field trials, a fair assessment is that a practical application of most of these techniques does not seem feasible in the state of present knowledge. Even the enthusiasm generated by the initial success of the sterile male technique in the control of tsetse fly, the vector of trypanoiomiasis, has been dampened by many practical difficulties, not least of which are mass techniques for rearing males in large numbers near where they are needed, and ensuring that the released males will be highly competitive under conditions of low population densities (WHO/FAO, 1979).

The use of chemicals or the so-called insecticides (for insect vectors), and molluscicides (for snail hosts of trernatode infections) appear to offer the best prospects for the control of these organisms. But there are a number of limitations, some of them quite serious, involved in the application of chemical control, the most important of which are:

(i) The need to apply the chemical repeatedly and constantly over a prolonged period measured in years, and the need for rigorous monitoring and surveillance in order to forestall recolonization by the organisms and their reinfection by the parasites. This often necessitates the recruitment of highly trained, specialized personnel who should be committed to working under hard conditions, and these are in short supply in tropical Africa. It also involves the use of expensive and sophisticated equipment which these poor African countries can not afford.

(ii) The harmful effects of these chemicals on the environment and non-target organisms,

especially economically important species and wildlife cannot be ignored, however effective they may be in their intended purpose.

(iii) Development of resistance by the vectors to the chemicals for example, the resistance to insecticides developed by the anophelese mosquitoes has been largely responsible for the resurgence of malaria in many parts of the world where it had once been eradicated.

(iv) Above all, the prohibitive costs of the chemicals; most of these chemicals are synthetic products, and since the endemic areas of tropical Africa where they are needed have neither the capacity nor the technology for manufacturing them, they have to be imported from the industrialized nations where they are developed and produced. This inevitably involves the expenditure of hard currency. With the state of the economy as it is today, if the control of parasitic diseases by attacking the vector with chemicals has been maintained anywhere above a low key in tropical Africa, that practice has now ground to a complete halt in most of the countries including Nigeria.

It follows from the foregoing that further progress at controlling parasitic diseases by attacking their intermediate hosts and vectors will be predicated on our capacity to find solutions to all these problems. Our scientists working in this area should therefore be encouraged to channel their energies into research of the "applied" variety i.e. research designed to find solutions to a pressing social problem.

SOCIOMEDICAL STUDIES IN EPIDEMIOLOGY AND CONTROL

The above review reveals how limited our achievements have been in the management of parasitic diseases applying the available procedures. The rest of this lecture will be devoted to examining the last option which entails the initiation of certain actions aimed at modifying or changing certain attitudes, beliefs and behavioural attributes which expose man to infection. According to Dunn (1983), the role of human behaviour as a major factor in the transmission and distribution of communicable diseases has been recognized for centuries (Dunn, 1983). When Burnet defined endemic disease as, "an infectious disease in a community in which the social circumstances do not offer any effective barrier to its spread", he was only reflecting the important role played by social, anthropological, and economic factors in disease causation, transmission, and control. According to him, .the pattern of parasitic disease in a cultural setting is regulated by a complex interplay of human factors including those which act as effective barriers to the spread of the disease, and those others which enhance its promotion. Therefore, a greater understanding of these factors is bound to help in determining what changes, if introduced, would upset the established culture-parasite relationship in favour of limiting the spread of the disease or bringing about a cessation in its transmission (Koctor et al, 1976). To be sure the results of such studies have so far not been widely utilized in the development of effective control strategies, particularly in tropical Africa where they are still in their infancy. However there is no doubt that they are essential for an understanding of the epidemiology of parasitic diseases in a specified area, and are indispensable in the formulation and designing of effective health education programmes (WHO, 1979).

Until very recently, the battle against parasitic diseases through research has been conceived as a predominantly biological and biomedical enterprise (Dunn, 1979). It is about time we harnessed the forces of the sociomedical aspects, a term which Dunn sees as, "encompassing those aspects of medical research that are focused on human behaviour and its social, economic, cultural and psychological determinants" (Dunn, 1983). Accordingly, we shall now examine how such studies, when undertaken in conjunction with regular epidemiological work, will help to provide explanation for the influence of the following parameters on the transmission of parasitic diseases, and suggest new or alternative approaches to prevention and control:

(i) ignorance, attitudes, and beliefs;
(ii) traditions, customs, and socio-cultural practices;
(iii) contaminative attitudes and behaviour having a bearing on environmental sanitation;
(iv) food and feeding habits;
(v) social and economic impact of parasitic diseases;
(vi) political will, ideological orientation and administrative capacity of government.

IGNORANCE, ATTITUDES, AND BELIEFS

In my lecture to the College of Medical Sciences at Benin, I argued that a society that does not possess a rational concept of parasitism, does not believe in the germ theory of disease, and is not familiar with the uses of the microscope, cannot be equipped mentally and psychologically to understand and appreciate the principles of disease transmission, and can therefore not be expected to be able to grapple with the intricate problems of prevention and control (Ukoli, 1986). They cannot, if they are also ignorant of the fact that most parasites are obliged to spend part of their life cycle outside the host's body. So also, if they are unaware that certain developmental stages of some parasites are actually free-living, or, indeed, that sojourn in another organism of a different species from the original hosts is obligatory for the completion of the life cycle of some parasites. For centuries the European societies, in a similar state of ignorance, could not register any appreciable progress in the control of their infectious diseases. But all that changed as from the second half of the 19th century when:

(a) Louis Pasteur established that the agents of fermentation (and infection) are microorganisms in the environment;

(b) the emergence of the light microscope made it possible to discover the various developmental and infective stages of parasites in both the internal tissues of hosts and in the external environment and:

(c) its intensive and imaginative use brought about the elucidation of the crucial role of vectors and other intermediate hosts in the transmission of parasites (Ukoli, 1986).

By successfully unravelling the mysteries shrouding the mechanism of disease transmission, the stage was set for the development of ideas and strategies for their prevention and control. This state of ignorance persisted throughout tropical Africa until well into the present century. Even to this day, the traditional sector which constitutes by far the greatest segment of the individual African nations, typifies such an outlook; they can have no answer to the problem of parasitic diseases!

A few examples will suffice to drive this point home. In the Roman times, malaria was thought to be caused by the effects of the "bad air" of the swamps, hence the name malaria (Latin for bad air), a view which flourished all over Europe until the incrimination of the mosquito (Anopheles) as the vector of the diseases by Ross in 1897. Similarly, any control measure based on the traditional conception of the nature of urinary schistosomiasis is sure to result in a wild goose chase. Surely the interpretation by the traditional Nigerian society that the symptom of the disease (haematuria) among boys is a male version of menstruation signifying the onset of puberty, cannot lead us very far. Neither can the covering of the tip of the penis with a metal cap made of gold, silver, or copper (depending on economic status) by the ancient Egyptians be seen as a viable preventive option. It cannot be because it is now known (thanks to Leiper in 1915) that the infection arises when a human skin is penetrated by a larval stage of the parasite *Schistosoma* after it has undergone some developmental stages in the tissues of the freshwater snail *Bulinus* spp. A case of outright ignorance of the aetiology of a disease is provided by the great difficulty Ward et al (1979) experienced in demonstrating to some peasants in southern Ghana, the relationship between drinking contaminated water now and suffering from guinea-worm disease twelve months later. Again it is the belief, in that society, that a person's chances of getting the disease are increased the more he talks about it (Conno, 1978). How can it be so when guineaworm is known to be contracted simply by drinking pond water contaminated by *Cyclops* infected with guineaworm larvae, a fact established by the Russian scientist Fedchencko as far back as 1869?

The work of Imperato and Sow (1971) amongst several ethnic groups in the part of the Senegal River Basin in the Republic of Mali, shows how the ignorance of the people and their beliefs constitute effective barriers to their understanding of the nature of onchocerciasis. In the first place most of them believe that the signs and symptoms of the disease i.e. the presence of the nodules surrounding the worms, the dermatitis and pruritus and ultimately the blindness, are separate and unrelated entities and are not manifestations of the same malady (Imperato and Sow, 1971). Furthermore, some of them believe that the nodules are congenital and are an inevitable and normal part of the anatomy or signs of ageing. While they know a lot about the habits and distribution of the *Simulium* fly around water courses, they are blissfully ignorant about its role as the vector of the disease, a discovery made by Blacklock in 1926. Thus they hardly make any attempt to protect themselves against the bites of the flies, regarding them "as nothing worse than a nuisance (Imperato and Sow, 1971).

All the theories about infectious diseases notwithstanding, how can people in the pre-scientific culture of our traditional society be expected to accept the rationality of such indices of infection as prevalence, incidence, rate and intensify of infection etc.? In a situation in which virtually everyone in the society is equally exposed to say, the bite of mosquitoes, what determines who gets infected and subsequently suffer or even dies from malaria? In the absence of any convincing proof, who can blame the people for invoking the powers of witchcraft, juju, or other supernatural forces in their search for explanations? That is a moot point. So, for that

matter, is the fatalistic attitude of the adherents of modern religions who are inclined to leave everything to the better judgement of God, when illness and death from infectious diseases like malaria strike. Of course, such interpretation of the cause and, the nature of parasitic diseases, having no scientific basis, cannot carry us very far in our quest to overcome them (Ukoli, 1986).

CUSTOMS, TRADITIONS, SOCIO-CULTURAL PRACTICES

The socio-cultural component in the epidemiology of parasitic diseases is very significant in tropical Africa (Ukoli, 1984). Indeed, many authorities believe the customs, traditions, and socio-cultural practices of the "backward" peasants of rural Africa predispose them to infection. Their unwillingness to change their "primitive" and '"uncivilized" ways and their resistance to change, even when introduced to improve their lot, is responsible for the continued prevalence and spread of these diseases. It is obvious that this attitude is closely linked with the factors of ignorance and beliefs discussed above.

One of the customs which is seen to enhance the transmission of schistosomiasis is the gathering of rural African women, accompanied by their children, at the local source of water supply for laundry, washing of household utensils, drawing water for domestic use and bathing, a custom which Wright (1971) considers as "an essential part of the social activity of the village" (Wright, 1971). On the contrary, I have argued elsewhere that this custom might have developed in response to pressures imposed by the harsh realities of rural life in tropical Africa (Ukoli, 1984). Certainly, this is a custom which the women would only be too glad to discard if suitable, conveniently-located alternatives like laundries (or even washing machines), and pipe-borne water were provided. In any case there is nothing intrinsically wrong or primitive about this custom, if custom it really is, but for the fact that the water body is ecologically conducive for the survival of snail hosts of the parasite, and provided an ideal setting for transmission to occur. Similarly, the ritual ablutions of muslims before prayers, and their customs of washing their anus with water after defaecation should have been perfectly harmless even commendable as acts of cleanliness. Unfortunately however, some of the ablution basins in some mosques have been found to be good habitats for the snails thereby increasing the risk of infection.

The role of custom and traditions in disease transmission is no where more dramatically demonstrated than when, as a consequence of their combined action, man becomes a substantial item in the food chain of wild carnivores. Just such a situation is said to exist in parts of Kenya where the tribesmen have a custom of putting out their dead or dying relations for the hyaena to eat. In Masailand for example, hyaenas are heavily infected with adult *Diphyllobothrium* spp., while cases of the disease sparganosis in man are not uncommon. This led Nelson et al. (1965) to conclude that man serves as suitable intermediate host for the effective transmission of the parasite to the "rather revolting hyaena ... an affront to human dignity" (Nelson Pester and Pickman, 1965). Similarly, it is believed that the Turkanas of Kenya maintain the highest prevalence of hydatidosis in the world because of similar customs relating to the disposition of their dead. Here also man, in which the hydatid larva develops, forms a part of the food chain in the sylvatic cycle, thereby effectively transmitting the parasite to wild carnivores (Gleeson,

1978). Ordinarily the development of the hydatid in man represents a dead end in the domestic cycle of *Echinococcus granulosus* because the flesh of man is not normally accessible to domestic dogs. A similar mechanism may be operating in the transmission of trichinosis in the sylvatic cycle in tropical Africa in which hyaenas feature prominently.

Certain procedures in traditional medical practice have been known to enhance disease transmission. For example, in South Africa, certain prescription by "witch doctors" for the treatment of tapeworm infection contain ground-up concoctions of the proglottids of the pork tapeworm, Taenia solium. This, when taken by the patient results in increased prevalence of cysticercosis, a condition which has been incriminated as a common cause of epilepsy and other neurological conditions in parts of Africa (Nelson, 1972).

One factor of great epidemiological significance in bovine trypanosomiasis in Nigeria is transhumance (a nomadic approach to cattle raising). The Fulanis have retained this way of life not merely to preserve and uphold the tradition, but also as a response to the demands imposed by a combination of factors including climatic, ecological, and economic ones. Thus, though the bulk of Nigeria's cattle is reared in the tsetse-free zone in the far north, they have to migrate southwards in the dry season in search of greener pastures and water, as well as to reach the consumer markets. By so doing, they traverse the vast tsetse-belt where the cattle are exposed to trypanosome infection resulting in substantial economic loss (Braide, 1980). One possible solution to the problem is to try to induce the cattle Fulani to settle down and change their cattle husbandry method to ranching. Alternatively, the cattle could be rapidly transported across the tsetse zone by means of vehicles, thereby reducing their exposure to infection; a practice which has led to a decline in the incidence of trypanosomiasis in cattle in the south observed in recent years (Kilgour& Godfrey, 1978). Those who expect to achieve success by adopting these approaches underestimate the power of traditional and socio-cultural influences on human affairs.

Finally, certain activities of man are known to indirectly create ideal breeding sites for, mosquitoes, thereby aiding and abetting greater man-vector contact and hence increasing the transmission of malaria. Thus man, through these so-called malariogenic activities, exercises very great influence on malaria epidemiology. Some of these activities include:

1. Those which promote peri-domestic breeding of mosquitoes, e.g. littering residential premises with discarded objects like cans, tins, plastic packages etc. which serve as containers of water, constituting man-made mosquito breeding sites; storage of water for domestic use around the house; growing near the house, plants which are capable of retaining sufficient water in their axils to support mosquito breeding.
2. Those involving development activities like building projects, and road, railway, and airport construction, which create breeding sites in the excavations and pits; major water development projects like construction of dams and irrigation projects, and
3. Failure to drain collections of water in puddles, drainage gutters, cesspools, potholes, footprints of man and his domestic animals etc.

The foregoing has been a review of the impact of man's ignorance, his attitudes and beliefs and his customs, traditions and socio-cultural practices on the transmission and spread of parasitic diseases. It shows how these factors serve as effective barriers to the adoption of appropriate preventive and control measures. However, it is now widely accepted that these barriers can be removed through effective health education campaigns designed to enable the people gain better understanding of the aetiology and epidemiology of these diseases, so that they can be persuaded to change, or at least modify some of their ways and beliefs. But this is easier said than done because, according to, Dunn (1983), the cord of accomplishments by health education programmes to date is very slim. The results of various campaigns have tended to confirm the established view that the people are simply reluctant to change their ways. The reason for this is mainly because the profession of health education has traditionally tended to emphasize educational methodology rather than behavioural research, (Dunn, 1983) attempting as it were, "to modify human behaviour by 'educating' people, or helping them to educate themselves, in biological rather than behavioural terms" (Dunn, 1976a).

Poor peasant masses, preoccupied with the problems of poverty, ignorance, and disease, are not likely to be disposed to study nor are they intellectually equipped to understand posters, diagrams, photographs or microscope slides of parasites and their life cycles. What is more, they are not likely to change their beliefs and socio-culturally bound behaviour merely because of that experience. What is needed here are ingenuity and innovation in educational research and the devising of persuasive and convincing health education strategies (Dunn, 1976a). The indirect method of appeal to make people change their ways advocated by Gillett (1975 & 1979) for the control of malaria, falls in line with this recommendation. In this approach, the message about the disease should be spread through entertainment programmes on radio and television, rather than by direct instruction or preaching about the problem which most people tend to reject (Gilbert, 1975, Gilbert 1979). But no effective education programme can be developed which is not based on adequate data concerning biological, as well as human behavioural and attitudinal factors, obtained in the course of epidemiological research (Dunn, 1976a). And we have seen how this area has been neglected in tropical Africa. It is for this reason that work on the sociomedical aspects of epidemiological research must be commended and intensified.

CONTAMINATIVE ATTITUDES AND BEHAVIOUR

The contaminative attitudes and behaviour of man have long been recognized as some of the most important factors contributing to the transmission and spread of intestinal parasitic diseases. These factors, which constitute what is collectively referred to as sanitary behaviour, usually deal with the process of excretion and excreta disposal. Thus, according to Dunn, we require quantitative as well as qualitative data on defaecatory latrine use or non-use, children's activities at play and their contact with soil and/or faeces, food handling, water use, in short all those behavioural factors affecting environmental sanitation (Dunn, 1983). Related studies on the social and economic status (especially as regards poverty), housing and settlement patterns, population density, religious and ethnic beliefs, attitudes and practices etc. must also be under-

taken. Systematic studies of some of these factors in conjunction with epidemiological research will not only help us to understand the basis and nature of the observed pattern of behaviour, but are indispensable in the planning of programmes on behavioural change and environmental modification (Dunn, 1979).

Although the significance of sanitary behaviour has long been appreciated, research to elucidate and substantiate the existence of any relationships between it and the epidemiology of disease are few. Of particular interest are the classic studies of intestinal parasitism in the Malayan aborigines by Dunn (1972), and the cultural ecology of hookworms in rural Bengal in India by Kochar (a social anthropologist) and his colleagues in 1976 (Kochar 1976), which set the pattern for such studies. There are, however, hardly any published reports of such studies in tropical Africa. Here in Nigeria, the pioneer in this field is Professor A.B.C. Nwosu whose work in Anambra State commenced only a few years ago supported by substantial grants from WHO (Nwosu, 1985, pers. comm.).

It is not as if the results of such studies have, actually been incorporated into any strategies for the successful control of these diseases. In fact, the control of hookworm (which was one of the first of these parasitic diseases to reveal the relationship between its transmission and human behaviour) proved an uphill task in the U.S.A. After many decades of work in trying to control it through public health intervention, the human element, though important, proved to be so intractable that by the mid-1950s it was concluded that pursuing this line of action was a futile exercise. (Dunn, 1983) Rather,it became apparent that the disappearance of hookworm and other intestinal soil-transmitted helminths would slowly and gradually take place *pari-passu* with the improvement of the economic, social, educational and occupational standards of the society (Dunn, 1983), precisely what seemed to have happened in the U.S.A.

HUMAN/WATER CONTACT STUDIES IN SCHISTOSOMIASIS TRANSMISSION

One of the most active areas of behavioural research is human/water contact behaviour in the transmission of schistosomiasis. According to the WHO Workshop on the subject in St. Lucia in 1979, enough information has not yet been compiled through research to back any general recommendations on the value of such studies in control programme-planning and implementation (WHO, 1979). Nevertheless, the studies undertaken, in conjunction with epidemiological surveys, are useful in describing and evaluating the contribution human/ water contact studies can make to schistosomiasis transmission.

Since the pioneering work of Dalton (1976) in St. Lucia (Dalton, 1976), these studies have become more refined and sophisticated in concept and scope. Essentially, they are designed to investigate water contact behaviour, both quantitatively and qualitatively, in relation to age, sex, ethnic, occupational, residential, religious and social division, together with snail occurrence, cercarial densities in the water and other relevant biological and physical observations (Dunn, 1979, Kloos, 1983). Obviously, such studies require an interdisciplinary approach, involving anthropologists, geographers, sociologists and statisticians, as well as epidemiologists, para-

sitologists and malariologists. They should involve, apart from the regular ethnographic and behavioural epidemiological techniques, the exploration of new methodologies in areas like mapping, geographical reconnaissance, and discriminant analysis (kloos, 1983). Above all, the WHO workshop stresses "a high degree of sophistication in study design", in the preparation of the research protocol (WIN, 1979). The work of Kloos et al (1983) in an Upper Egyptian village (Kloos, 1983), gives a fair idea of the degree of complexity water contact studies can attain. Very few studies have been conducted in this area in tropical Africa, notable among which are those by Dalton and Pole (1978) in Volta Lake in Ghana (Dalton, 1978), and Tayo et al (1980) in Malumfashi in Nigeria (Tayo, Righ, and Dudley, 1980). But none of these is as comprehensive in scope or as sophisticated in concept and execution as envisaged by both WHO (1979) and Kloos et al.

It can be concluded from the foregoing, that contaminative and water contact behaviour studies are promising as tools for devising control programmes. However, having regard to our modest contributions, both conceptually and operationally, it would appear that the prospect of achieving control, based on the behavioural changes and environmental modifications suggested by such studies, belong to the distant future. In the meantime an alternative preventive and control strategy for hookworm and schistosomiasis would involve (a) an improvement in the general standards of sanitation through the installation and maintenance of an efficient sewage treatment and disposal system and, (b) the provision of pipe-borne water in order to reduce human contact with natural freshwater bodies to a minimum. In another paper (Ukoli, 1983), I have shown that the cost of providing adequate water supply with a complementary sanitation programme in Nigeria between 1980 and, 1990 is estimated at N34.7 billion. Obviously this mind-boggling figure puts paid to any thought of attacking the problems from this otherwise well-conceived and simple angle, having regard to our present economic predicament.

FOOD AND FEEDING HABITS

The food and feeding habits of man play a major role in the epidemiology of certain parasitic diseases, particularly in cases of zoonotic infections. Prevention and control of these diseases entail no more than either abstaining from eating such food, or merely changing or modifying the methods of preparation or presentation. As simple as these measures appear to be, attempts to persuade people to adopt them have often met with serious resistance, revealing yet another intriguing and fascinating facet of human nature. Furthermore, descriptions of the diverse foods and feeding habits, their cultural and ethnological origins, and accounts of the kinds of problems usually encountered in trying to convince people to change their ways and attitudes towards food, have anecdotal appeal, which is the approach I intend to adopt here.

War and civil strife have sometimes been drummed up as the cause of outbreak of certain parasitic diseases when they bring about a change in feeding habits. For example the outbreak of paragonimiasis in isolated foci in eastern Nigeria, soon after the civil war, which was reported by Nwokolo (Nwokolo ,1972a,b) - it was attributed to "changes in feeding habits occasioned by starvation (Muller, 1975), which forced the people to eat raw freshwater crabs, the intermediate

hosts of Paragonimus spp. However, as I argued elsewhere (Ukoli, 1989), the fact that the diseases was first reported by Nwokolo in 1964 (Nwokolo, 1964), (before the civil war), and that similar infection rates have been reported for endemic areas of Nigeria and West Cameroon (where there was no civil war) seem to suggest that civil war and/or a change in eating habits have little to do with prevalence of the disease. Again, Nelson (1972) attributed the reported fatal outbreak of trichinosis in Kenya in 1961, to change in human behaviour brought about by the Mau Mau 'insurrection" which made young Kenyans abandon the old Kikuyu tradition of disdain for the flesh of wild animals, and eat undercooked meat of bush pig (Nelson, 1972). I have countered this assertion by pointing out that what Nelson calls an insurrection (in this case a struggle for political independence), cannot be the basis for changing or discarding traditional practices. Besides, the flesh of bushpig and warthog is commonly consumed in different part of Africa where trichinosis has not been reported as a serious problem.

There have been reports of the belief among certain tribal groups in Africa that the consumption of the infested flesh of certain animals improves their sexual prowess and their capacity for procreation. Thus, for example, while the male members of the Maasai and Kikuyu tribes of Kenya are said to believe that the consumption of measly beef guarantees their virility, the Suk women of Uganda believe that it enhances their fertility; just as raw freshwater crabs are supposed to be able to do when eaten by adolescent girls in certain African communities (Wright, 1971). In the latter case, this custom cannot possibly account for the occurrence of paragonimiasis among male members of these communities, or for its incidence at all in communities where such a custom or belief does not exist. Crabs are widely eaten all over Nigeria, even in places where paragonimiasis is not endemic. Therefore, the evidence that the consumption of raw crab as part of a fertility rite plays any significant part in the epidemiology of this disease is tenuous at best.

Some parasitic diseases have been reported to be prevalent amongst people who have acquired exotic tastes in their choice of meat and the mode of its preparation. The most spectacular example is the case of some tribal groups in Kenya who, in relishing the taste of undercooked dog intestines roasted over an open fire, ingest the hexacanth embryos of *Echinococcus granulosus*, thereby developing hydatidosis. But the example most frequently cited is the case of taeniasis due to *Taenia saginata* which, though prevalent amongst beef-eating people, is nevertheless restricted to those who have acquired the taste for raw or undercooked beef. For example vast areas of southern Nigeria consistently show no taeniasis infection or prevalence rates of less than 1.0 percent, probably because the people there tend to boil their beef thoroughly (even sometimes overcook it) before eating. On the other hand, in parts of east and central Africa where prevalence rates of over 10 percent are commonly encountered, the people are known to indulge in eating chunks of beef roasted briefly over an open fire "charred on the outside and raw on the inside (Ford, 1979). A similar taste for undercooked beef exists among some Europeans and Americans in the "civilized" world who relish the flavour of rare-steak and barbecued meat.

Other kinds of undercooked beef preparation which were originally indigenous to certain parts of the world have become standard fare worldwide, e.g. shashlik in parts of the Soviet Union and shish kebab in the Middle East. Nigeria's equivalent is "suya", a kebab-like beef preparation. Originally developed in the north, it is now widely consumed all over the country. However, the risk of contracting taeniasis from eating suya was confirmed when Dada and Usman (1978) showed in Zaria, that the temperature for its preparation is not high enough to kill the cysticerci (Doda and Usman, 1978). Then there are those who enjoy the taste of semi-cooked meat in manufactured food products like hamburgers and sausages.

There is nothing inherently wrong or dangerous in the acquisition of a taste for under-cooked beef which, as we have seen, is a world-wide phenomenon. All that can be said is that those who live in areas where taeniasis is endemic are vulnerable, and are therefore advised to exercise greater care and discretion in their feeding habits. A more radical approach would be to abstain from eating beef altogether; a tall order admittedly. If beef must be eaten, then at least, it should be well cooked such that the heat reaches the centre so that it is no longer pink. But there are still those who relish the flavour and taste of raw and undercooked meat! For these the only guarantee of safety is an efficient and honest meat inspection service which can be relied upon to condemn, as unfit for human consumption, any carcasses found to be infected with cysticerci. However, most African countries are unable to provide such services for a variety of reasons, not the least of which, are severe financial limitations which make it difficult to set up meat inspection facilities and procedures to cover the whole country. There is also an acute shortage of properly trained personnel, devoted and incorruptible in the performance of their duties. Finally, the bulk of cattle slaughtered privately especially in the rural areas, is never presented for inspection.

A few more interesting tit-bits. People of the muslim and Jewish faith who are prepared to be guided by the tenets of their religions which preach a disdain for pork and pork products, are unlikely to suffer from trichinosis, toxoplasmosis, or taeniasis. The Christians would also be spared if they paid heed to the warning about the dangers of pork eating by Moses: "and the swine is unclean unto you - Ye shall not eat of their flesh ...." (Deuteronomy 14:8). The fatal case of trichinosis reported from Senegal by Gretillat&Vassiliades, (1969) involving nine Europeans, occurred because they indulged themselves by feasting on barbecued warthog, an obvious act of indiscretion in any country with poor standards of meat hygiene. Finally, *Diphyllobothrium latum* infection (with its attendant pernicious anaemia arising from avitaminosis-B) a tapeworm disease which is got by eating raw or undercooked fish is uncommon, if not completely absent in tropical Africa (Ukoli, 1984). But those who have developed the expensive taste for caviar beware! This delicacy, a product of pickled fish eggs imported from the endemic areas of Europe has been known to cause diphyllobothriasis! (Nelson, 1972)

SOCIAL AND ECONOMIC IMPACT OF PARASITIC DISEASES

There is no doubt that the socio-economic status of a community is a significant factor in the epidemiology of these diseases. One of the classic examples often cited is that of hookworm dis-

ease, the prevalence of which is clearly related to socio-economic status, the poorer sections of the community being more liable to infection. Thus, that iron-deficiency anaemia, the hallmark of hookworm disease, is observed to have a higher prevalence among the lower social groups than the more affluent sections of the community, is the result, not only of mal- and under-nutrition but also because, according to Foy &Kondi (1960), "sanitary habits and facilities are worse, and footwear less commonly used…" (Foy and Kondi, 1960) (all of which are indicators of poverty). Similarly the socio-economic realities in rural tropical Africa indicates that schistosomiasis control by preventing, or at least, limiting contact with natural bodies of water through the installation of laundries, swimming pools, modern sewage treatment and disposal system, and provision of pipe-borne water is not going to be feasible in the foreseeable future. Furthermore, the victims of parasitic diseases (like onchocerciasis for example) are normally usually illiterate, poverty-stricken peasants in remote rural areas, aptly described by Rosenfield et al (1981) as "the poor, sometimes unaware poor, possibly a politically unimportant poor..."(Rosenfield, Widstrand, and Ruderman 1981).

However, I am more concerned here with the social and economic consequences of parasitic disease. The impacts of these diseases must be measured and fortunately the Special Programme for Research and Training in Tropical Diseases (TDR) of the WHO has tried to develop research design guidelines for assessing the social and economic consequences of these diseases (see for example reports by Hunter 1976 and Rosenfield et al 1981).Of these, the assessment of the social cost is much more elusive to accomplish. How can we measure, for instance, the psychological and. emotional stress of a young woman who has suffered the agonies of multiple infant mortality caused by malaria? What is the social cost of the disruption of family life by these diseases? How degrading and humiliating it must be for a young villager suffering from elephantiasis, when his enlarged scrotum not only hampers his farming activities, but interferes with his enjoyment of a normal sex life? What a source of embarrassment it becomes, when this provokes laughter from the village belles? What a life of misery for a poor peasant woman who is incapacitated by the loss of one eye and suffers visual impairment in the other, thanks to the ravages of onchocerciasis! Or think of the despair and feeling of inadequacy a family head or chief must bear who, in the prime of life falls a victim of guineaworm or onchocerciasis, and is therefore unable to provide for his family, and becomes socially unproductive because of sickness and premature ageing. Can all these be measured and a price put on them? Consider the emotional trauma, or for that matter, the opportunity cost to a student who misses or performs poorly in JAMB examination, and so fails to secure admission into the College of Medicine in the university of his choice, all because of a bout of malaria at the wrong time. But it does further than the individual level, for as Hunter (1976) declared, "What is the cost to a village in term of lost leadership, energetic guidance, lack of innovation and, in extreme cases, cultural atrophy? Ghost villages of the onchocercal zone and tsetse fly belts bear witness to settlement collapses under the weight of diseases", just as "the ill-kept and listless atmosphere of the village with extensive guineaworm infection" (Selcher *et al* 1975).

It is obvious that any disease which causes death or results in acute illness or chronic disability

must exert an impact on productivity, and hence the national economy. It should therefore be instructive if methods are devised for measuring such parameters as wages lost, work loss, or reduction in work output, reduction in agricultural output, and absenteeism from work or school etc. as a result of the effects of these diseases. Unfortunately, however, results of such studies have been largely unsatisfactory, (Hunter, 1976) and conclusions reached about the seriousness of their effect often equivocal. (Rosenfield, Widstrand, and Ruderman 1981) Hunter attributes this to weakness in the design of the research protocol arising from:

(i) Inadequate assessment of disease intensity, clinical pathology and the physical impairment associated with the disease among the subjects under investigation. Without accurate identification of impairment, correlation analysis of disability and economic impact becomes difficult.

(ii) Inadequate sampling of total infected populations.

(iii) Failure to allow for socio-cultural and other influences on the productivity of labourers, since health is only one factor of labour productivity (Hunter, 1976).

On the whole, there has not been much research into the influence of parasitic diseases on the ecology and behaviour of human populations. For example, the periodic abandonment and desertion of settlements in fertile valleys in the hyperendemiconchocercal zone of attitudinal and behavioural aspects of epidemiology and control of parasitic diseases West Africa, is the result of the escape maneuvers from the scourge of the dreaded river blindness - literally running away from the problem. This forces whole populations to migrate to, and settle in upland water-shed areas, which not only are less productive, but become overpopulated and overcropped as well. Similar trends have been observed in the mobility and settlement of populations in the savannah region of Africa, as they try to avoid the tsetse belt, because of their fear of both bovine and human trypanosomiasis. All these have serious economic implications which are worthy of study.

Obviously, there is an over-riding need to initiate full scale control measures. But, certainly, the implementation of such programmes will be of little value if not integrated into well-conceived plans for settlement, exploitation, and general economic development of the freed areas (WHO/FAO 1979).It has been suggested that the agricultural poverty of this area of West Africa is due to the effect of complex of factors of which, the simulium and tsetse problems represent only a part. The solution of these problems through the control of these disease vectors may therefore not be the key to the prosperity of this already impoverished area (Ormerod, 1978). The impact of parasitic diseases, with particular reference to trypanosomiasis and onchocerciasis on agricultural development in Africa, has been examined by Ford (1979), Jordan (1979), Melville (1975), and Ormerod (1976 &: 1978). From all this, it became obvious that there is great need to integrate simulium and tsetse control programmes into rural development, involving land and water use, and a general policy of socio-economic development of the area. This is the for¬mat adopted in the comprehensive Onchocerciasis Control Programme in the Volta River Basin of West Africa (Anon, 1974, Le Berre et al, 1978).This calls for extensive, research into the various aspects of the interaction between land use and settlement/resettlement and agricultural development, with human and bovine trypanosomiasis, a subject that has been

greatly neglected to date.

POLITICAL AND ADMINISTRATIVE ASPECTS

There can be no doubt that the political set up and the administrative framework of a society, determine to a large extent, the nature of its health delivery system. Thus the ideological orientation and the political awareness of a people, the quality of its leadership, the organizational structure of its government, and the capacity of its administrative machinery to respond to the pressing needs of the people, all of which are expressed through their decision making processes, policy formulation, planning and implementation programmes, all exert a tremendous influence on the spread of parasitic diseases and on the efforts to control or prevent them as well. For example, a government which is capitalist oriented will, in pursuing a policy of evolutionary change, tend to develop a health service which will cater for the needs of the individuals who can afford it. Such a system cannot be expected to respond positively or promptly to the problems of the poorer segments of the society, specifically the problems of parasitic or communicable diseases generally. On the other hand, a socialist-inclined government, being more committed to revolutionary change, will place more emphasis on the welfare of the community as a whole (i.e. "the masses") (see Djukanovic and Mach, 1975 and Newell, 1975). Such an emphasis implies that prevention and control of infectious diseases will automatically receive the top priority that it deserves, since they are the principal causes of morbidity and mortality' in the bulk of the population living in the rural areas. Socialist regimes have a way of mobilizing the people for political awareness, and harnessing the impetus so generated for tackling problems confronting the community. The people are then persuaded to embrace the principle of self-reliance and motivated, not only to participate in, but to actually take a measure of responsibility for dealing with matters affecting their own welfare.

This is in tune with the concept and objectives .of primary health care as enunciated by WHO/UNICEF/i.e. "essential health care made universally accessible to individuals and families in the community by means acceptable to them, through their full participation, and at a cost that the community and country can afford".(WHO, 1978) It is quite clear therefore from this definition, that government pronouncements and actions concerning primary health care delivery has, until very recently, hardly gone beyond the realms of mere rhetoric. The post-civilian regime (1984 to date) must be given credit for introducing the Environmental Sanitation Programme which draws its inspiration from the basic principles of primary health care, and is a first step in the implementation of primary health care programme. In fact the current emphasis which the Federal Ministry of Health places on primary health care is most welcome. It is only to be hoped that this policy will be backed by government (i) with adequate budgetary allocation (ii) fostering imaginative and innovative ideas and appropriate technology for the task in hand and (iii) developing the capacity, according to Dunn, to spread through the community, a contagious sense of commitment by the people to offer their cooperation, encourage community participation and the assumption of some share of the responsibility for the various measures adopted for the control of these diseases (Dunn, 1976a and 1979). The realization of this dream will depend on the emergence of a strong leadership which is sensitive to the needs of the masses

of the people, which will provide a rallying point and moving spirit, and with which the people can identify. It goes without saying that success here is incompatible with political instability, frequent changes of government with the attendant upheavals in policies (such as they are), and functionaries etc., lack of direction and corrupt practices in high places.

A good example to illustrate the way in which government policies and actions affect the epidemiology of parasitic diseases is that of water development projects. We are all aware of the cry of African governments to develop irrigation schemes to bring more land in the savanna and semi-arid regions under cultivation for increased food production, and to construct dams for hydroelectric power as a source of cheap energy and water supply. Laudable as the rationale for embarking on these projects, they have nevertheless been found to create suitable habitats for the breeding and thriving of the vectors of such diseases as schistosomiasis, onchocerciasis, and malaria, resulting in increase in their prevalence and intensity. However, the spread of these diseases can be checked or controlled if adequate precautions are taken during their planning stage, when appropriate safety measures can be built in. Unfortunately, however, the authorities in these countries invariably fail to enforce or insist on these safety measures because of ignorance, or the power of political expediency which pressurizes them to complete the projects in a hurry, or as a concession for the promise of kickbacks.

The dangers to human health in permanently altering the structure of the ecosystem through major engineering construction have been recognized, and failure to build in safety precautions right from the planning stage has given birth to the concept of "careless technology". The term "careless engineering" has also been applied to the engineering practices which created ideal breeding sites for mosquitoes, snails and other vectors of parasitic diseases resulting from the construction of roads, bridges, culverts, airports, and even buildings.

No appreciable progress can be made towards the eradication and control of parasitic diseases without the purposeful action of a government imbued with the political will and commitment to seek the welfare of their people. This commitment must be backed by competent administrative machinery which has initiative and drive. For example, apparent lack of concern about the plight of the people, and indifference to the grave socio-economic effects of onchocerciasis are demonstrated in government lethargy over the reactivation of the National Onchocerciasis Control Programme (NOCP). This body, in 1986, is still trying to find its feet due to a very serious financial constraints, (see the circular letter from the Federal Ministry of Health of 1/2/86 and its attachment) (NOCP, 1986). This is not surprising because, according to Connot (1978) the victims of the disease, being usually illiterate and poverty-stricken peasants in remote rural areas, hardly "make a hue and cry" about their plight, and even if they did, they do not wield sufficient influence to make government and public health officials do something about it (Connor, 1978). But even more disturbing is the fact that the initiatives as well as the financial, material, and manpower resources for implementing most of the control programmes in different countries in Africa are derived from external sources. So also are the strategies for sustaining the backup and follow-up actions. It is as if the leaders, not appreciating, or not caring about the

enormity of problems of such great public health significance, and with such grave consequences on the economic development of their nations, are unable to muster the will to enable them take appropriate positive action.

A case in point is that of the WHO Onchocerciasis Control Programme (OCP) in the Volta River Basin of West Africa, in which four United Nations agencies, WHO, UNDP, FAO, and IBRD are, through a joint effort, assisting the seven West African nations touched by the Volta River Basin to mount an attack on onchocerciasis. This area has been described as one of the most hyperendemic areas for onchocerciasis in the world, where "all the suffering and adverse effects on the economy and livelihood of the communities brought about by the disease, reach their peak" (see Ukoli, 1984). And yet the nations involved namely, Benin, Togo, Ghana, Ivory Coast, Mali, Bourkina Faso and Niger, and indeed all other West African countries similarly afflicted, have been unable, by themselves, to do anything about it.

The OCP whose occupation, objectives, scope and implementation have been described in superlative terms, was estimated to cost US $120 million, (value as at 1974), and was expected to extend over a 20-year period (1974-1993), at the end of which, it will be handed over to the seven countries for follow-up action. Having regard to the high level of sophistication of technology for the operations and surveillance procedures, the speculation in some quarters is whether the seven countries will be able to generate the funds or the resources - human, material and technical - to continue the fight after the 20 years of grace. This notwithstanding, considerable reduction in black flies density and transmission rates has been achieved. On the other hand, Nigeria, which was not included in the OCP, has been unable to go it alone in mounting her own control programmes. In fact, all past attempts in selected places like Kainji and Hawal areas, as well as Oji, Kaduna and Mimi Rivers, and even Abuja area (which is highly endemic) have ended in failure (NOCP, 1986).

The development of fresh insight into the various problems of parasitic diseases which will give the new impetus for the generating of novel and original ideas for control, calls for active research into the various aspects of the problems. But research can achieve very little without substantial financial support. Unfortunately, the major source of research funding, the government, has virtually dried up. In any case, the Federal Ministry of Science and Technology to which one looked for funds, has been hamstrung since its inception, by its failure or inability to formulate a national science policy on which hangs any rational basis for budgetary allocations for research. Olaniyan (1981) (Olaniyan, 1986) has given a most illuminating account of the evolution of a national science policy in Nigeria. One of the direct consequences of this lack of policy, coupled with the depressed state of our economy, is that the two research institutes concerned 'specifically with research into problems of parasitic diseases, namely, the Nigerian Institute of Trypanosomiasis Research Kaduna and the Medical Research Institute Yaba, have been severely starved of funds. As a result, no new ground has been broken for some years. The Malaria Eradication Unit has not been able to report a reduction in transmission of malaria, presumably for the same reasons. It is no use looking up to university researchers because they

too are afflicted by the same ailment, lack of funds to prosecute research programmes.

The only other internal source of support, the Federal Ministry of Health is in the same predicament as the Ministry of Science and Technology - it has been operating without a well articulated national health policy. In fact, if newspaper reports are anything to go by (see back page of *Daily Times* of 8/7/86), "a National Health Plan is to be ready by the end of this year". But what is even more revealing is the indictment, by the Minister of Health, of past governments who "started to build Nigeria's health care system 'upside down' by constructing specialist hospitals first". The Minister was also quoted as saying: "By the year 2000, we would have developed a perfect health care system". Maybe by then there will be adequate provision for the war against parasitic diseases!

The source of support for research in Nigeria is now invariably through some international agencies, notably WHO, UNDP, FAO and World Bank. But even such funds are getting harder to come by. Thus, the prospects of achieving control through research are getting slimmer.

Is the investigation of the relationship between political and administrative factors, and health services going to be a worthwhile research enterprise? In particular, will it be feasible to mount research studies into the impact of decision making, policy formulation, planning, and implementation on the epidemiology and control of parasitic diseases as suggested by Dunn?(Dunn, 1983). If it is, what type of result should we expect, and to what use can they be put? How can these results be integrated into the control programmes? Whatever the answer may be, it is quite evident that if sociomedical research is a relatively new enterprise, then this aspect of it represents a *tabula rasa* as an intellectual exercise in tropical Africa.

TRAINING OF A NEW BREED OF SOCIOMEDICAL WORKERS

In this lecture I have tried to make a case for the study of the human attitudinal and behavioural aspects of epidemiology and control of parasitic diseases in tropical Africa. One difficulty that we shall come up against, is the lack of personnel with the appropriate training to undertake research in the various aspects of the subject. The "intellectual discontinuity" which exists between the behavioural disciplines, and the physical and bio-medical sciences has made it difficult for scientists with competence in both fields to emerge (Dunn, 1979). This social scientists and anthropologists lack knowledge and training in the biomedical disciplines, while conversely, biologists and medical personnel are hardly conversant with the concepts and practices of the social sciences. Similarly, health educators who are engaged in controlling infectious diseases usually place more emphasis on practice than on research, and what is more, they have hardly developed communication links with epidemiologists. The epidemiologists for their part, not being aware of the research needs of health education, have not been too concerned with building these into their work (Dunn, 1979). It is therefore imperative to devise intensive and comprehensive training programmes which will bridge these gaps, and produce a new breed of sociomedical workers with the relevant expertise and competence to carry out the studies identified in this lecture. Anya (1983) has also hinted at curriculum reforms for the

training of medical and health personnel (Anya, 1983).

A long term approach will be for the universities and health institutions to collaborate in designing suitable curricula which are multidisciplinary in nature, which will prepare the graduates for the challenges ahead. A case in point is the production of a new breed of experts known as "social malariologists" advocated by Gillett (1975, 1979). Such people, in addition to good undergraduate training in biological sciences, and postgraduate training in social anthropology, should possess more than a smattering knowledge of agriculture, engineering, economics, geology, public health etc. With these credentials, such a new cadre of health workers will be expected, in collaboration with professional producers, film actors, cameramen, and audiotechnicians etc. to produce the programmes which will influence the people to change their ways in malaria control. The cost of such a programme is bound to be astronomical and, in any case, it is a long term measure.

For the short term, training workshops could be organized dealing specifically with social and economic research methods in relation to tropical diseases. WHO/TDR, in collaboration with other agencies, has sponsored a number of such workshops; notable among which are, the one on human/water contact in schistosomiasis transmission in St. Lucia (1979) (WHO, 1979), another at Enugu in 1983 (WHO, 1983), and yet another at Kisumu, Kenya in 1982 (WHO, 1983). The last workshop had as its main purpose, "the strengthening of social science research skills among African medical and biomedical scientists" (WHO, 1983). Other studies sponsored by WHO/TDR which present details on research objectives, design, and methodology on various aspects of sociomedical science, include the following reports by Hunter (1976), Dunn (1976), and Rosenfield et al (1981).

All these represent a mine of information which will serve as a guide for conceptualizing, designing, conducting, analyzing, and disseminating research on the social science aspects of tropical diseases. They also indicate the priority research activities that could be considered for support by the Social and Economic Scientific Working Group of the TDR. So it can be seen that the impetus for the growth of sociomedical parasitic disease research in the past decade has been provided by WHO/TDR.

The main stimulus for the growth of behavioural research was the urge to satisfy the needs of the mathematical model builders who, right from the pioneering work of Macdonald (1957 &1965) on malaria and schistosomiasis, found themselves handicapped deficiencies or total absence of behavioural data (Dunn, 1983). Modeling, which has become an invaluable tool for assessing the various factors operating in the transmission process, and identifying those that can be manipulated to prevent or ensure cessation of transmission, is also useful for cost/benefit analysis and for deciding on resource allocation. Modelers have made greater progress with two-factor diseases like TS and typhoid than with three-factor diseases like malaria, schistosomiasis, trypanosomiasis and onchocerciasis. This, according to Hunter (1976), is because of the added complexities of intermediate hotx population dynamics, habitat relationships infectivity,

and contact with man (Hunter, 1976). Human behavioural research is therefore important in trying to redress the dearth and deficiencies in information about the human dimensions of the problem, to assist the modelers in their work. To date modelers have tended to concentrate on malaria and schistosomiasis.. It is about time they directed their attention to other mass parasitic infections as well as to the problem of poly-parasitism (Dunn 1983).

CONCLUSION

Professor G.S. Nelson of the London School of Hygiene and Tropical Medicine when asked, at a symposium, on the behavioural aspects of parasite transmission in 1972, to comment on the prospects of controlling schistosomiasis by altering human behaviour patterns, had this to say:

"We are likely to have even less success in preventing children in the tropics from bathing in infectious water or preventing indiscriminate defaecation than the health educationalists in the western world have had in preventing people from committing suicide by smoking" (Nelson, 1972).

One need not be as pessimistic as that, neither should one underestimate the magnitude of the numerous formidable obstacles to be overcome in trying to control parasitic diseases through behavioural intervention. It is too early to assess the impact of sociomedical studies on epidemiology and control ot parasitic diseases for, being a relatively new field, it is yet to provide a research foundation for the planning and execution of projects and programmes of social, cultural, and behavioural change (Dunn, 1983). Certainly, the results of such studies have not been used in isolation in the planning, development, and management of control programmes, nor are they likely to produce any dramatic results if so applied. It is only when they are coordinated with, and integrated into epidemiological research that the maximum benefits can be derived, for in the words of Dunn, "it is only in a trans-disciplinary context that they can be incorporated into the design and operation of control programmes" (Dunn, 1979).

In the last five years or so,I have had the opportunity and privilege, in a series of public lectures, to examine various aspects of the control of parasitic diseases in tropical Africa. The first was the Faculty of Science Lecture at Ibadan in 1981 (Ukoli, 1981) at which I examined the compelling reasons why these diseases must be controlled, the main obstacles in our way, and our capacity to overcome them. The second was at Bendel State University in 1983 (Ukoli, 1983) where I discussed the relevance of research in the control of parasitic diseases, and showed how the contributions of our parasitologists in tropical Africa have been limited by inadequate financial and even moral support. In the third lecture, delivered at the College of Medical Sciences, University of Benin in May 1986, I showed how the main thrust in our parasitological research seems to be to characterize our local conditions, and warned that if we continue to tread this well-worn path, nothing new is likely to come up; no breakthroughs are likely (Ukoli, 1986). Now today, I have been able to complete the quartet by being so highly honoured to address the Academy on this little explored, but very important, subject dealing with the behavioural and attitudinal aspects of parasitic diseases in tropical Africa.

In our effort to reduce the prevalence and severity of these diseases, we must ensure that we leave no stone unturned. It is for this reason that I have tried in these lectures to take stock of our achievements and limitations, and to give an idea of the scope and complexities of the problems still left to be tackled. I have also tried to identify and assess our capacity for providing the wherewithal for attacking them, as well as the prospects of success crowning our efforts. By thus getting our correct bearing, it is my hope that we shall be better able to chart a realistic course of action. It would appear that all I have been able to achieve in this venture is to reveal how every step of the way is dogged by problems, gigantic problems, sometimes seemingly insurmountable problems. I can't help if that is the way it is, for our people say: "If you don't know where you are going, at least you ought to know where you are coming from." There are some people who would have preferred a catalogue of successes and achievements, and no doubt our researchers have some to their credit. But this is an area where achievement is so easy to measure. It is simply a function of the level of prevalence of the diseases, both individually and collectively, a figure which from most accounts seems to be rising in many parts of tropical Africa,

I wish to express my thanks to Professor Fred. L. Dunn of the Department of Epidemioldgy and International Health, University of California, San Francisco for stimulating my interest in this subject and' making copies of his publications and the relevant unpublished documents of WHO/TDR available to me. I wish also to thank Mrs. Lydia Sodeke for excellent secretarial assistance so willingly and cheerfully rendered, almost always, under great pressure.

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MATHEMATICS, SCIENCE, AND CULTURAL CHANGE

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According to Roger Bacon (1214-1294), "Mathematics is the gate and key of the sciences. Neglect of Mathematics works injury to all knowledge, since he who is ignorant of it cannot know the other sciences or things of this world, and what is worse, men who are thus ignorant are unable to perceive their own ignorance and so do not seek a remedy".

Mathematics enables various branches of science draw implications of their observations and experimental findings. A computer is now an inevitable tool in science; its internal working rests on basic mathematics -arithematic to base$_2$

Mathematics is at the heart of our important scientific theories; Newtonian mechanics, Electromagnetic theory of Maxwell, Einstein's theory of relativity, quantum theory of Planck etc. Further, vast areas of mathematics grew out of efforts to find solutions to problems in science. We give two examples. The first one is about geometry, also sometimes referred to as the gift of the Nile. The story goes that in the 14th Century B.C., King Sesotris divided the land among Egyptians, each receiving a rectangle of same area, and was taxed accordingly. If anyone lost some of his land during the annual overflow of the Nile, he had to report the loss. An overseer would then be sent to measure the loss and make an abatement of tax. Some sources claim that this is the origin of geometry. The second example is more recent; it is about topology, whose origin is associated with a problem on a bridge. During the 18th century, in the German town of Konigsberg (now the Russian city of Kaliningrad), people enjoyed strolling along the banks of the Preger river, which meandered through the town, and was crossed by seven bridges which ran trom each bank of the river to two islands in the river, with a bridge joining the islands. One question asked is as follows:
"How can you take a stroll so that you cross each of the seven bridges exactly once?".

Leonhard Eu!er (1707 -1783) converted this problem to one on vertices and networks in a diagram. He made general discoveries about networks, and found that the answer to the Konigsberg bridge problem, is in the negative, namely, that it is impossible to take a stroll so that each of the seven bridges is crossed only once! In the process of obtaining this result, he originated a new kind Of geometry, a geometry which does not depend on the size or shape of the figure, but about places, and how they are connected by arcs. Out of this grew the branch of mathematics called 'Topology".

According to H.E. Wolfe, (Introduction to Non-Euclidean geometry (1945)),"It has been said that no subject when separated from its history, loses more than Mathematics.....".

In this lecture, we shall discuss the evolution of mathematics from ancient limes to about the last century. This is a vast subject, and it is not possible within the hour to give more than a brief sketch of some of the areas. The choice of material gives an edge to areas associated with the explanation of physical phenomena at the time. Because of such inter-relationships between mathematics and science as already indicated, which inter-relationships date back to early times, we consider that our talk should also touch on some of the related science. We also consider it reasonable that our talk includes reference to the society at a time. It is in this spirit that the title, "Mathematics, Science, and Cultural Change" was chosen.

As far as I know, very few ancient civilizations had what may be regarded as rudiments of mathematics. Examples include Egypt and Babylonia, with civilizations dating back to 4,000 B.C. In their records were developed number systems: whole numbers, fractions, a fair amount of arithmetic, solution of some simple problems involving unknown quantities, and very simple rules for finding areas and volumes of geometrical figures. These simple rules were obtained through accumulated experience and inductive reasoning, and not surprising then, some of them were incorrect. For example, the Babylonian rule for calculating the area of a circle of radius r is $3r^2$, while Egyptian rule is $3.16r^2$. They respectively used, 3, 3.16 in place of π. Thus, one serious weakness in Egyptian and Babylonian mathematics is that the conclusions were obtained empirically. There was hardly any conscious thought about abstraction, nor formulation of general methodology and no concept of proof. There was no conception of a theoretical science.

The Babylonians did more arithmetic and algebra, while the Egyptians did more geometry. The Egyptians were great builders, and applied geometry in the building of their temples and pyramids. Also, by observing the motion of the sun, they ascertained that a year contains 365 days. In this connection, the Babylonians, developed a calendar of a year consisting of 12 months of 30 days each, with a 13th month at the end of every sixth year.

Whatever may be regarded as achievements of Egyptians and Babylonians, there was hardly any discernible search for theoretical systematic knowledge. Partly because of this, it is now usually taken that mathematics as an organized and reasoned discipline did not exist before the lime of the classical Greek civilization, about the sixth century till the third century B.C., continuing during The Alexandrian Greek civilization which lasted till about the seventh century A.D. Greek Mathematics developed in several centres that succeeded one another, each building on the work of its predecessors. At each centre, an informal group of scholars carried on its activities under one or more great leaders. An example is the Pythagorean school noted for its study of the properties of numbers. Others noted for Mathematics and methods of deductive logic include those of Socrates, Plato, Aristotle, all these before Euclid went to Alexandria about the 3rd century B.C. and Archimedes,(287 -212 B.C.).

The Greeks believed that truths came from the mind. These truths were either innate and merely recalled, or they were suggested by experience and immediately recognized as self-evident In Mathematics and Science, the Greeks selected some of these truths or obvious facts as starting points: they are referred to as axioms, in the case of Mathematics. By and large, the Greeks, especially of the classical times, were unwilling to observe and experiment. They regarded this means of obtaining knowledge as unnecessary. The belief that truths can be found by exploring

the mind instead of exploring the physical world persisted till modem times.

Having selected their axioms, the Greeks applied the method of deductive reasoning, with these axioms as premises. In this case, given that we accept the premises, then we must accept the conclusion it produces. This method clearly has a serious advantage over reasoning by induction or analogy or obtaining results by trial and error. Also in contrast to observation and experimentation, deduction can be carried out without recourse to equipment - which could be expensive. In some cases, deductive reasoning is the only method available, as for example in the measurement of astronomical distances. The Greeks appreciated the value of persuasive argument to the full, and insisted that all mathematical conclusions must be established only by deductive reasoning. The exclusive use of deduction has served as an important factor which differentiates Mathematics from other fields of knowledge, and has served as a source of strength. According to Hermann Hankel, "In most sciences, one generation tears down what the other has built, and what one established, another undoes. In mathematics alone, each generation builds a new story to the old story". A prominent factor in this assertion is the method of deductive reasoning used in obtaining mathematical results.

In addition to insisting on the deductive method, the Greeks effectively made Mathematics abstract. To the Egyptians for example, a line was no more than either a stretched rope or the edge of a field, and a rectangle was the boundary of a field. In contrast, the Greeks recognized and emphasized that mathematical entities - numbers, geometrical figures - were abstractions, ideas entertained by the mind, and distinguished from physical objects and pictures. In particular, the words point, line, triangle became mental concepts. Since the Greeks reason about general concepts, their conclusion would apply to all objects of which the concepts were representative. Sometimes one would obtain new knowledge relating to the different representatives which experience might not suggest.

(i) The area πr^2 of a circle radius r applies to a circular field, the floor of a circular auditorium, or the cross-section of a circular tree trunk.
(ii) The same equation $v = u$ - at space that governs the motion of a body starting with velocity u and having a constant retardation a, also governs the state v of a bank account in which u is originally lodged, and a is withdrawn at regular intervals.
(iii) The same differential equation describes the motions of light waves and electromagnetic waves. Since both waves travel at the same speed, Maxwell deduced that both waves are in essence identical.

That $\sqrt{2}$ is not a rational number is due to the Pythagoreans. The Greeks refused such numbers into their algebraic system, calling them irrational numbers. In order to think of irrational numbers with exactness, they represented numbers geometrically. This became complicated, and not much progress was made in algebra in general. However, the Greeks made lasting contributions in high arithmetic or the theory of numbers, and in geometry. An important result in the first group is a result of Euclid, still considered an example of elegance in Mathematics today - that there is no greatest prime number. For if n is such a number, and p is the product of all the primes, then the number $p + 1$, which is greater than n, is a prime number since the number 1 is a remainder when $p+1$ is divided by any of the primes. Not only are both the idea and proof easy to understand, but in addition, they are just as important and meaningful today

as in Euclid's time.

According to G.H. Hardy, "If a young person did not appreciate the proof of Euclid's theorem that there is no greatest prime number, then indeed, he was blind to the charms of Mathematics".

The Greeks favoured geometry, and built up a huge structure, most of which Euclid included in his "Elements". Whatever their other contributions in Mathematics, such contributions must rank behind the development of logical procedures, the examination of evidence, the sifting of axioms into ten, and the combination into thirteen books, constituting Euclid's Elements, of 465 theorems based on the ten axioms. The geometry in Euclid's elements - Euclidean geometry is still essentially studied in schools today, and has accordingly exerted enormous influence in succeeding civilizations, not only supplying inspiration for mathematical activity, but moulding generations, in the direction of logical thinking.

The civilization that preceded the Greeks regarded nature as chaotic and mysterious. To them, the happenings in nature were manipulated by the gods, and prayers and magic induce the gods to be kind. From about 600 B.C., we find among Greek intellectuals, a new attitude towards nature: rational, critical, and secular. They saw man's value in terms of his rationality. They thought of man as a rational being living in a rational world operating by precise laws that were waiting to be discovered. They insisted that nature was rationally, and indeed mathematically designed, and that by reasoning, chiefly with the help of Mathematics, the mathematical design of nature could be obtained.

The chief culture centre during the classical Greek period was Athens. When Alexander the Great conquered Greece, Egypt, and the near East, and found Alexandria as his capital, he made deliberate effort to fuse Greek and Near East Cultures. Consequently, the civilization centre at Alexandria, though predominantly Greek, was strongly influenced by Egyptian and Babylonian contributions. The mixture of the theoretical interests of the classical Greeks and the practical outlook of the Babylonians and Egyptians is evident in the Mathematical and Scientific works of the Alexandrian Greeks. The purely geometric investigations continued, and indeed, Euclid lived in Alexandria, though his work reflects the achievements of the classical Greeks. Appolonius and Archimedes pursued their Mathematical and Scientific studies during the Alexandrian period. For practical applications, which usually require quantitative results, the Alexandrians revived the crude arithmetic and algebra of Babylonia and Egypt, and used these empirically derived tools and procedures along with results derived from exact geometrical studies.

One major achievement of the Greeks in the search for a mathematical design of nature is the Ptolemaic theory in astronomy. In this theory, the earth is the centre of the universe, and is stationary. To account for the motion of a planet, the theory goes that the planet moves at a constant speed along a circle whose centre at the same time also moves in a circle at a constant speed round the earth. The radii of the circles and constant speeds as above, were different for different planets, and were chosen to agree with observed positions of the particular planets. Ptolemaic theory was accepted as the true design of the universe and held sway for about 1,500 years. However queries were raised as to the difficulty of fitting the motions of all the planets to a system of two circles. In some cases, a system of three or more circles was used to explain

the motion. In order to make the theory fit the increased amount of data available, the number of circles needed also increased. At some stage, seventy seven circles were used to account for the motion of the sun, moon, and five planets! Nicolans Copernicus (1473-1543) studied these modified versions of the ptolemaic law, and about 1530, he proposed a new system of astronomy, called the heliocentric theory. This theory was considerably improved by J. Kepler (1571-1630). In the heliocentric theory, the sun is fixed. The earth, like any other planet moves in a circle at a constant speed round the sun, and at the same time rotates at a constant speed round its axis. The heliocentric theory permits us to look at the motion of a planet in terms of one circle only - round the sun, in contrast to the ptolemaic theory, however, with the improvement by Kepler, the planets do not move in a circle. Each planet moves in an ellipse, and the sun is at one common focus of each of these elliptical paths. Further, the planets do not move at constant speed. Indeed in Kepler's third law, he established the equation T^2 - KD^3 between the period T of revolution of any planet, and its mean distance D from the sun.

A sharp break with the past, the work of Copernicus and Kepler had far reaching effect on the formation of modem culture. Having got used to the idea of a fixed earth for about 1,500 years in accordance with the ptolemaic theory, difficulties in readjusting thinking in the new theory led to many scientific questions being raised. In addition, there was the weight of religious thought against the new theory. The Christian theology was built on the notion that the universe revolves round man, and that man was God's most important creation, everything in the universe including sun, moon, stars being designed to serve him. It was very convenient for this theology that the earth was regarded as the centre of the universe, further suggesting that heaven was in the heavens, and that hell was in the interior of the earth which occasionally erupted through volcanoes, showing that hell fire really existed. The new theory placed no significance on the earth viz-a-viz the other planets, and consequently there was no special focus on man. Also the arrival of the heliocentric theory was not long after the protestant revolution. At the time, both protestants and catholics had become alarmed by any movement that tended to undermine religious beliefs. Leaders of both faiths then joined to attack the heliocentric theory and its sponsors. When verbal attacks failed to discourage leaning and convictions in favour of the heliocentrc theory, the church applied the power and threat of the inquisition, nevertheless, the theory appealed to more and more people including astronomers and navigators.

Very helpful in the cause of the heliocentric theory at this time were the observations of Galileo, made with the newly invented microscope. He observed four moons rotating round the planet Jupiter. These observations showed that planets, other than the earth, had bodies revolving round them in space. He then claimed that it was equally likely for the earth to be moving and yet having a moon revolving round it. He noticed that there were more than seven moving bodies in the heavens, a number that had been earlier on claimed as sacrosanct on scriptural grounds. Galileo also saw mountains on the moon, and spots on the sun. These observations contradicted the belief that the heavenly bodies, unlike the earth, were perfect bodies. These observations of Galileo, while not proving the heliocentric theory as correct, helped to destroy earlier convictions standing in its way of acceptance. Galileo's support for the heliocentric theory angered the Roman inquisition. In 1616, he was called to Rome. His teaching of the heliocentric theory was roundly condemned by the inquisition, and he had to promise not lo publish anymore on the subject. In 1630, Pope Urban VIII gave him permission to publish, provided that Galileo would make his book mathematical, and not doctrinal. In view of this he published

in 1632, only to be called again in 1633 by the inquisition. Under the threat of torture, he was forced to deny his advocacy of the heliocentric theory. He was forbidden to publish his material, and was virtually under house arrest. His manuscript was however smuggled out to Holland and published in 1638. By the middle of the 17th century, the scientific world had virtually accepted the heliocentric theory.

In Greek society, Mathematicians, Philosophers, Artists were members of the highest social class. This upper class either completely looked down on commercial pursuits and manual work or regarded them as unfortunate necessities. To them, such would reduce time available for intellectual and social activities amongst others. The Greek attitude to work might have had little influence on their culture were it not for the fact that they had a large slave class to whom they could pass the work. Slaves ran the business and the house holds, did unskilled and technical work, managed industries etc.

The slave basis of the classical Greek society encouraged development of the abstract side of Mathematics and science, with a consequent neglect of experimentation and practical application. However, about the 16th -17th century, time had changed from those of the classical Greeks. The introduction of the gunpower, muskets, and canons revolutionized methods of warfare, and gave a new social class of free men an important role. With the compass known in Europe, long range navigations became easier, resulting in more raw materials, belter trade routes, the discovery of America, influx of ideas into Europe etc.

Greek intellectuals believed that basic truths exist in the human mind. The purpose of their study of nature was lo determine the implications of these truths, to satisfy their curiosity and to organize their conclusions in patterns pleasing to the mind. In the 16th - 17th century, the general outlook of society had changed and so the purpose of the study of nature had also changed. The new goal of the study of nature as set out by Galileo (1564-1642) and Descartes (1596 -1650) was not only to understand nature, but also to make nature serve man. Mathematicians and scientists then sought facts not only from the mind as in the past, but also from engineers, technicians, etc. A new method for the pursuit of the truth of nature was gradually evolved: Experience and experiment were lo supply basic mathematical principles, and mathematics was to be applied lo these principles lo deduce new truths, just as new truths were derived from the axioms of geometry.

According to Galileo,
"Philosophy (nature) is written in the great book which ever lies before our eyes -I mean the universe - but we cannot understand it if we do not first learn the language and symbols in which it is written. The book is written in the mathematical language, and the symbols are triangles, circles, and other geometrical figures, without whose help it is impossible lo comprehend a single word of it, and without which one wonders in vain through the labyrinth".

According lo Descartes,
"Neither admits nor hopes for any principles in Physics other than those which are in geometry or in abstract Mathematics, because all phenomena of nature are explained and some demonstrations given".

Descartes insisted that the most fundamental and reliable properties of matter are shape, extension and motion in space and time. Since according to him, shape is just extension, he asserted. "Give me extension and motion and I shall construct the universe". These two seventeenth century philosophers, Galileo and Descartes revolutionized the very nature of scientific enquiry, altering the methodology of science. Because science was being asked to use quantitative axioms and mathematical deductions, the mathematical activities that were directly inspired by science became dominant.

One might for example, determine by some geometrical argument what type of curve a projectile from a canon follows, but geometry could not possibly answer such questions as how high or how far the projectile would go. The search for new methods in Mathematics that would be more efficient in giving numerical results led to intense focus on arithmetic and algebra. Descartes and Fermat established a system called coordinate geometry, whereby points of a curve are associated with certain ordered pairs of numbers called coordinates; an algebraic relation between these coordinates is called the equation of the curve. By specifying that a curve is any locus that has an algebraic equation, Descartes and Fermat provided an algebraic tool for studying the physical world, since through it, we now have a representation of geometrical figures by algebraic equations, and studies of these algebraic equations yield properties of the curve. In addition, algebra supplies quantitative knowledge. In the example just mentioned of a projectile from a canon, suppose we are given that the initial speed of firing is U in a direction making ∞[9] with the horizontal. By applying physical laws, one obtains the horizontal and vertical distances (x(t), y(t) travelled after time t as follows

$$x(t) = (U \cos \infty)\, t,$$

$$y(t) = (u \sin \infty)t - \tfrac{1}{2}gt^2$$

At this time, the relative horizontal and vertical speeds are $U \cos\infty$, and $U \sin\infty - gt$. At the highest point, the relative vertical speed is zero, yielding $t = \frac{u}{g}\sin\infty$, and

$$y(t) \; u\frac{U^2}{g}\sin^2\infty - \frac{1}{2} g \frac{U^2}{g^2}\sin^2\infty = \frac{1}{2}\frac{U^2}{g}\sin^2\infty$$

However, at the furthest point, $y(t) = (u \sin\infty)\, t - \frac{1}{2} gt^2 = 0$

yielding $t = 2\frac{U \sin\infty}{g}$, and $x(t) = 2\frac{U^2}{g}\sin\infty\cos\infty$

Finally, from the expressions above, for x(t), y(t) at time t, we get the equation.

$$y = (\tan\infty)\, x - \frac{g}{2U^2\cos^2\infty}\, x^2$$

of the curve on which the projectile moves,

While seeking fundamental quantitative physical principles for description of physical phenomena, Galileo introduced the all important concept of a function. After this had been done, the next two centuries witnessed considerable mathematical activity in constructing examples of functions, and studying their properties. Most of these examples were tied to physical situations, and both the functions and physical situations were studied together. Newton (1642 -1727) considered the area z under the curve as given by a function $z = a x^m$, where m is an integer or a fraction. He considered an infinitesimal increase ∂x in x, so that if y is the ordinate corresponding to the abcsissa x, then the new area is given by

$$z + y\,\partial x = a(x + \partial x)^m$$

He then applied the binomial theorem to the right hand side. On subtracting $z = ax^m$, dividing through by ∂x, and neglecting terms that still contain dx, he obtained

$$y = max^{m1}$$

In this process, Newton not only gave a general method for finding the instantaneous rate of change of one variable with respect to another, but also showed that the area can be obtained by reversing the process of finding a rate of change.

Eudoxus (408 - 355 B.C.) a member of the Platonian School of Classical Greece, had originated what eventually came to be known as integral calculus, through the Method of Exhaustion for computing areas bounded, not by polygons, but by more general curves. We inscribe in the domain, an approximating domain with a polygonal boundary, and thus an easily calculated area. By choosing another polygonal domain which includes the former, we obtain a better approximation to the given domain. Proceeding in this way, we gradually "exhaust" the whole area, and we obtain the area as the "limit" of the areas of a properly chosen sequence of inscribed polygonal domains with an increasing number of sides. This comes to treating the area as the Limit of sums. Eudoxus and Archimedes applied this method to special areas (circle, parabolas etc.). During the 17th century, many more cases were successfully treated. In each case, the actual calculation of the area was made to depend on an ingenious device specifically suited to the particular problem. One of the main achievements of the calculus was to replace these special and restricted procedures by a general and powerful one.

Combining the work of Newton as above, and the Eudoxus method of exhaustion, yielded the fundamental theorem of the calculus, which seeks to relate the process of integration as that of finding limits of sums, to a process of integration as one opposite to differentiation. Thus, the basic concepts of the calculus - the derivative and integral were introduced and their relationship established. Leibnitz (1646 - 1716) also independently obtained similar results about the same time as Newton, leading to controversy as to priority, and then polarisation between British and continental Mathematicians. Both Newton and Leibnitz must be credited with seeing the calculus as a new and general method, applicable to many kinds of functions. After their work, the Calculus was no longer an appendage or extension of geometry. By building on algebraic methods, they not only had a more effective tool than geometry, but it also permitted many geometric and physical problems to be treated by the technique. In obtaining the Funda-

mental Theorem of the calculus, they reduced the problems of instantaneous velocity, tangents, maxima, minima, and summation to differentiation and its inverse process - integration.

The immediate association of the calculus with geometry (tangents, lengths of curves), Mechanics (motion) etc., enabled the subject grow naturally in several directions in the 18th century leading to the subsequent opening up of such specialized areas as ordinary and partial differential equations, infinite series, calculus of variations, differential geometry etc., and the domain referred to as "Mathematical Analysis" was built up.

An assessment of the extent of contributions of Newton to Mathematics, may be summed up by a remark of his arch rival in the calculus controversy, Leibnitz, "Taking Mathematics from the beginning of the world to the time of Newton, what he has done is much the better half".

Inspite of all the growth in mathematics, the work of Newton and Leibnitz was heavily criticized at the time, from the angle of logical rigour. While their new invention, the calculus, led to correct results, their proofs and procedures were criticized as unsound and lacking in rigour. For example, neither Newton nor Leibnitz in the tradition of the Greeks rigorously defined his fundamental concepts of the calculus - the derivative and the integral. The concept of a function had to be put on a firm basis. Before the calculus, there were five common algebraic processes: addition, subtraction, multiplication, division, and extraction of roots. The work of Newton and Leibnitz in the calculus - obtaining areas, volumes, length of curves etc. involved a new algebraic process - the limit process for which algebraic tools had not been developed to put the subject on a firm logical basis. Rigorous axiomatic constructions gave way to induction from particular examples, intuitive insights, loose geometrical evidence, and physical arguments. Apparently, the mathematicians were abandoning the hallmark of their subject - deductive proof. The truth is that most of the mathematicians of the time were basically scientists concerned with major and pressing problems of science, and the mathematics they employed handled those scientific problems. However, the need to develop a strong foundation for the calculus was soon felt, Bolzano (1781-1848) and Cauchy (1789-1857) initiated a move in this direction. The concepts of a function, and limit of a function were defined. A real valued function f of a real variable x is a rule which associates a real number f(x) with each real number x. A real valued function f of a real variable x is said to tend to a limit 1 as x tends to x° if, corresponding to any positive real number t, there can be found a positive number ∂ such that whenever o < 1x - xol < ∂, we necessarily have that I f(x) - LI < t. If in this situation, f(x°) exists and is L, then the function F is said to be continuous at x°. The derivative of a function f at x (if it exists (here) is defined to be the limit of $\frac{f(x)\ f(x^0)}{x-x^\circ}$ as x (ends to x°.

The Riemann (1826-1866) integral may also be defined to be limit of sums of terms - which terms are essentially algebraic expressions for small areas in the Eudoxus Method of Exhaustion.

Earlier on, a continuous function was usually taken as one whose graph could be drawn without lifting pencil from paper. And a differentiable function was looked on as one for which tangents could be drawn to the graph. These earlier conceptions of continuous functions, differentiable functions, and integrable functions, depending as they were on areas, tangents to curves etc., rested on geometrical intuition, in contrast to the modern one depending on algebraic repre-

sentation through the notion of a limit. Geometrical intuition suggested, for example, that a continuous function is differentiable and integration appeared limited to continuous functions. However, Weierstrass (1815 -1897) gave an example of a function, continuous everywhere, but nowhere differentiable;

$$f(x) \quad - \quad \sum_{n=o}^{\infty} b'' \ \text{Cos}\ (a''\pi x).$$

where a is an odd integer, and b is a positive real number such that $ab > 1 + \frac{3\pi}{2}$

Riemann gave an example of a function which is discontinuous an infinite number of times in every interval but which has an integral that is continuous. Moreover this integral is not differentiable in an infinite number of points in any interval. This function is given by

$$g(x) = \frac{h(x)}{1} + \frac{h(x)}{4} + \frac{h(x)}{9} + \ldots\ldots\ldots\ldots$$

where h(x) denotes the difference between x and the nearest integer except that h (x) is zero if x is halfway between two integers. The discovery of these weird functions violating laws which had been deemed perfect, were in some quarters looked on as signs of anarchy and chaos which mocked the order and harmony that previous generations had sought . According to Charles Hermite, "I turn away with fright and horror from this lamentable evil of functions which do not have derivatives".

The reaction of Henri Poincare to these functions is similarly summed up by his observations as follows, "Logic sometimes makes monsters. For half a century, we have seen a mass of bizarre functions which appear to be forced to resemble as little as possible honest functions which serve some purpose. More of continuity, or less of continuity, more of derivatives, and so forth. Indeed, from the point of view of logic, these strange functions are the most general; on the other hand those which one meets without searching for them and which follow simple laws appear as a particular case which does not amount to more than a small corner. In former times when one invents them purposely to show up defects in the reasoning of our fathers and one will deduce from them only that".

Inspite of all these feelings of surprise and reservation, the discovery of these pathological properties of certain functions: that continuous functions need not have derivatives, that discontinuous functions can be integrated etc., made Mathematicians realise that the study of functions extends beyond those used in the calculus and the usual branches of analysts where the requirement of differentiability usually restricts the clan of functions. The work of Bolzano, Cauchy, Weierstrass and others freed the calculus and its extension from all dependence upon geometrical notions, and intuitive understanding. Usually referred to as the "arithmetization of analysis", this development was one of the profound mathematical events of the last century. Important bye-products of these efforts include the establishment of a logical basis for the real number system and the development of the theory of infinite sets, a subject arousing much controversy since Greek times.

In the preface to his Principia, Newton says, "Since the ancients (as we are told by Pappus) esteemed the science of mechanics of greatest importance in the investigation of natural things, and the moderns, rejecting substantial forms and occult qualities, have endeavoured to subject the phenomena of nature to the laws of mathematics, I believe this treatise cultivated mathematics as far as it relates to philosophy (science), and therefore I offer this work as the mathematical principles of philosophy, for the whole burden in philosophy seems to consist in this - from the phenomenon of motions to investigate the forces of nature, and then from these forces to demonstrate the other phenomena.....". This summarises Newton's views of the function of science.

The extent of his contributions in seeking a description of nature may be summed up by the following well-known saying, "Nature and nature's laws lay hid in the night God said, "Let Newton be", and all was light". In Newtonian mechanics for example, Newton showed that the law of gravitation, together with the two laws of motion give a constant acceleration for bodies falling near the surface of the earth, as well as a description of planetry motion in consonance with the heliocentric theory, and that, in addition, Kepler's laws of motion follow mathematically from them. In particular both terrestrial and planetary motion follow from one set of physical laws: the laws of gravitation, and the two laws of motion. By applying these, man can now create satellites which circle the earth. Newton got due recognition from his country. He was honoured with a Knighthood. And when he died, he was buried in Westminster Abbey with such pomp and Voltaire, who attended the funeral, said later, "I have seen a Professor of Mathematics, only because he was great in his vocation, buried, like a king who had done good to his subjects". The progress made in the 17th - 18th century led to more vigorous pursuits of science in the last century. One major scientific development then, which also stimulated mathematical activity was the study of electricity and magnetism. Physical principles were expressed mathematically, and mathematical techniques were applied to get new information, as Galileo and Newton did in their study of motion.

As mentioned earlier, the last century saw the "arithmetization of analysis". The last century also saw amongst others, the rise of abstract algebra. In particular, W. Hamilton, created a new algebra, by discarding the commutative postulate for multiplication. The introduction of the non-commutative quaternions was in itself significant, but perhaps its larger significance lay in the consequent discovery of the tremendous freedom that mathematics enjoys to build algebras that need not satisfy the restrictions imposed by the so called "fundamental laws". In this direction, amongst the mathematical developments of the last century, perhaps the most profound in intellectual significance was the creation of non-Euclidean geometry.

Euclidean geometry had ten axioms. Lets state five of them as in Euclid's Elements.

1. A straight line can be drawn from any point to any point.
2. A finite straight line can be produced continuously in a straight line.
3. A circle can be drawn with any centre and radius.
4. All right angles are equal.
5. If a straight line falling on two straight lines makes the interior angles on the same side together less than two right angles, then the two straight lines, if produced indefinitely meet on that side on which the angles are together less than two right angles. It was noted early that this

fifth axiom lacks the simplicity of the first four. Further its converse is proved in the "Elements". It was therefore felt that the fifth axiom should not be an axiom, but should be derivable from the other nine axioms.

The fifth axiom is equivalent to the following:
Through a given point not on a given line, there is at most one line parallel to the given line.
The fifth axiom is therefore referred to as the parallel axiom. Effort dating back to Greek times to reduce the number of axioms from ten to nine, by removing the parallel axiom failed, and in the last century, Gauss (1779 -1855), Bolyai (1802 -1860), and Labochesky (1793-1856) independently replaced the parallel axiom by the assumption that more than one parallel line to a given line can be drawn to pass through a given point. They went on to develop a geometry - naturally referred to as a non-Euclidean geometry, a geometry unrelated to the every day world of field, plans, boundaries etc. from which the original geometry started in ancient Egypt, but a geometry which nevertheless forms some picture of the world. In this geometry, the results of Euclid which are independent of the parallel axiom are still true. Moreover, in the new geometry for example the sum of the angles of a triangle is less than 180°, this sum varies with the area of the triangle in such a way that the smaller the area, the nearer is the sum of angles to 180°.

Riemann instead, replaced the parallel axiom by proposing that any two straight lines in a plane meet He also changed axiom-2 above of Euclid. Riemann then constructed a geometry, in which all straight lines have the same length, the sum of the angles of a triangle exceeds 180°, decreasing to 180° as the area of »triangle decreases to zero. The non-Euclidean geometry of Riemann applies directly to the surface of a sphere, provided that a "straight line" is interpreted to mean a "great circle on the sphere". That there can be geometries other than Euclid's was in itself a remarkable discovery, and like the heliocentric theory, it had tremendous effect on the history of thought. The question that followed their discovery was whether these new geometries are of use in physical interpretations. In the theory of Relativity, Albert Einstein in this century employed a non-Euclidean geometry,'his predictions had wider areas of validity than in the older theory of Newtonian mechanics based on Euclidean geometry. Also, the non-Euclidean geometry of Riemann supplies answers to practical and scientific problems involving geometrical relationships on the surface of a sphere, and hence it is a geometry of the physical world, the earth being regarded as spherical. Mathematicians and scientists had sought to understand the physical world by adopting axioms which seem to fit it, and then deduce theorems from these axioms. It is now clear that unlike the insistence by Descartes in his philosophy of science, there is no reason to identify the mathematical construction with physical space, since several different mathematical theories may fit equally well. This mathematical theory of space is like other scientific theories, the one used is that which fits best at the time.

The original concepts of Mathematics, for example, straight lines (the natural numbers: 1,2,3,..... were immediate idealizations of, or abstractions from experience. The negative numbers, the irrational numbers are not, but they eventually gained acceptance. By the 17th -18th century, more of these concepts that have no immediate counterpart in the real world gained acceptance, forcing the recognition that mathematics is afterall a human, somewhat arbitrary, creation. With the creation of the non-commutative quarternions, and non-Euclidean geometry last century, the view that Mathematics can introduce and deal with rather arbitrary concepts was strengthened. Thus, the view point emerged that the subject matter of mathematics is

afterall not the study of numbers or space or elaborations thereon, but simply the determination of consequences of systems of axioms.

There have, of course, been valuable contributions to the development of mathematics not mentioned so far. For example, the Indians (Hindus) conceived of the number zero, negative numbers, the decimal numeral systems etc. There are contributions from Arabs and Chinese. Indeed, whereas it is true that during the ancient tones and middle ages, the Greeks, and then die Arabs stood head and shoulder above others, in the modem period no national group remained the leader for any prolonged period. And the centre of mathematical activity shifted repeatedly from Germany to Italy to France to Holland to England etc. Modem mathematical activity seems now to be primarily inspired by European thought, and by men who studied in Europe and America and helped build up centres in their own countries. We seem to fall into this latter category .'As at now, do we have enough to show? If not, why not and in this case, what is the way ahead like? Perhaps a glimpse at the history of the development of mathematics could be useful, together with knowledge of paths taken by others who were similarly placed in the recent past, as well as the capacity and the will to meet wishes with effort.

SPACE TECHNOLOGY AS BINOCULARS FOR LIFE ON EARTH IN THE 21ST CENTURY

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INTRODUCTION

Man's romance with Space remains one of the wonders of all ages. In material terms, it has inspired quantum leaps in the technology of flight and transportation; on the metaphysical or spiritual plane our imagery of heaven and hell are both conjured and inspired by space and the myriad balls of fire and dark holes that define and decorate its spacescape. Biblical account of the divine act of creation merely confirms its pre-eminence in man's thoughts when it says:

> *"And God said, Let there be light in the firmament of the heaven to divide the day from the night: and let them be for signs, and for seasons, and for days, and years;*
>
> *And let them be for lights in the firmament of the heaven to give light upon the earth: and it was so.*
>
> *And God made two great lights; the greater light to rule the day; and the lesser light to rule the night: he made the stars also.*
>
> *And God set them in the firmament of the heaven to give light upon the earth,*
>
> *And to rule over the day and over the night, and to divide the light from the darkness: and God saw that it was good".*
> (Genesis 1:14-18)

For it was against the forboding vastness of space and the warmth, and mystery of the beckoning stars that man discovered both his identity and consciousness. Homo Sapien's early confrontation with nature must, most probably, have been so traumatic and intimidating as to make him seek refuge in the caves to contemplate his frailty and helplessness and in the process

fashion out a survival kit. Such a survival kit evolved over just a few millions of years to transform him, not only into a master of his planet, but also in recent times, into a space adventurer. His survival kit was built around two central themes viz:-

(a) the need to know himself and everything about anything around him .

(b) the use of what he knows to improve and manage his present condition of life on the one hand and predict and plan for the future on the other.

After all, physical and scientific or metaphysical explorations and discoveries are predicated in the need to know, whereas innovation and technology merely reflect the ends and use to which man has put what he knows.

Within the context of man's intellectual evolution, the 20th century would stand out as an epoch of startling discoveries and stunning feats for it was during this century that man looked deep into the atom and reached out into space. By unlocking certain secrets of nature, man has unleashed the possibilities of new technologies in such areas as: bio-engineering and medicine, energy production, space technology, cybernetics and information technology.

For a start, he took a trip to the moon to see things for himself as it were; he also established manned observation posts in space and sent both probing and landing spacecrafts to sister planets like Mars and Jupiter. It was only natural that, intoxicated by such success, man dared to think that he could go wherever he wishes in space provided he could harness the energy required for such an undertaking. Also, having unraveled the chemistry of life, he is beginning to enjoy the luxury of thinking that, should he be displeased with the way God has created him, he now has the option and ability to remake himself as he wishes.

Although science made a lot of fundamental progress in the 20th century, the world was not ruled by scientists neither did they have much say as to what use. their results were put in the conduct of human affairs.

In this respect, the 20th century was not different from its predecessors as the dominant issue remained the contest and conflict for access to and use, of the world's resources and surplus. This was the origin of warfare. In such conflicts, each society deploys all its technical and human resources to achieve its objectives and it is not unexpected that any advances in science and technology (S & T) would be enlisted in such an effort, after all the military engineer was the predecessor of his civilian/municipal counterpart.

What was unusual about the 20th century however was that the advances in S & T were so rapidly deployed and with such startling success as to radically transform the nature and character of warfare.

Prior to the 17th century, religious wars were held in reverence, in the hierarchy of warfare, because of their scope, intensity, and the widespread devastation that accompanied them. Fol-

lowing their era, wars were mostly fought over specific interests of individual sovereigns and were therefore limited in both scope and objectives. This was to change with the French Revolution which broadened the objectives of warfare to the ideals of the revolution and made its scope total as it involved the mobilization of entire populations. There were two such major coalition wars in this century. The first world war (1914 - 1918) resulted in the loss of some 8.5 million lives but by the second world war (1939 - 1945) the casualty rose to a staggering figure of an estimated 40 to 50 million casualties.

With the evolution of nuclear weapons of mass destruction, war could no longer be regarded as an ordinary instrument of foreign policy and diplomacy as it now came with dire consequences for the survival of mankind.

In fact starting from the late 30's the world could be said to be mostly preoccupied with the business of war. This was to hold sway for the next 50 years. The era began with the Second World War but this was followed by a long drawn ideological battle between capitalism and socialism. Thus, for the next four decades, the main political project was the resolution of the ideological conflict and the primary item on the economic agenda was no other than the preparation for war; this was the major assignment of not just armies but entire economies. Under such a geo-political climate, defence drove the entire world economy and reconversion to civilian economy was soon to become a major problem of global concern.

Driven by such ideological differences, the world, by the middle of the century, was officially in a permanent state of war; the only difference was that hostilities were covert, not overt i.e. cold, not active, war.

Having realized the use to which scientists and their work could be put during the two world wars, governments made deliberate efforts to court and enlist their services in the national war efforts. In this regard, research funding was used as an effective tool for targeting strategic areas into which scientific effort and development would be focused. Thus, application of scientific results was progressively channeled into those areas that would support national interests of the leading economies in support and propagation of their ideological maxims.

It was within such an ideological conflict that the door to space was unhinged and the Yuri Gagarin's maiden flight into space was interpreted by politicians more as a challenge for ideological dominance than as a scientific breakthrough. In the context of such circumstances, space was projected as a new theatre of ideological warfare.

2. THE PUSH FOR SPACE

Whilst the cold war might have been an essential catalyst for the space race, three other factors influenced and promoted man's drive into the firmament viz:

- the spirit of exploration
- the search for knowledge/science

- the promise of commerce

All these factors were subsumed within the geopolitics of the period. With lime it became clear that Sputnik was merely an expression of man's spirit of adventure and exploration. This was soon to be followed by series of manned and unmanned trips to the Moon, and well as nearly to planets such as Mars and Jupiter. The recent successful landing of Pathfinder on Mars on July 4, 1996 has shown that the question is not whether but when will man extend his physical exploration of the Moon to Mars.

Another aspect of man's exploration of space has been to find out whether he could make his abode in the firmament and, if that is possible, to what extent can he make his living by exploring the resources of those planets to augment those on earth that are fast depleting.

With the breathtaking developments in wireless telecommunications, point to point microwave energy transmission, information technology, and materials science, to mention a few, came the progressive and irreversible qualification of space as a theatre of highly profitable commercial activity. It is also becoming increasingly apparent that the scramble for national presence in space is gathering momentum, but like the scramble for Africa, and indeed before that Asia, has shown, such moves are hinged on a credible force projection by the nations involved. For example, we know that since 1957, a total of over 22,000 satellites have been launched into space and as of today, over 7,000 of them are still in orbit. Following Yuri Gagarin's 90 minute epic (night of 12th April 1961), some other 700 men and women have escaped gravity and lived in space for periods varying from mere minutes to over 436 days' (Vallerani, 1997). In fact, cosmonauts and astronauts have altogether accumulated some 20,000 days orbiting over our planet.

In the US, several private companies have unveiled plans to launch constellations of satellites over the next few years (Spacerews, 1997). Boeing of Seattle, for example, plans to launch 16 MEO satellites to offer navigational information to commercial airplanes while Globalstar LP of San Jose, California, plans on launching 64 LEO and 4 GEO satellites for voice, data, and fax communications. Iridium LLC of Washington wants a 96 satellite-constellation to supplement the current 66 Iridium constellation.

At least some 30 other US companies have either announced their intent or are considering proposals to fly constellations of satellites. The rush is so much that the FCC is complaining of being overflooded with licence requests. Within the African region we have two entrants in the space race. South Africa (Sweeting, 1997) has two microsatellites Sunsat (Vallerani 1997, Space news 1997) whilst Israel also flies a mini satellite for military reconnaissance purposes. Egypt, in the meantime, now runs a fully automatic laser tracking station at Helwan near Cairo which is the first of its type in Africa and, with technical assistance from Czech Technical University (CTU), can now track satellites like Lageos-2, Ajisai, Etalm, Topex and ERS-2 to an accuracy of 10-25mm RMS. In nearby Cote de Voire, on the West African Coast, a Rascom-1 satellite

is being proposed to be launched in 2001 as a regional African satellite communications and broadcasting service for some 1.2 billion US Dollars (ISIR, 1997).

Another way to look at this is to estimate what proportion of worldwide revenue is currently allocated to the space industry and what are the projections for the near future.

TABLE 1: PROJECTED GROWTH OF THE WORLD-WIDE SPACEINDUSTRY

1996 Worldwide Revenues	$76.9 billion
Anticipated Growth thru year 2000 (57%)	$120 billion
Employment by year 2000	840,000

Source: Compiled **from the US** (1997/98); European (1997); and Russian **Space Industry** (1996/97) Space Directories; Space Publications; **Reston; 1997.**

From the work of Einstein and others, man has found that the basic elements of life emanate and are circumscribed by the interplay of four basic forces viz: weak short range nuclear forces, strong short range nuclear forces, electromagnetism, and gravity and, whilst he has learnt to exploit the first three here on earth, he has come to realise that by using space as his platform, he might be able to exploit his release from the earth's gravity to evolve new commercial products and processes that would enhance the quality of life here on earth. New materials, new alloys, new drugs, and enzymes; new proteins and other substances are destined to evolve under such a microgravity environment (10^{-3} to 10^{-4} g).

Furthermore, using the vantage platform of space, he has also realised that many of the activities carried out on earth can be viewed from a clearer and better perspective and consequently tackled from a more holistic framework. This gave birth to earth observation satellites for monitoring its weather, animal, vegetable, and mineral resources. The Russian space Station MIR has helped to answer some of the questions in this area and we now talk of an International Space Station (ISS) that is supposed to be progressively assembled in space starting from 1999.

These achievements have progressively pushed the development of space science into public consciousness and to such an extent that distinct areas of application have emerged to radically change our way of life. Such technologies include:

(a) Remote sensing: These are earth observation satellites that have many applications varying from military to civilian such as reconnaissance, agriculture, disaster management, pollution, etc.;

(b) Solar energy power generation;

(c) Satellite communication;

(d) Meteorological satellite applications;

(e) Space and atmospheric sciences (such studies are important since space craft operate in space and have to move through space and the atmosphere as well as receive and transmit electromagnetic radiation signals, through these media).

3. A NEW WORLD ORDER

Given the demise of the cold war what future can we expect in the next century? If we are to believe what the scientists promise us, strange things are expected to happen in the next century. The world is destined to be a completely different place within the next thirty to fifty years. For very soon physicists expect to know more about the origin of the universe; what dark matter occupies the interstellar space and make up the COSMOS.

In the coming times, people should be able to work less, shop at home, work freely for clients in several continents whilst retaining their freedom as to where they live and operate from. Many commercial and service organizations will be virtual companies existing only in what we now know as the global electronic super highway. For those wishing to travel a lot, short interplanetary holiday trips will be possible to the moon and if you have the time, perhaps to mars. There will be little fear of getting lost in the vastness of space because existing Global Positioning Systems (GPS) are capable of being developed to take care of such eventualities. A lot of these feats will be made possible by the new developments in space technology.

That is not all; our health should be much better. Parents should be able to prepare and lodge specifications with their doctors for the type of offspring they desire and with the announcement, late in 1997, by a British scientist that they might have isolated the intelligence gene, the day is not far when almost every child can be a genius!

4 MESSAGE OF TODAY'S GEOPOLITICS

If indeed geopolitics is the driving engine of our world view and our development projections what then are the lessons from the present scenario? As stated elsewhere (National War College, 1998), the message of today's geopolitics can be summarised as follows:

(a) The balance of power doctrine of the cold war era was an ill wind that did no one any good; at best it was a burden to the strong and lured the weak into a false sense of insur-

ance or security.

(b) There is now an emerging paradigm shift from an East-West to a North-South dichotomy. This:-

i promises an era of bliss and dominance for the strong

ii earmarks technology to be the metaphor for the era and R & D shall remain the primary dialectics

iii space to be the amphitheatre as:

- it provides strong linkage and symbiosis between the defence and civilian economies and promises a less disruptive and painful process of conversion from a defence to a peace economy;
- assures the super-powers a position of relative advantage

iv The strategy for developing and sustaining space technology shall mainly be one of col laboration:

- between a government and its private sector
- between governments on bilateral basis
- between government agencies on regional basis
- through the International Space Station (ISS) based on global participation

(c) The U.S. has emerged as the undisputed main actor in the new order and whilst its main political objective appears to be the enthronement of the doctrine of western de mocracy it also includes preservation of the western domination in world order.

The so cio-economic game plan calls for the entrenchment of laissez-faire entrepreneurship and western value system within the context of a global division of labour.

The main actor's strategy for achieving these objectives includes securing authority through:

- forging American hegemony and nursing northern alliances such as in G7 group etc;
- control of multilateral organisations such as the UN, IBRD, World Bank, ITU and similar agencies
- maintenance of technological and military superiority

The main-actor is prepared to enforce compliance by deviants through:

- economic sanctions
- socio-political isolation
- direct group intervention

(d) The challenges for the weaker nations include:

i the ability to craft more flexible, imaginative, and resourceful development and technology procurement policies.

ii the pursuit of self-reliance at an enhanced threshold than was possible under bi-polar ideological geopolitics.

iii the fashioning of regional economic and security arrangements based on the joint effort of the regional actors.

5. CHARACTERISTICS OF SPACE TECHNOLOGY

The question then is what are the characteristics of space technology that make it a suitable binoculars through which we can preview and project terrestrial activities and life style for the next few decades? Some of the more salient characteristics of space technology include the following:

- it is highly capital intensive
- it is global in reach and perspective. More than any technology, space technology hardly recognises geographical or political boundary. It is therefore hard to control or manipu late for exclusive use. In fact, its scale of operation is so large as to, for the meantime, intimidate man and overwhelm/contain his greed and acquisitive instinct.
- it cannot stand on its own; instead, it is tied to major infrastructure such as communications, informatics, robotics etc. the dual nature of [he technology and the industrial infrastructure that support it is a major asset.

- in particular space technology:
  – has both military and civilian applications

  – lends itself to easy conversion from military to civilian technology and applications; same applies to the industrial infrastructure that supports it

  – is dramatic in speed and scale of penetration/ proliferation. Evidence of such effects abound in the fields of communications, information gathering, environmental monitoring, and resource development

  –facilitates transparency and can therefore serve as cornerstone for promotion of international peace, security, and stability on the political, military, economic and environmental fronts.

- must remain rugged under fatigue in very harsh environmental conditions. For example although the ambient temperature in outer space is around - 270°C the surface temperature of a space module goes from a high temperature of 135oC while the sun is illuminating the surface to an extremely cold temperature of - 90°C when it is in shadow, all within a time frame of under an hour.

6. UNRESOLVED PROBLEM AREAS

This is not to say that all is rosy with space technology or that it is destined to be the panacea of

man's problems in the near future; in fact, with increasing use and better understanding of the requirements of the technology, areas of unresolved problems are multiplying with time. Some of such basic problems include:

(a) Definition of outer space and its delimitation from air space.
(b) . Equitable use of geostationary orbits (GEO).
(c) Use of nuclear powered satellites.
(d) International direct television broadcasting.
(c) Remote sensing.
(f) Military use of outer space.

Nonetheless it is customary these days to discuss space technology activities in the context of three segments and a supporting infrastructural system viz:

* Space Segment
* Transport Segment
* Ground Segment
* Infrastructure System

However before we embark on a general description of the activities and challenges associated with any of the itemised segments it is appropriate to discuss the general framework within which space activities operate.

7. SPACE LAW AND TREATIES

Early in the space race majority of nations recognised the need to evolve and agree on a set of rules, principles, and guidelines that would regulate and govern the exploration and use of outer space, its resources, and the celestial bodies contained therein. The United Nations provided the forum and umbrella for such an exercise. As a result, a committee on the peaceful uses of outer space (COPUOS) was created and an office for outer space affairs was established under the leadership of the UN Expert on Space Applications. The thrust of COPUOS activities derives from the basic principle that space and all its resources belong to all mankind and should not be used for military activities. For example the Moon Treaty of 1979 bars military activities of any sort on the moon whilst the outer space treaty of 1967 prohibits nuclear weapons or weapons of mass destruction from being orbited around the earth.

To date there are five main Treaties/Agreements and a set of basic principles that regulate the outer space activities of all space faring nations as itemised below;

7.1 Space Treaties

1. 1967 Treaty on Principles Governing the Activities of States in the Exploration and use of Outer Space.
2. 1968 Agreement on the Rescue of Astronauts, the Return of Objects launched into Outer Space.
3. 1972 Convention on International Liability for Damage caused by Space Objects.

4. 1975 Convention on Registration of Objects launched into Outer Space.
5 1979 Agreement Governing the Activities of States on the Moon and other Celestial Bodies. Most important are treaties on Principles and Liability.

Under COPUOS Treaty (1967), nations cannot claim sovereignty over the moon or other celestial bodies.

Nations are fully responsible for their activities in space, are liable for any damage caused by objects launched into space from their territories and are bound to assist astronauts in distress. Their space installations and vehicles shall be open, on a reciprocal basis; to conduct outer space activities openly and in accordance with international law.

7.2 <u>What Basic Principles?</u>

a) Outer space, including the moon and other celestial bodies, are not subject to national appropriation.
b) The state of registry of space object retains jurisdiction and control over such object and over any personnel thereof while in outer space or on a celestial body.
c) States bear responsibility for national activities in space and must subject such activities, either by officials or private individuals, to authorization and control.
d) States that launch or procure the launching of a space object or from whose territory or facility a space object is launched are internationally liable for damage caused to another state or its nationals by such object.

8. PROBLEMS OF SPACE LAW

Since states are forbidden from making claim to space territories, for instance, there is need to establish regulations governing the apportionment of usable resources that space may provide.

Another area of interest is the use of the upper atmosphere and geostationary orbits for purpose of communications. Satellite technology has, for example, expanded the range and lowered the cost of international communications.

8.1 Problem Areas

Although the article IV of 1967 Treaty prohibits the stationing of nuclear or other weapons of mass destruction in outer space or on celestial bodies it went on further to prescribe that the moon and other celestial bodies (without mentioning 'outer space') shall be used exclusively for peaceful purposes. The issues here are:-

(a) From evidence to date we are not sure that this provision is generally accepted or adhered to.
(b) What does 'peaceful purpose' mean? Is it 'non-military' or 'non-aggressive? The latter interpretation which is the position of the super-powers appears to be gaining currency.

Other than the UN, one of its agencies, the International Telecommunications Union (ITU),

has been active in regulating the use of radio frequencies for telecommunications and direct television broadcasting by artificial satellites.

9. WHAT CAN SPACE TECHNOLOGY DO FOR MAN?

If space technology is to occupy a central position or engage the ingenuity and attention of mankind for a prolonged period", it must hold promise for solving some of the major problems, that threaten or compromise man's progress and survival in the near future. Prominent on the list of such problems are the following:

* Food and quality life for an exploding population
* Adequate and safe energy supply
* Managing the environment . .

The issue would then be to consider to what extent space technology could be deployed to either solve or contain and manage these problems within the next few decades.

9.1 Food and Population Explosion

The exponential population growth and the progressive and irreversible urban drift pose serious problems to man's quality of life in the near future. The world population which was put at 5.4 billion some 8 years ago in 1990 is expected to almost double by the year 2025 with a projection of 9.2 billion. Of this number, majority are expected to be urban dwellers since it is expected that, by the year 2000, not less than 55% of the world's population will be city dwellers and roughly two dozen of those cities will be classified as megacities with populations in excess of 10 million (Rao, 1996). An immediate consequence of such growth rate is the shrinking of the per capita arable land. Unless science and technology can find new ways of food production, poverty and malnutrition pose serious threats. The crowding of populations into cities also accentuates problems of proper land management, management of the local environment, integrated approach to urban planning and development of water supply, open spaces, transportation, housing and other infrastructure. Such megacities, which will be mostly located in developing countries, will require sound organisation, financial, and legislative framework for management and monitoring purposes. Remote sensing has been sufficiently developed to differentiate between different classes of urban zones such as residential, industrial, green belts, and their growth over time can be easily monitored to enable authorities plan for the physical growth of the city and the necessary infrastructural facilities.

The sea is increasingly becoming the other viable source of meeting the food demand of the globe's inhabitants during the next century. Most of the catch is located in the proximity of the continental shelf in the coastal regions of the world. Unfortunately this region also contains a high percentage of the world's inhabitants and is therefore prone to waste pollution emanating from the domestic, industrial, and agricultural activities of the dwellers.

Some of the relatively important basic facts about the coastal zone include the following. The

coastal zone:

* occupies 18% of the surface of the globe
* contains less than 0.5% of the ocean volume
* is the region where roughly 25% or the primary productivity on the globe takes place
* is the region where around 60% of the world population resides
* serves as home for two-thirds of world cities with population in excess of 1.6 million
* supplies approximately 90% of the world fish catch

In view of the various activities which coastal waters are, subjected to (e.g. natural fish stocks, recreation, effluent discharges, aquaculture etc) the water quality can be used as a barometer for gauging the productivity or suitability of the zone for any of the itemised activities. One way of doing this is to correlate the quality with the colour of the water as remotely sensed.

Table 2: High-Resolution Sensors for ocean colour

Sensor	TM	HRV	MOMS	AVNIR
Agency	NASA	Spot Image	DARA	NASDA
Country	USA	France	Germany	Japan
Satellite	Land sat	Spot	Priroda - MIR	ADEOS
Operation Dates	07/82 -Date	1990 -Date	23/04 '96 - Non - Operational	17/08/96 - 21/06/97
Swath (Km)	185	60-80	95 - 105	80
Resolution	30	20	16 - 18	16
Spectual Coverage (nm)	450 - 900	500 - 890	443 - 670	420 - 890
Number of Bands	4	3	4	4

Source: Space Applications **Institute** (SAI); Commission Joint **Research Centre** (1997)

Such schemes have been successfully used by SAI in the past to monitor toxic algal blooms in the Baltic and provide early warning 'white - tide' signals in the Northern Adriatic sea. Several new sensors are planned to be flown within the next few months.

9.2 Energy Supply

The per capita energy consumption is generally used as an index of development. If the rest of the world were to develop along the lines of the North, then the energy demand will far outstrip supply. Recent studies have however shown that while other renewable or non-renewable conventional energy sources being studied might, ultimately, be viable as commercial ventures, the cumulative ultimate production capacity merely reduces but cannot close the shortfall in the projected energy supply requirements. On the contrary, what is called for are bold new initiatives that can meet projected requirements (Mankins, 1997). Thermonuclear power plants could at the appropriate scale provide such an alternative but in view of public opposition arising from their adverse environmental impact, the possibility of harnessing the sun's energy in space holds considerable promise. The original idea of the Solar Power Satellite (SPS) dates back to 1968 when it was first suggested by Peter Glaser but it has taken almost three decades of development work to bring us to the point of flying a technology demonstration satellite by NASA. Basically the plan is to configure solar satellites and associated systems that could deliver energy into terrestrial electrical power grids at prices equal to or below ground alternatives in a variety of markets and to do so without major environmental drawbacks. Following the initial concept, at least 4 SPS symposia have been held in Paris (1986 and 1991), Rio de Janeiro (1992), and Montreal (1997) and several modifications introduced. There is now some level of optimism that by deploying relatively small SPS in lower orbits such as the LEO-SS and MEO Sun Tower Systems, it might be possible to commence space solar power generation early in the 21st century. The moon has also featured as a possible base in the generation of solar power from space under three different scenarios viz:

i construction of solar power satellites from the moon.
ii construction of power stations on the moon's surface.
iii tapping of lunar helium 3 for terrestrial energy production in fusion reactors.

9.3 The Global Environment

Three of the major sources of threat to the global environment that have been identified are global warming, toxic and nuclear waste disposal, as well as natural disasters. Global warming could lead to partial melting of the polar glaciers; this would subsequently raise the water level in the oceans leading to massive flooding of the coastal lands and cities where, as stated earlier, 60% of the human population lives. Space provides a vantage platform for observing phenomena that occur on global scale such as, for example, meteorological phenomena. Whilst some of these phenomena derive from natural forces that cannot be easily manipulated by man, as of now, the acquisition of prior knowledge of their existence and provision of early warning to the public can, sometimes, reduce the level of damage, especially in cases involving natural disasters.

On the other hand, sensors have been developed that are capable of detecting presence of toxic and nuclear waste in ocean waters and on the global surface in general. It is well known, for instance, that the amount of oil illegally dumped from ships every week is equivalent to a disastrous spill from a supertanker. The scale of the problem underscores the need for effec-

tive monitoring and adequate legislation to protect the environment especially in coastal areas which are particularly at risk from such practices (ERS 1997). Forest fires can also be detected using remote sensing so that preservation of the green belts of the world would be facilitated.

Thus, we can observe that space offers a good platform for tackling two out of the three listed problems on a holistic basis. Whilst the problem of the environment and energy can be satisfactorily handled by deployment of space technologies, the level of involvement, in respect of the food problem, will have to be limited to areas like precision farming, as well as the management and monitoring of food resources.

This is not to say that there are no foreseeable problems with respect to the energy and the environment sectors. On the contrary, there are several, but the overall assessment is that such problems can, and will be solved, in the near future. For the energy requirement, such problem areas involve the development and availability of enabling technologies in such areas as robotics and artificial intelligence. Tethers, inflatable structures and superconducting materials. We will also need to develop and build modest energy storage systems at the ground site to service the inherent periodic shading of the SPS either by the earth or by its own arrays.

The use of space for conducting any technical or production activity carries risks of its own as it may have negative impact on the environment. Such risks will have to be managed with respect to their biological effects, and their possible effect on the upper atmosphere and the communications and electronics systems.

There is also the separate, but important, problem of keeping space projects within affordable limits. Even for the richest nations, the cost of transportation (launch systems) is prohibitive. The current rate of US 510,000 per kg is programmed to fall to as low as $2000 per kg within the next 5-10 years but the target is to be able (o keep this figure within the range $200 - $1000 per kg and it is hoped that this can be achieved within 10 to 20 years from now (Boudreoult et al, 1997).

The legal regime needs to address how to deal with the issue of making nations accountable for their use of not only space but also our terrestrial environment. In the final analysis, we cannot run away from the issue of how to meet the needs of all nations even when they do not all have equal access to or use of space resources. There is also the need to define the extent to which space technology can be allowed to compromise the sovereignty or security of a nation.

10. THE STAKE HOLDERS

If space technology is here to stay, it stands to reason that all stakeholders in society be put on notice and alerted as to their proper role in the deployment of this technology. In the present circumstances the stakeholders fall under four main categories viz:

Government

Multilateral organisations

Professiona bodies and non-governmental organisations (NGOs)

Private sector.

We next examine the posture of these stake holders towards participation in space activities.

Government: The position and activities of governments in the advanced countries mostly mirror the geo-political world order. Led by the U.S space agency, NASA, the emphasis appears to be to:-

- underwrite infrastructure;
- underwrite development and scientific explorations;
- exploit military applications;
- encourage private sector's involvement, by way of commercialisation either in an independent capacity or in conjunction with government in some hybrid arrangement, as was, for example, done on the Lewis Project.

Multilateral Organs: The UN and its agencies emphasize and encourage international cooperation and peaceful and scientific exploration and use of space.

Regional Space Agencies: involved in collaboration and concerned about issue relating to standardisation of equipment and environment.

Professional Bodies and NGQs:
Emphasis is on collaborative scientific exploration, need for standards for protection of space and terrestrial environment.

Private Sector: Emphasis is on development and application of space technologies. It wants to play a major role in the commercialisa tion of space (transportation: communications, manufacturing etc). Also, it wants to undertake these ventures within the context of globalisation and liberalisation.

11. THE DILEMMA OF DEVELOPING COUNTRIES

We are all familiar with the debate as to what should be the correct posture of developing nations towards the allure of space technology. Whilst it is agreed by all, on the one hand, that space technology is a capital intensive business, on the other hand, the field is relatively new and open to innovative and forward looking developmental strategies. Each enterprising nation still has the chance to partake in this venture especially in the downstream areas through Value Added Products. Thus, can we really say it is a distraction for them? Even if it is not, can they truly afford to commit their meagre resources to Space Technology, given their serious developmental problems?

Is it true that the issue of infrastructural development and utility services can be done cheaply by deploying some aspects of space technology?. The experience from China seems to give support to this point of view where space technology has been used in the areas of mass education broadcasting, cartography surveying, and mapping.

In fact, in 1997, the UN/IAF organised a workshop in Turin to sensitise the developing countries on the cost-effectiveness of space technology as a tool for improving infrastructures in developing countries.

Luckily, certain aspects of space technology can be acquired and developed on a small scale by focusing on the use of micro-satellites. This can also allow the richer countries to focus on the power and launch sectors of the industry whilst poorer nations focus on pay loads and application of the technologies. Having decided to develop an indigenous capability to build and operate space-borne remote sensing hardware, several newly industrialising countries (NIC) have adopted this strategy and they appear to have scored some success to date.

12. NATIONAL POSTURE

If indeed space technology is beneficial for developing countries, what has been the effort of our local scientists? Where are we in Nigeria? Where do we want to be and how do we get there?

The first thing is to consciously establish major principles, objectives, and guidelines for the Nigerian space activities. One of the most effective ways of doing this is to prepare a national policy statement or document for the development of space activities and there is the need to establish an organ for the realisation of the policy objectives. In simple terms, we need both a national policy document and a space agency. Whilst work has been virtually completed on the former there is to my knowledge no concrete plan afoot to establish a Nigerian Space Agency. Such an agency will be responsible for the establishment and support of programs in major areas like:

* Space application; (mostly RS activities)
* Satellites and payloads
* Satellite launching vehicles and sounding rockets
* Space infrastructure
* Space sciences
* Research and development on space technologies
* Training and development of human resources
* Development support for a national space industry

Such a space agency should not be expected to directly execute all these programs. Instead its role should be mainly that of a midwife using ail the human and material resources available within the country at its disposal. It is, for example, conceivable that such an organ will be more effective if it uses as much as possible, the facilities and resources within the higher institutions to execute its training and human resources program, whereas, in matters of space infrastructure, it might have to collaborate with both the private sector and multilateral organisations.

Even for the relatively ambitious program on satellites and payloads there are models of collaboration with foreign countries or institutions for the acquisition and internalisation of the skills that allow for indigenous participation in the space industry.

One of such models is the SSTL Technology Transfer Scheme of the University of Surrey, England that provides an affordable access to space for developing countries. The scheme involves the selection and training of client staff to enable participate in the design, construction, launch, and operation of a first microsatellite over a two year period whilst such trainees can in the next phase build another model of the same microsatellite by themselves in their own country. They receive both academic and technical training in the course of their programme and are able to operate ground stations and manage the orbital operation of the miccrosatellite once it is spaceborne. The initial set of engineers trained under sad) a programme can be expected to now form the nucleus of an indegeneous space industry. If properly executed such a scheme can:

(a) build indigeneous industrial and academic strengths.
(b) develop a nucleus of trained space scientists and engineers.
(c) launch and operate its first satellite and thereby
(d) demonstrate and explore small satellite applications
(e) progressively develop national capability and confidence by starting with microsatellites and gradually advancing to mini and large satellites.
(f) stimulate young people into science and technology and space.
(g) do all of the above at affordable cost and low risk.

Some of the emerging space nations that have benefited from such a scheme within the last

Table 3 List of Emerging Space Nations under the SSTL Scheme

Country	Period	Microsatellite
Malaysia	1996 - 98	TuingSat - 1
Singapore	1995 - 97	UoSAT - 12
Thailand	1995 - 97	TMSAT
Chile	1994 - 95	FA Sat - A & B
Portugal	1992 - 94	PoSAT - 1
South Korea	1989 - 93	KITSAT - 1 & 2
South Africa	1989 - 92	UoSAT - 3/4/5 (SUNSAT)
Pakistan	1984 - 88	BADR - 1 (BADR - B)

decade are listed below:

A second model for Transfer of Technology in space technology is provided by the China-Brazil Earth Resources Satellites (CBERS) programme featuring South-South collaboration. The programme, which started in 1988, involves the collaboration of China and Brazil in the development of two remote sensing (AEB, 1997) satellites designed for global coverage using optical cameras similar in characteristics to those of landsat and spot, flying on a polar sun-synchronous orbit and earring DCP Transponders. The first satellite CBERS 1 is due for launch in 1998 but both countries are already studying the possibility of extending the program to include two more satellites. Brazil is also considering flying an environmental data collection system to operate in Africa based on the Brazilian data collecting satellites (INPE, 1997). For this purpose it plans to fly the satellite SCO 3 on a circular equatorial orbit.

A third model, based on regional cooperation, is provided by NASDA (Saito, 1997). This provides tor cooperation between Japan and individual countries in the Asia-Pacific zone either on bilateral basis or under multilateral cooperation. The satellites belong to Japan but under bilateral cooperation, recipient countries are offered direct data reception, data analysis research cooperation, and, sometimes, they even jointly undertake pilot projects. In respect to the African Region, only South Africa and perhaps Egypt would be in a position to offer Nigeria such collaborative support.

Payload and Instrumentation

Choice of Payload and instrumentation are strongly influenced by mission objectives and application requirements, as illustrated in the table below:

Payload	Applications
High Resolution Camera	*Disaster managemernt. damage assessment *Urban planning * Agriculture and forestry * Coastal erosion
Hyperspectrial Images	* Sea and coastal pollution * Clorophyll monitory * Suspended sediment * Vegetation health sums
Infrared Radiometer (IR)	* Temperature mapping * Geology * Vegetation stress * Thermal imaging
Synthetic Aperture Radar (SAR)	* Surface movemeo: phrnomma; oil spill, earthquakes, volcanoes, landslides glacier surgessubsidence due to water or oil removal.

These payloads are, at the high performance and generally characterised by

- high spatial resolution
- high spectral resolution
- night and day operation
- short revisit time
- high flexibility in pointing and
- short time availability of data

There are however tradeoffs between resolution, grond coverage, data rate, and data storage volume. As pointed out by Glackin (Glackin 1997), there are developments under way to seriously downsize from large, complex, and expensive systems to focused missions on small satellites with multi-use systems and lower costs.

Local Research Effort in Transport and Ground Segments

Within the field of space technology, our effort at the University of Lagos was initially in the transport segment as we were interested in the flight performance characteristics of the launcher be it in the context of a rocket or a reusable aircraft. In particular, we tackled the problem of ascertaining and ordering the relative magnitude and effects of flow characteristics such as the skin friction or drag and the lift or pressure distribution over wings at supersonic speed or blunt bodies at hypersonic speed.

This was done in a series of publications (Ludford and Olunloyo, 1972a and b; Kapila, Ludford and Olunloyo, 1973; Olunloyo, 1973; Olunloyo, 1979a and b), over the period 1972 - 1981, and put to rest a lot of controversy that was needlessly retarding progress in this field at that time. The work was partly done in collaboration with my mentor and late Professor GSS Ludford of Cornell University contributed to the subsequent design, construction, and deployment of such vehicles.

Subsequently we moved into the allied area of data processing and informatics, starting with the establishment of the Nigeria Water Data Bank over the period 1977 - 1984. The Data Bank which was subsequently relocated to NIWR Kaduna was at that time the first attempt to establish a data bank of its type in Nigeria and perhaps in this sub-region as reflected in the references. Our work in this area led us into AI and robotics. This was a natural progression because if we study the development and ascent of the expert system as illustrated in the connotative view representation below:

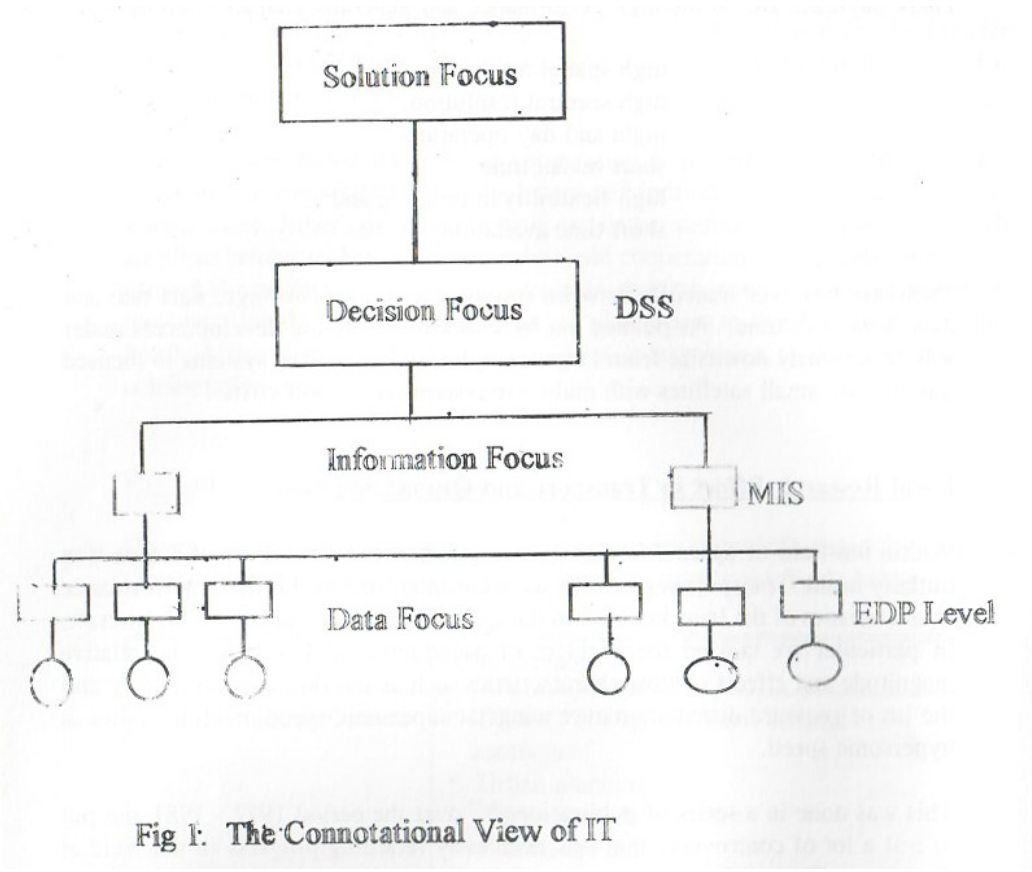

Fig 1: The Connotational View of IT

We will find an easy explanation for the evolution of the work and research interest at the EAU of the University of Lagos. Subsequently, Prof. Oye Ibidapo-Obe and one of his students, A. Alonge, veered into robotics and the design of bided mechanical (Ibidapo-Obey, Alonge and Badiru, 1995). In recent times he and his students have been responsive to the mood of the nation and are studying the design of decision support systems in strategic management environments. Some of our other students are interested in designing expert systems for managing essential services and utilities in a crisis environment such as what is now our traditional fuel crisis. We have also looked at neural computing in. the context of pattern recognition and interpretation of remotely sensed data (INPE 1997a and b). There is a strong remote sensing applications group in our Geography Department led by Prof Peter Adeniyi. He and his colleagues have been-responsible for generating a host of thematic maps that are so essential for our national socio-economic development programmes The Surveying Department of the Faculty of Engineering also fields a few experts in applied areas of geomatics and remote sensing applications. The work in "space, related technology is not limited to University of Lagos alone. In fact, there is a strong team at University of Ife spearheaded by Prof. Balogun of physics and Prof. Lere Ajayi of the Department of Electrical Engineering. Whilst Prof. Balogun is interested in the atmospheric physics aspects and meteorological applications of space-based systems, Prof. Ajayi is looking at radio signals and data transmission protocols. The same can be said of some of the space related research going on in some of our other institutions but the problem has been the inability to find an effective forum for peer interaction and the focusing of effort

towards some clearly defined objectives.

Apart from the research effort at the universities, there is a National Centre for Remote sensing (NCRS) in Jos that is currently being operated as one of the development centres under the aegis of NASEM and the Federal Ministry of Science & Technology

NCRS is mandated among other things, to undertake research, development and production into:

(a) satellite remote sensing payload systems.
(b) satellite data ground receiving systems.

There are plans to establish and operate a satellite ground receiving station at NCRS capable of receiving data from a range of satellites. If such a facility can be fully established and equipped, then the centre will be in a position to meaningfully contribute to the development of the country.

The UN has selected University of Ife for the siting of the African Regional Centre for Space Science and Technology Education for capacity building for local expertise to build competence in the use of space systems and technologies. Whilst this is a beneficial thing, the lime has come when we need to put more emphasis on utilisation rather than the building of local expertise. As food for thought I discovered some three months ago that the UN office of Outer Space Activities has the names of over 40 Nigerian experts on its mailing list but the impact of such an expert manpower base is still to be felt around here.

I believe that one area where early success can be scored would be in the ground segment and especially in the context of value added products.

Whilst we are at this, the scientific community and professional engineers, in particular, should make the effort to popularise space studies and promote the formation of space clubs at the secondary and tertiary institutions. The Association of Consulting Engineers of Nigeria (ACEN), at its last annual general meeting, deliberated on this issue and is currently spearheading some initiatives to bring the importance of space technology into our national consciousness.(ACEN, 1997) It is surprising that one of the factors retarding the penetration of space technology is the lack of awareness among decision makers about space technology and its usefulness in the development of infrastructure and the achievement of sustainable development.

The planetarium can always be a veritable tool in the public enlightenment and popularisation drive. Prof. Emovon of Sheda Science and Technology Complex (SHESTCO), I am told, is working hard on making one such planetarium available in the science museum before the new millennium arrives. There is need to have such facilities in our major universities. We also need to review the curriculum at such institutions to reflect the fact that space technology is here to stay for some time. Space studies should, therefore, be adequately reflected in the Physical Sci-

ence, Engineering and Law degree programmes.

13 CONCLUSION

In conclusion, we have reviewed the dramatic ascent of space technology in the 20th century. We found that it was initially propelled by the East-West ideological conflict but, given its dual nature, it did not suffer significant setback at the end of the cold war but metamorphosed into the mechanism for conversion from a defence to a peace economy. Driven by advances in telecommunications, material science, and artificial intelligence, space technology appears destined to remain with us for some time and would marginalise those who would not give ii its due.

Given such a scenario, suggestions are made as to how the country could enter the space race at an affordable cost and with minimal risk. In this regard the ground segment and the value added products offer a safe starting points whilst the space segment can be progressively attacked in a calculated and affordable fashion. For this to happen, the educational curriculum will have to be received to reflect the new realities of our times, the professional bodies will need to be more aggressive in educating the public as to the importance of the emerging technology, and the decision makers must be made to understand and appreciate the promise this technology has for our dreams of sustainable development.

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UNDER-DEVELOPING NIGERIA: THE CONSPIRACY OF SCIENCE AND SOCIETY

Oyewale Tomori, FAS

INTRODUCTION

Delivering one of the Academy lectures is a distinctive and unique honour. I want to express sincere gratitude and appreciation to the President and Fellows of the Nigerian Academy of Science for providing me with this incomparable and inimitable opportunity coming, as it is, as the Academy celebrates its silver jubilee and soon after my tenth year as a Fellow of the Academy. I thought I should use the opportunity to examine the role of science in our development, to see how science and society have interacted and how Nigeria has benefited from such a marriage. I also wished to examine the role of the Nigerian scientist in a country that has little respect for learning, a near utter disregard for excellence, a disdain for quality and brilliance. We live in a country that celebrates mediocrity and places the mundane on the golden pedestal of repute. You may suspect from the onset that I am a frustrated person. I may sound annoyed and displeased about the-situation of science and technological development in Nigeria. Quite the contrary, I assure you I am not. I am only in a state of agony and lamentation for my country. I am mourning for a lost past, a disastrous present, and an unknown future.

Distinguished ladies and gentlemen, in conclusion, I declare that science, scientists, and the society have all conspired to under develop our beloved country. Do not be amazed that I am starting with the conclusion, because a few years ago, so much unpredictable and undesirable things could happen in the short space of time it takes to deliver a one-hour lecture, ridiculous things that could prevent us from hearing the conclusion of the lecture. For example, NEPA could strike or the Senate Human Rights and Fair Play Sub-Committee may decide to send police in here to drive all of us out because this hall is required to hold a reception in honour of one of her members who has just received the Honorary Doctorate Degree in Jurisprudence and Human Rights. But I am assured that we live in a new country, where NEPA is the New Electric-Power Authority. A new country, where I am free to say what is on my mind as a free citizen of this beloved country. A new country, where there is respect for human dignity and justice. A new country, where there is respect for liberty, where corruption is rare, where the benefits of science is within the reach of the majority of the population. Please do not laugh, as that was my dream for Nigeria forty year ago.

Forty years ago, I sat for the Cambridge School Certificate at my alma mater, The Government College, Ughelli, in the Delta State of today. I remember vividly the essay topic I wrote for the English paper one. It was titled: Nigeria, twenty years from now. I wrote, and wrote, till my fingers ached in cramps of excitement. I was excited for the future of my dear country, and I wrote furiously. I dreamt dreams and wrote my dreams on paper, Oh, I saw a country where tribe and tongue differed, but in brotherhood we stood, I saw a vision of a country where Nigerians all were proud to serve our dear motherland. In my- dream, I saw macadamized roads criss-crossing the entire land of Nigeria. Every house had running potable water, where electricity never 'blinked 'for one day. Only those who chose not to go, did not attend the new primary and secondary schools found all over the country. Our universities were offering courses relevant for the development of our country. Technical schools and polytechnics dotted every nook and corner of Nigeria, training people who turned Nigeria into a technological paradise, people who made Nigeria a beauty to behold. So, it was it a delight to be sick in the Nigeria of my dream. We had hospitals where good care with humanitarian touch marked the order of the day. There were no armed robbers as those who would have chosen the profession of armed robbery were in good schools or polytechnics. Nigeria in 1982, was the utopia. I wrote with the fervour of a young man who was very proud of his motherland. A teenager, who wanted to live and die for his country. I had plans for myself too. I would go into science, maybe medicine, maybe engineering. I would discover cures for diseases or build bridges across the river Ethiope in Sapele, and others linking all the riverside towns of Nigeria's delta and mangrove swamps.

Distinguished ladies and gentlemen, that was 4O-years ago.

The topic of my presentation this evening: **UNDER-DEVELOPING NIGERIA: THE CONSPIRACY OF SCIENCE AND SOCIETY**, will give you a clue to what happened to my well laid out dreams. The dream that has turned to the nightmare: the horrendous noonday horror that is my beloved country. Not two years after I wrote that essay, we woke up to operation "wet e", the mayhem in the old Western Region, then to emergency, then to coups upon coups, and then to the civil war, the festering wounds of yesteryears, now the scars of remembrance. Then we had military administrations, the less said of which the better, and then to what Nigeria is today. During the course of this lecture, I will discuss what the society should expect from her scientist and what the scientist should expect from her society. I will consider why the marriage between society and. science has been more for the worse than for the better in Nigeria. In conclusion, I will look at the way forward for a better and more fruitful relationship between science and society.

Let me start with a few general definitions so that we understand each other. I am reminded of the story of the teacher who asked his student to spell plantain. And a discussion ensued between the teacher and the student:

Student: Which kind plantain, you want make I spell?

Teacher: Plantain is plantain. Spell the thing o jare

Student: Oga, no be so o.
If the plantain.ripe, and you fry am, that one na "dodo"
If he no ripe well well, and you fry am, that one na "pekere"
If the plantain ripe o, if he no ripe o, and you roast am, that na "boli"
So, Oga, which one make I spell?

For the purpose of this lecture, I am looking at science in the broadest sense of the word. To me, it is the curiosity to seek the unknown, to find an answer to a question, the methodical way of finding out the truth, the orderly way of seeking knowledge. Arising from the word 'science' is the word 'scientist'. It is the curious one seeking answers to the unknown in a methodical arid orderly manner. Through seeking the truth, science and the scientists, afford us the opportunity to free ourselves from the bliss of ignorance. By applying the knowledge derived from science, we can improve on life and prevent the monumental, sometimes fatal, cost of ignorance. By extension, I consider as part of science, the application of this truth and of the knowledge derived from the pursuit of science and the use of such technology for improving human life. You will by now appreciate that the "us", and the "we" called human beings, form the society. Again, in this lecture, the focus is on science in Nigeria and the Nigerian society.

EXPECTATIONS OF NIGERIAN SOCIETY FROM SCIENCE AND TECHNOLOGY.

Science, rightly pursued and wisely applied, be it in medicine or engineering, should impact positively on our daily life. This should be the expectation of the society from science and scientists. Just as health is not only the absence of disease, but also a state of mental, physical, and emotional well being, so also we should see the evidence of the impact of science on our day to day activity, whether we are at work, at home, on the road, or even sleeping. Science and technologies derived from it should, according to Sydney Brenner, "form the basis of all human activity, from the houses that we live in, the food that we eat, the cars that we drive, to the electronic gadget in almost every home that we use to remain informed and entertained". The Nigerian society should not expect less from her scientists.

Muhammad Yunus, the founder and managing director of the Grameen Bank of Bangladesh, described how he left the ivory tower to the wooden kiosk of Jobrain, Bangladesh. He began his career in 1974, as the Chairman of the Economics Department at Chittagong University in newly independent Bangladesh. Bubbling with the idealism of a young economist, he filled his head with all of the elegant models and theories of development in the western developed world, which was very much in vogue at the time. He was caught up in the euphoria of a hard-won liberation struggle and supremely optimistic about the ability of his country to transcend its poverty-ridden past. The 1974 famine of Bangladesh violently shattered his confidence. While he lectured his students on optimal strategies for economic development, the poor villagers of Jobra, were dying of hunger just outside and in the vicinity of his classroom. He left his textbooks and went to the villages to learn about poverty from the people. He discovered that the poor possess extraordinary survival skills. He also discovered that what a villager needed was just $27 to free him from the eternal bondage of the moneylender. So he set up the Grameen

Bank (Grameen means village, or of the village) in Jobrain, and loaned $27 to the 42 villagers. Today, more than 2.3 million Bangladeshis, spread over 37,000 villages, have borrowed from Grameen Bank. Cumulatively, the bank, a financially sustainable, profit-making venture with 12,000 employees, has loaned $2 billion, and virtually every cent has been repaid. It is not a charity, or a program based on good will or political favours. It does not subsidize the poor; they are its borrowers and .its shareholders. The bank makes small loans that average about $60 each, thereby proving that microcredit is an effective tool. Ninety-four percent of Grameen Bank borrowers are, Jandless rural women who have made great strides as a consequence of these loans, Studies on the health status of residents of Jobra, have cited improvements in nutritional status, sanitation, access to food, health, pure drinking water, and housing. A recent World Bank study estimates that more than one-third of all Grameen Bank borrowers have risen above tbe poverty line, and another third are close to doing so. Other initiatives under the Grameen Bank are the Grameen Telecom, a nonprofit company, established in 1997 to launch cellular telephone operations in rural areas. Another technological venture being designed by Grameeri Communications and Grameen Foundation USA is the Village Internet Program, a pilot project in which borrowers will take loans to purchase and operate "Cyber Kiosks" for profit. These village computer centres will make it possible for Grameen borrowers to access the Internet in search of income-generating activities and to provide education and computer-based employment, I can hear many of us saying "Bangladesh ke!". Well, many of us will remember the famous People's and Community Banks of Nigeria. Tbey were patterned along the lines of the Grameen Bank, but they ended up as something else.

In summary, what does the society expect from science and her scientists? It is to be provided with opportunities to take advantage of scientific and technological innovations particularly in energy, communications, and information technology. The society expects its scientists to transform the elegant models and theories of development into practical solutions for their daily existence. The society wants science arid the scientists to adapt theory of relativity into something practical, relating to their daily needs.

WHAT IS NIGERIA GETIING FROM HER SCIENCE AND TECHNOLOOY?

In 1990, Professor Wole Soyinka, Nigeria's first and so far, only Nobel Laureate came at the invitation of the Postgraduate Institute for Medical Research (PIMRAT), College of Medicine, Ibadan, at a time when I was the Director, to deliver a lecture on contemporary Nigerian issues. It was a typical Soyinka lecturer, incisive, to the point, biting the nail squarely on the head, and TIMELY. At the end of the lecture, Professor Soyinka revealed that he wrote the lecture in-1975. That the lecture was still relevant in 1990, 15 years later, tells much about the absence of progress or rather outright deterioration of our social condition. In preparing this lecture, I went back into history and found newspaper articles, I wrote in the 1980s and 1990s, which are as still as relevant today as they were in the 1980s and 1990s when I first wrote them. But before I share some of those articles with you, let me illustrate the quality of life the Nigerian society is getting from her science, with three examples. These three examples are electricity, air transportation, and health.

SUPPLY OF ELECTRIC POWER

Distinguished audience, please picture this scenario. Nigerians are all congregated by the mouth of a long tunnel: At the end of this dark and long tunnel is NEPA! I need not say much more, but I will. Let me be fair to the NEPA of 2001. In the Guardian Newspaper of 22 December 2001, the NEPA Technical Board Chairman, Mr. Liyel Imoke, declared that NEPA's power generation rose from, 1,600 megawatts to 3,300 megawatts. This, he said ''was a world record". World record or not, without a reliable power supply, everything from industry to education will grind to a halt. Computers cannot be booted on kerosene lamps, nor can the wheels of industry run on firewood. In the hospitals, you do not carry out operations with untamed power of sunlight, nor run diagnostic tests by energy derived from the whistling sound of a gusty wind. We certainly cannot keep vaccines potent with candlelight, nor guarantee that the children we vaccinate with such impotent vaccines are protected against the disease for which the vaccine was given in the first place. We therefore end up with vaccinated children that are not immunized. Can we ever count the cost of equipment/gadgets ruined by our unreliable power supply?

Can we put a price to lives lost in our country at home and in health centres to .unreliable, unpredictable, defective, fickle, erratic, and capricious power supply? Without a reliable power base, we may as well forget our hope fur development.

AIR TRANSPORTATION -NIGERIAN AIRWAYS

I came on a flight from South Africa, a South African Airways flight. The wise SAA officials have inscribed "Nigerian Airways" to the SAA logo. And like 'dundee', the dimwit of Idi Araba, we are smiling because our name has been written on a SAA plane. Three years since the present 'government came to power, we are leasing planes from Air Djibouti, and obtaining approval to fly from Air Gambia. Meanwhile, the Minister of Aviation is still receiving all due monthly salaries plus allowances and too much more. No one is caring for our safety, and when the International Civil Aviation Organization, is worried about the safety of the people we would carry on such planes, we cry' "NEO~COLONIANISTS! INTERNATIONAL CONSPIRACY!!!!" I wonder why the "neocolonialists" should even care if the plane crashes. After all only 300 or so will die out of our 120 million population! Nigeria has more human and natural resources than most African countries, more aeronautical engineers, more pilots, and more resources. No less than 80% of passengers leaving our country on any airline are Nigerians. None of those airlines belong to Nigeria. Air Gabon, Air Cameroon, South African Airways, Ghana Airways, Ethiopian Airlines, British, German, Italian, Dutch Airlines. They all make a roaring trade transporting millions of Nigerians from Lagos to Lome, Jos to Johannesburg, Aba to Anchorage, but not Nigerian Airways! It is now over 40 years of our independence, and we are still dependent on foreign airlines to provide air transportation for our Head of State, when he is visiting Lome across the road! Our elephant metamorphosed to an eagle. The eagle has landed to fly no more. This is not just the problem of science, but also the conspiracy of science and society!

HEALTHY ISSUES

Let us look at the health of the nation. One of our recent Ministers of Health once described the status of our health as worsening. That was the greatest understatement of the year. He should have told us that our health situation is in tatters. Any wonder 217 of 1000 children die before they reach the age of one year, and 239 of 1000 children die, yes, die before they can start primary schools. Our Minister of health told us that up to 1,716 of our mothers out of 100,000 die from a disease called childbirth!

The last time we saw figures like these, John Rankine was Governor of Western Region and our respected Nnamdi Azikwe of blessed memory was the Editor of West African Pilot. Each of the 217 children that never made it to one year is not a statistic, but the child of someone, a potential doctor, a future engineer, or a prospective economist. Each mother that dies from childbirth, is someone's wife, another person's mother, and who is a sister to yet another person. It could be that we do not have enough doctors to work in our hospitals, or it could be that we are not providing them with the materials to practise their trade. May be we are not allocating enough funds for our health care, or someone somewhere is using what is allocated to care for himself or herself, to the detriment of the society. That person could be a scientist, he could be a politician, or a civil servant.

NIGERIA YELLOW FEVER EPIDEMIC: 1986-1992

Fifteen years ago, yellow fever (YF) disease invaded Nigeria. It started in Oju LGA, in Benue State. By the time the investigation team got there, the village was decimated with over 1000 dead, many of them children under the age of 15 years . The village chief welcomed us with these words, " You are welcome to Oju. You come at a time when most of our young ones are dead, and lie unburied, because the old ones are too weak in body to bury their young, and too weak in spirit to bury their future". Medical attention was inaccessible, and where accessible, it was not affordable. Who could tell how many actually died? "It is not easy to say the exact number of the dead," said the village dispenser. But the picture can be obtained from a situation where an average of five people die daily. The village pastor at the service for the dead, quoted from Rev. 11:8-9. "And their dead bodies shall lie in the street and they of the people and kindred and tongues and nations shall see their dead bodies three days and a half, and shall not suffer their dead bodies to be put in the graves".

Oju was the beginning, not the end of the yellow pestilence that left devastation in families across the country. Our country was thrown into unprecedented disarray for five to six years by the yellow plague. For five years, the disease went round the country claiming thousands of life.

Yellow fever became a regular feature on the pages of our newspapers, radio, and television. Where next? Who next? These were the questions on everybody's lips. That was a terrible time for our country. It was as if the Nigerian was a trespasser in his own country, if he escaped the military harassment, and the accidental discharge from the police gun, yellow fever was waiting to shoot him again. All ages and all groups were affected. Long before AIDS orphans became a feature of African development, there had been yellow fever orphans. So much was the dev-

astation caused by yellow fever in Nigeria that our country accounted for over 90% of global cases of yellow fever. Indeed, WIIO con- cluded that these figures were the largest number of yellow fever cases and deaths ever reported by any country since 1948 when the WHO started receiving reports.

Yet a potent YF vaccine has been in existence since the 1930s. The vaccine was used to bring the disease under control between 1934 and 1952, in the French speaking West African countries, where a mass yellow fever vaccination campaign was in operation. Indeed the earliest research on yellow fever was carried out on this very location way back in 1926. The vaccine was used to bring yellow fever under control in countries of West Africa, where mass YF immunization was in practice. Right here in Yaba, less than 2 kilometres from here, Nigeria produced for many years, sufficient YF vaccines for the control of the' disease. But what happened to us in 1986? In the background is the epidemic, the bars represent the number of millions of doses of YF vaccine imported to Nigeria to control the epidemic. It is obvious that, although Nigeria was flooded with over 20 million doses of yellow fever vaccine, the disease ran riot all over Nigeria for five or six years. Many reasons and many groups and people were responsible for these horrible seven years. Our inability to control yellow fever was a classical example of the conspiracy of science and society, the collusion of society with science, to under-develop our nation .

During those yellow fever dark days, the government, the civil servants, the scientists, and the society, worked hand in hand: callous indifference wallowed in corruption, greed swam with avarice in deliberate incompetence, truth was calculatedly denied for self gain, while societal ignorance reeled and lurched in self-pity. But all that is history. Today, YF has been reported in Liberia, Burkina Faso, Guinea, and Senegal. This is a repeat of the 1984 scenario, which preceded the Nigeria yellow fever epidemics of1986-1992. Today, we have no facilities for producing YF vaccines. Today, the carcass of Nigeria YF production laboratory lies buried in the coffin of greed, avarice, and callous indifference. Today, instead of building on our national capacity for vaccine production, we are preparing to sell our national heritage to any commercial bidder and turn our educated technicians, and scientists to factory bottlers and dispensers. Let me stop talking in parables, and say it as it is. The time has come for vaccine production in Nigeria to be released from the greasy palms of the government arid its agents. The time has come for vaccine production to be privatized in Nigeria. In December last year, I heard from, the grapevine that our government is seriously considering privatizing vaccine production in Nigeria. This is a step in the right direction, but let the selection of the Chief Executive be based solely and purely on merit and integrity.

Perhaps there is someone here this evening, who has lost a wife, a mother, or a sister to childbirth. Or there is one person, whose son or daughter never saw the light of day because of the deplorable state of health care delivery in our country. May be you have lost a dear one to a vaccine preventable disease. Please accept my condolence, but allow me to ask, 'What have you done to prevent the recurrence of such a disaster either in your life or of other Nigerians?.' Before you ask me, 'What can I do?', Let me tell you what Bruno Latour said in his paper 'From the world of science to the world of research' (Latour, 1998). He said: “Science and society cannot

he separated, they depend on the same foundation. They are like two branches of power defined by the same constitution. If you alter the separation of powers, you immediately alter both the view of what science is and of what society can do."

THE NIGERIAN SCIENTIST

Let me share with you some of my thoughts on why science has been so irrelevant in the consideration of the Nigerian society? These thoughts form the basis of a paper I presented, at the plenary session of the Xth International Congress of Virology in Jerusalem in 1996. The title of the paper was "Africa: Verdant Pasture for Newly Emerging and Re-Emerging Viral Diseases" (Tomori, 1997). I quote "The African scientist is a talented expert who has become largely irrelevant to the needs and aspirations of his society. From the onset, the African scientist was trained in a system that assumed it understood the peculiar needs of his people. Be he a doctor or an engineer, he is well versed in techniques and-methodology of science, but not in its adaptation for the needs of the society that paid for his education and training. He is measured against a "global standard" that hardly addresses the situation in his society. He struggles vainly to catch up with the world of technology, getting further and farther away from his society, becoming an alien to their yearnings, aspirations, and hopes.

As gigantic technological strides are taken in other parts of the world, the African scientist must decide whether to run a race in pursuit of the other world and away from his society. In the end, he succumbs or he is forced to crawl in an unending and unequal race after his counterparts from the western world. In the process, the African society suffers, deprived of the expertise of indigenous scientists. Back home, the situation is worsened by a government, which prefers and would rather depend on foreign expertise and consultants. Disdained, disregarded, discarded, and without the facility, or funds to perform effectively, the African scientist becomes a piece of costly but counterfeit ornament, hanging in no man's land, a special one way ticket, non-reroutable, non-refundable and non-transferable. The African scientist reminds me of the African cow that went to Exeter and came back as corned beef

The African cow went to Exeter
And came back as corned beef
At the village reception to welcome the cow
There was drumming and dancing
As different groups loudly declared
Give the cow head to the brave, said the hunter
Release the cow thigh to strong, said the youth
The intestine is for pepper soup, said the woman
The young shall grow on bone marrow, said the child
The cow brain is for the sage, said the toothless old man

A hush descended on the village
As the Chief called for the cow
Entombed in the Exeter corned beef can
Where is the African cow?, the people yelled
In the can, oh yes, in the can, the Chief said
Open the can, open the can, the people shouted
And away in sorrow, the people left
As the can of worms was opened
To reveal the African cow from Exeter
Now metamorphosed into excreta

THE NIGERIAN POLITICIAN

Many of my colleagues, in the Academy, in our universities and research institutes, will certainly not agree with me on my opinion about African or Nigerian scientists, but wait until you hear what I think of our government, our industries and our society. Please wait until you hear my answer to the question: Why Is Nigeria getting a raw deal from her science and technology? Appropriate training and utilization of scientists are profitable and beneficial for societal well being and advancement. Therefore, a society that pays scant attention to the training of her scientists or does not provide a suitable environment for scientific research and statement will remain underdeveloped and poor. Africa's poverty, stemming mainly from misplaced priority, has led in most countries to the utter disregard for science and scientists as instruments for positive change. Does a country deserve her politician? Political leadership in Nigeria is like the figure you get when you divide 1 by 3. A recurring decimal of 0.33333333333333333333333333333333, that has no end. But for the inevitability of death, the politicians of our independence, forty-one years ago, have remained largely on the scene, resurfacing in different garbs and occupying different positions. The Minister of Mines in 1960, became the Minister of Power in 1967 under the military regime, stayed on till 1983, when he transformed to become the Chairman of Resource Allocation Committee, driven out briefly again by the military on new year's eve. He spent the first day of the new year in 'Kirikiri', but was sworn in on January 15 as the Minister of housing. Building no house, except for himself, he moved successively between the military governments and the present civilian administration, through the ministries, of roads and transport, aviation, rural development, ending up as Minister of Youths and Sports on his 79th birthday. In the current dispensation, I will not tell you his position, for security reasons. Our politicians make the modern history of Nigeria read like Joel 1 verse 4.

1960: That which the palmerworm hath left, the locust hath eaten 1966: That which the locust hath left, the cankerworm hath eaten 1983: That which the cankerworm hath left, the caterpillar hath eaten. 1999: That which the caterpillar left, the maggot is currently eating!

Our politicians also remind me of a cartoon I once saw in the West Africa magazine. The cartoon asked its readers to spot the difference between Mobutu and the dreaded disease Ebola. The only difference I found was that Mobutu certainly created more disaster than Ebola

virus. In the 21st century Africa, 5 million children die in the first month of life. A quarter of a million of our children were sent to fight the politician's wars in Liberia, Sierra Leone, Somalia, and Democratic Republic of Congo. Through the assistance of HIV/AlDS, we produce 600,000 orphans in Africa. Our governments say we are poor, and they are mortgaging our future to international lending agencies. Yet for the people of Angola, the government's expenses on defence and weapons of war is 273 times more than the expense on health and education combined. Our own government only spends 63 times more on defence than it spends on health and education combined. I am not sure if these figures take into account squandermania years of ECOMOG adventure in Liberia and Sierra Leone. And yet we say we are poor! We should be putting our money on our life.

For grenades, let us acquire tablets. For AK-47s, let us purchase auto-destruct syringes for our hospitals. Instead of laying land mines, let our governments lay the foundation of health centers and schools and libraries. While politicians in other parts of the world are wrestling with matters of significant human development, and trying to understand the need to have alternate sources of energy, our politicians and leaders are scrambling for cuts in unethical contracts and shady deals. They are debating such vital issues of national interest as legitimizing the order of precedence of who enters the National Stadium last at a charity match. Instead of planning against the possibility of anthrax spores coming through the NIPOST, or the importation of foot and mouth disease into Nigeria by the millions of passengers entering through Lagos, Kano, and Abuja, or what to do about the effect of erosion in Anambra or the effect of oil spillage on agriculture of the riverside areas, they are seriously debating the bill on who is authorized to use the. Senate chamber toilets! As a result of this blatant neglect of what matters most to the people of the country, we are vigorously matching away from technological advancement into the Stone Age. We have replaced electric bulbs with kerosene lamps and candles. Cell phones are yet to displace our talking drums for sending messages. We have refused to equip our schools with computers and told our children to add from one to twenty using their fingers and toes. We have turned our hospitals into butcheries. The society, through acquiescence and idle indifference, to the criminal neglect of issues that affect her has colluded with the leaders to return us into the Stone Age. However, it seems we ate beginning to see some light at the end of the tunnel. In the same Sierra Leone, where we had gone to squander our national resources in the name of ECOMOG, our Head of State on October 19 2001, joined the leaders of Mali and Sierra Leone in signing the Lungi Declaration, pledging human and financial support for polio eradication in the ECOWAS sub-region. It is gratifying to see the change from ECOMOG to ECOHEALTH. Let me however say, that most of us here today, leaders of the society, in politics and business, have the means to benefit from the products of science and technology. We only need to look across the other side of Victoria Island, or pay a visit to Ajegunle, to see the difference science has made in our lives. The leaders of the society in government and business are enjoying the fun benefit of science as others in other developed countries. Our inability to ensure that the majority of our people enjoy such improvements in their lives is the basis of the conspiracy between science and society that has led to the underdevelopment of our beloved nation. And our own different ways, each of us, the privileged and educated class, and the other side, the vulner-

able and uneducated poor, have contributed to the underdevelopment of our beloved country through the practice of impoverished science and poor technological applications.

EXPECTATIONS OF SCIENCE FROM THE NIGERIAN SOCIETY

Nathan Myhrvold, Chief Technology Officer and a member of the Executive Committee at Microsoft Corporation, writing on 'Supporting Science', said: "The twilight of the 20th century is an age of enormous technological, change. Every day brings new examples of advances in computing, communications, and biotechnology that change the way we live, and the way we look at the world". He went on to say, "Economically speaking, technology companies founded in just the last 30 years have created an aggregate capital value of close to a trillion dollars, making technology a major engine driving the U.S. economy. The foundations of these advances are the funding of basic scientific research and the entrepreneurial spirit in the United States. After World War II, the United States poured money into basic research, creating a strong and vibrant scientific community. It is no accident that Silicon Valley and other high-tech enclaves in computing and biotechnology are largely U.S. phenomena. Technology businesses grew up in the shadow of great universities and research institutes, and the apple did not fall far from the tree. Science is the raw material that applied research and engineering refine into their products".

Today we are witnessing the personal computer and internet revolutions. The personal computer was developed on research done in the Xerox Palo Alto Research Center (PARC). The US Defence provided funds for more than 25 years in support of research, which made the internet, one of the most dynamic and social developments of the last decade, what it is today. A less patient source of funding, like our government, would have cut the support and accused the scientists of wasting national resources. Where would the world be in Nigeria today without the internet? We would still be dependent on the NIPOST! The government and industry must recognize science as the fountain of technology miracle. Consequently, support for science must be provided, and scientific funding must not be subjected to a protracted dissection and review based on its relevance to immediate and short-term economic goals. Scientific research is by nature an uncertain undertaking, just as voting for any political party could not only be a perilous and hazardous venture, but also a fatal gamble. A businessman does not expect each investment to yield the same amount of profit, nor does the insurance agent expect every person to live precisely to the life expectancy. I believe the whole point of business is to create enough portfolios of investments with reasonably predictable degree of yielding profits. No less should be expected of scientific investments. Given a sufficiently large portfolio of research projects, and enough time to bring them to fruition, science is a great and reliable investment. Unfortunately, those in government and industry who fund science, see funding science as a wasteful and profitless business. If scientists employ advertisement agents to predict research results up front; guarantee low risk of failure, and present a clear and certain path from results to great commercial utility then research funds will be available. The trouble is that a research proposal that meets those criteria, and meets the additional burden of being readily understandable by an Honourable Member of the House or Senate Committee for research, is almost certainly not worth doing. Such a research proposal is nothing but "you-chop-I-chop research". It usually

does not consider the benefit to society, but is strictly and solely for the benefit of the scientist and the clerk working for the funding agency. In Nigeria, neither government nor industry has much regard for science or scientist. Nor do they think Nigerian science and scientists can produce the base for the social and technological transformation of Nigeria. They would rather support imported technology, forgetting that imported technology needs local research for its adaptation and translation to needs of Nigeria.

As we all hear of, but are unable to see the dividends of democracy, I am sure our government is telling us, while patting itself on the back, that millions of naira have been poured into science in Nigeria. After all we have a Ministry of Science and Technology with a Minister and a Minister of State to run the ministry. We have a saying that if you do not have another farm to compare with your father's farm, you may think that your father's farm is the biggest in the world. In 1984, I wrote an article in the Guardian, titled 'Research and research funding in Nigeria'. I will quote parts from the article: "Let me use Japan as an example, and this for obvious reasons. According to the scientific journal, Nature of 29 September, 1983, Japan is now spending more than six thousand. billion yen each year on scientific research and development. This is almost one-tenth of the world total. At the 1983 conversion rate of approximately 400 Yen to one naira, this amount comes to fifteen thousand million naira or fifteen billion naira.

Furthermore, this amount is equivalent to 2.2% of the gross national product of Japan. Another unique aspect of the generation of funds for scientific research is that 65.9% of the funds are provided by industry. The importance of science to the Japanese is further illustrated by the way science is run in the country. The top policy maker for science in Japan is the Council for Science and Technology, a ten member advisory committee chaired by the Prime Minister; and including the Ministers of Finance, and Science and Technology, as well as the President of Science Council of Japan. Besides setting general policy, the Council also supports research directly through special coordinating funds. Fourteen ministries and agencies in Japan have scientific research budgets of which the big three are the Science and Technology Agency with an annual budget of 320 x 109 yen or 800 million naira., the Ministry of Education, Culture, & Science with an annual budget of 60 x 109 yen (150 million naira), and the Ministry of International Trade and Industry (MlTI) with 13 x 109 yen.(32.5 million naira). Between these three ministries, funds are provided for nuclear, and space research, basic research in national institutes, research with industrial applications etc. Remember that these are 1984 figures. There is an overall bias towards applied and product-oriented research rather than basic research. Of course, the benefits of such a bias are obvious for all to see. There is hardly any aspect of our life that Japan does not hold us by the jugular vein. If you are not riding in a Toyota, Datsun, or Isuzu-brand car, then you must be commuting to work in a bus of like brand. If you own a motor scooter, it is likely to be a Suzuki or a Yamaha. Your electric fan, your photocopier, not to mention your Hitachi, Akai, National, and Sanyo sound and television systems, all bear Japanese tags. So close to our daily life is the stamp of Japan that even our pounded yam machine was made in Tokyo. Only a few years ago, Japanese products were synonymous with low and poor quality, but today the only Nigerian who is not making use of a Japanese product is a dead

Nigerian, but that may not be true as we now import coffins from Osaka. Also in 1991, when our Ministry of Science and Technology was merged with the Ministry of Education, I wrote another article titled: 'Requiem for technology in Nigeria?' Again, some extracts from the 1992 article: "With deep sorrow, heartfelt regret, and consuming grief, the announcement is made of the death of science and technology in Nigeria. The rationalization of the ministries and the pruning of the parastatals as announced by the Head of State in his last budget took along with it and erased the Ministry of Science and Technology as we knew it. The remains of the Ministry are now interred with the Ministry of Industries, while the ashes of cremated science, the research institutes, are to be scattered into the rapids of the Niger and drained into the creeks of the delta." Continuing, I wrote: ''Nigeria's pretended appreciation of science and technology has often been mistaken for seriousness of purpose. It was not until 1969 that a National Council of Science and Technology (NCST) was established by military decree. It is one thing to decree a Council, it is another to allow the Council to function. Starved of funds and denied the freedom of operation, the Council made little impact on science and was of no consequence on technology. The NCST eventually "chameleoned" into the National Science and Technology Development Agency (NSTDA) which subsequently metamorphosed into a Ministry of Science and Technology during the second republic. The Ministry vas neither created for science nor for technology. It was established at a time when we had a Minister of, another Minister for, and a third Minister in, the same Ministry, thus giving 'jobs to party boys". The Ministry neither advanced the frontiers of science nor did it lay down the foundations of technology. As time went on, the absolute lack of impact of the Ministry on Nigeria's development became apparent. The Ministry got lumped with that of Education having nursery and kindergarten education, nomadic education for the unsettled, and the non-formal adult literacy agency for the adult illiterates, as counterparts. Our utter national contempt and scorn for science and technology can be illustrated by two examples: During the four years when the Science and Technology unit was in the wilderness of the Ministry of Education, the Unit moved from Stranchan street, by Tafawa Balewa Square, to Victoria Island, then to two widely separated buildings on Awolowo Road in Ikoyi, back again to the Glasshouse in Tafawa Balewa Square before settling in Kofo Abayomi in Victoria Island, where it was compressed, compacted, and "sardined" into wooden and cardboard paneled offices." I ended this article with these words: "I lament the death of science in Nigeria. I weep for the strangulation of technology. I cry for the future underdevelopment that today's neglect of science and technology will unleash on the future generations of Nigerians. I bemoan the future hope that is being dimmed today. I wail for Nigeria's descent into poverty, misery, and retrogression through the dangerous route of hazardous planning and uncaring attitude to science and technology."

I am not the only one that has wept, cried, lamented, and bemoaned the state of science and technology in Nigeria. The Guardian of Saturday 22 February, 1992, carried the lamentations of retired General Mamman, who was the Minister of Industry and Technology". 'Hear his lamentation: " after 32 years of political independence and 12 years after the establishment of six assembly" plants more than 80 per cent ofthe complete knocked down (CKD) component inputs were still imported for the plants". After he recovered, the Minister inaugurated "....a 10-

man council to DESIGN, DEVELOP AND PERFECT A FULLY INDIGENOUS FUNCTIONAL VEHICLE before December'", that is within 8 months!

An engraving on the entrance hall to the Institute of Scientific Investigations in Havana, Cuba reads "The only way out of underdevelopment is through science and technology". No nation has made significant improvement in her standard of living without tapping available resources of science and making use of technological know-how. Nigeria has attempted to sidetrack developing science and technology and tailoring it to her needs. Instead, Nigeria has taken a shortcut by importing other peoples finished technology, and calling it transfer of technology. Nigeria imports complete knocked down parts of vehicles, and appoints a Nigerian Executive Managing Director to oversee the screwing together of these parts.

THE WAY FORWARD

From the foregoing, it is obvious that all of us have contributed to making Nigeria a scientifically-stunted and technologically-backward nation. The misplaced priority of government, the protective self-interest of the elite and scientist, and the indifferent ignorance of the general society are the ingredients of the conspiracy that have led to the under-development of Nigeria. We all have a role to play in developing Nigeria through science and technology. Let me start with the scientists. Jose Goldemberg is a physical sciences Professor at the University of Sao Paulo, Brazil, who has held Brazil's top government posts in science and education, the environment, and state education. Writing on the 'Role of Science in Developing Countries', he observed that after the Second World War, a small technical elite arose in developing countries such as India, Pakistan, Brazil, and Iraq. Educated as scientists in the industrialized world, they thought that by pushing for Manhattan project-type enterprises in nuclear energy, electronics, pharmaceuticals, or space research they could leapfrog the dismally low level of development of their countries. For example, India initiated a nuclear energy program that mobilized thousands of technicians and cost hundreds of millions of dollars. Although India developed nuclear weapons, the project failed to meet India's power demands. Worse still, it encouraged Pakistan to develop nuclear power, with both countries unable to meet the basic human needs such as health and education of their teeming populations. Many scientists and national leaders find it difficult to understand that development does not necessarily coincide with the possession of nuclear weapons or the capability to launch satellites. Rather, it requires modem agriculture, industrial systems, and education. The idealism of the scientific elite make them believe that spin-offs from their nuclear energy or space programmes would dramatically transform their countries to 20th-century industrialized states. Such programmes have only reaped heavy economic and political costs.

THE WAY FORWARD FOR NIGERIAN SCIENTISTS

Scientists in Nigeria need to do four things to bring Nigeria back from the brink of technological disaster. First the Nigerian scientists must be seen by the society as part of the society. Scientists must identify with the society. We must participate in debating contemporary issues, making timely and appropriate comments on issues that affect our everyday life: from petrol

shortages to political issues that affect the life of the people, such as the budget, and even sports. The Nigerian scientist must make the society aware of the benefits of science and technology. Interest in science must be stimulated in the minds of our children from a very young age. We must put science in the hands and domain of the public. We must demystify science and offer people, especially the young, the opportunity for a life-long learning, enlightenment, and entertainment. This can be achieved through informal science education based on exploration of the physical and technological world. We must make science a little more inviting, a little friendlier, and a little less obscure and distant. In doing so, we will draw minds, particularly young minds to science. We must make science more enjoyable through appropriate televisions shows, reading magazines, hands-on scientific do-it-yourself(D!Y) activities. We must set up community-based organisations, science clubs etc.

Second, we should be asking the right questions relating to the problems of our society, based on our intimacy and identification with the society. What can we do about AIDS? What role can we play in getting a vaccine for the disease? Why is Nigeria, which once produced yellow fever vaccine, now importing the vaccine from a country like Senegal? Can we tap the solar energy to supplement NEPA? According to Eugene Ionesco, "It is not the answer that enlightens, but the, question".

Third, we need to focus research activities in the directions of questions we have asked. We must use research for finding solutions to those basic needs of the Nigerian society. The Nigerian scientist needs to know his people, see them and their problems through the eyes and ears of the people themselves. The Nigerian scientist must learn from his society what the society really needs. He must make himself relevant to the society through adaptation and development of technologies appropriate to our local circumstances. The poor standard of living and status of life in Africa places an extra burden on the Nigerian scientist that transcends the confines of his learning and expertise.

The Nigerian scientist must appreciate that his learning and expertise have conferred on him the additional position of guide, teacher, mentor and the beacon to his society. He must expand his role and be the adviser to government and industry. He must bring all these to bear on his research activities, in order to be relevant to, and in his society. This is one way by which we can prevent being out of touch with the problems of our country or when we face indifference, and poor financial support from government and industry.

And fourthly, the Nigerian scientist, in collaboration with the government, must seek relevance in serving and meeting the identified needs of the society. The priority of the Nigerian scientist must be to use science as a channel for all round development and a better life for the neglected majority of the society. Let me share with you the Brazilian experience of using ethanol to replace gasoline as fuel for automobile. By encouraging the wide use of ethanol produced from sugarcane, a traditional crop in the country, as fuel to replace gasoline, the government of Brazil was able replace half of the gasoline used by automobiles in the country (about 200,000

barrels of ethanol per day) with a renewable energy source. In so doing, Brazil became a pioneer in an area that had been neglected by industrialized countries.

The entire technology; from the agricultural to the industrial phase, was developed or improved upon by local scientists and technologists. Brazilian scientists first had to convince the government that this approach was technically feasible, even though it had been ignored in industrialized countries. To do this, they had to address questions regarding motor technology, environmental concerns, and the trade-off between raising crops for food versus fuel. It is important that we must avoid the attraction of costly, but ineffective, programs and establish a system that rewards solving practical problems. If we are to be relevant to the society, we must train scientists with relevant vision to tackle society issues and problems. Our universities need to have another look at the training given to our scientists. I believed I had a better training in science in my secondary school than the present crop of natural scientists being churned out of our universities and their "comer side, pepper soup" satellite campuses, Currently, whether trained at home or abroad, the Nigerian scientist seeks to advance science and scientific knowledge primarily from a global perspective. Thinking globally, he often does not, or cannot, act locally. He serves the scientific community responsible for his training and which provides the instruments of his trade. Rarely breaking away from the tradition of his apprenticeship, he is detached from the needs of the society responsible for funding his training. The society, finding him irrelevant to its day-to-day problems, discards the scientist, who in turn seeks relevance in foreign countries where he is appreciated for his "global" skills." We need to end the isolation of our universities and research centres from the rest of the country and society. We need to get our universities and research centres out of tile ivory towers, which are more connected to research centres in Europe or the United States. We need to get them to focus on the obvious needs of industry, agriculture, and education in our country. So far, Nigeria has not appointed a vulcanizer as Minister of Science and Technology, but if we fail to be relevant, the saving of Nigeria may come through the bricklayer Minister of Science and Technology.

THE WAY FORWARD FOR THE SOCIETY-GOVERNMENT AND INDUSTRY

I will divide this into two groups: the government and industry, and the society at large. In spite of government-declared intentions, the Nigerian government has a lackadaisical attitude, a laissez-faire approach and disinterested excitement about science and technology in Nigeria. It is difficult to believe, going by past history of government support for science in Nigeria, that any Nigerian government, past and present, sees any significant role for science in the transformation of the Nigerian society.

We expect our governments to stop playing lip service to the development of science in Nigeria; we look forward to a government that will see science as an instrument for improving each aspect of our chilly living. One should not expect industry to support fundamental research because some of it may take more than fifty years to reap any benefits. Not many shareholders will benefit from such a long time investment. However, a government of the people, by the people, and for the people, a government that is literarily forever, has time on its hand to lay the

foundation for a legacy of scientific achievement and economic prosperity.

From what we see around us, in Abuja and many state capitals, it is clear that we can afford to spend more on science. If we want to move Nigeria to this modern age of technology, and continue to enjoy a technologically-based economy, then we need to spend more on scientific development. The two elements preventing our dear country from deriving benefits from science and technology are the will and the vision to bet on the scientific enterprise. Our governments must appreciate that supporting science makes money and brings tangible monetary benefits. Government must work with industry for Nigeria to derive maximum benefits from science and technology. However, it is the scientists who must educate both government and industry on the benefits of supporting science.

THE WAY FORWARD FOR THE SOCIETY AT LARGE

The society at large must demand, as of right, a better and improved standard of living from the government and scientists. The public must work with government and scientists in ensuring that science is made public property and available in the public domain. Society must demand from government and scientists that our children receive appropriate science education. Society must ensure that our children spend more time in zoos and natural history museums than they spend in disco and cinema halls. Our industries should sponsor scientific programmes rather than sponsor "Fadeyi oloro" type of films on our television screens. The society must work hand in hand with the government and industry in setting science-based developmental targets. We must neither separate society from science nor science from the society. On the issue of public enlightenment, I see a huge role for the Academy, the various scientific associations, as well as ministries such as those of Science and Technology, Education, Information, Youths and Sports. A positive role in scientific enlightenment of the public can be found for some of the First Lady organizations all over the country, desperately struggling to be relevant.

CONCLUSION

Distinguished Ladies and gentlemen, on Friday, November 23 2001, the Nigerian High Commissioner to Zimbabwe, hosted Chief Shonekan, Chairman of the Interim National Government to a reception. As always happens when two or three Nigerians are gathered, you can be sure they will discuss Nigeria. At the end of the reception, Chief Shonekan reviewed his tenure as the UAC Chief Executive, his brief stint as the Head of State, and a few other things. He mentioned how he led a group of Nigerians, and for ten months, they turned the searchlight on the question: What is wrong with us? At the end of the ten months, this group of eminent Nigerians, from all walks of life, produced the Vision 2010 document. This document was submitted to the same man that pushed Chief Shonekan aside, and accordirig to Chief Shonekan, he accepted the document without a word! When the Vision 2010 group was set up, Chief Shonekan was of the belief that Nigeria still had time to turn her destiny around by the time of the 50th independence anniversary in 2010. The document was submitted some five or six years ago: we have eight years to 2010. History has shown that when a group of people or a nation was willing to change, it reinvented itself in a new process of creative thinking. I believe Vision 2010 was a first

of hundreds of steps we need to take to change Nigeria. But, how many of us here in this hall, know the contents of the Vision 2010 document? How many of us are involved in the implementation of that vision? Knowing my country that Vision will be our illusion and the mirage in the desert, come 2010. It is not that we have no bright ideas, nor is it that we do not have solutions to the problems that confront us. I think we are a nation that can just not be bothered with development. We seem to consider many things more important than enhancing the status our life, improving our health, making our cities safe.

Consequently, Nigeria has refused to invest in science and technology as a means of transforming the country and the society into a prosperous nation and improving the life of the people. Rather Nigeria has opted for a wholesale importation of technology without funding its adaptation to meet the needs of the country. Nigeria continues to export her best in human resources to develop other parts of the world, while ensuring that the home environment renders these same human resources impotent and irrelevant. We are a nation of scientifically and technologically backward people, writhing in ignorance and sliding back to the stone age of underdevelopment. The Nigerian society must demand a better life from her government. The government must show that it cares for her people by providing funds to support science and its application to technologically advance Nigeria. As the Academy celebrates the 25th anniversary, we need to look back and consider what our society expects from us, and what we need to do to fulfill the aspirations of the society. We have buried our heads in the sands, for for too long. Now is the time to exhume our heads from the sand of ignorance, or else we will remain irrelevant like the African cow that went to Exeter and came back as excreta. Distinguished ladies and gentlemen, thank you 'very much for your attention and patience.

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ENVIRONMENTAL DEGRADATION WITH PARTICULAR REFERENCE TO THE SUB-HUMID AND ARIPARTS OF NIGERIA: PROSPECTS FOR CONSERVATION

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(Fourth Sir Kashim Ibrahim Memorial Lecture, July 2000)

1.0 Introduction

Natural resources are our most valuable inheritance. Indeed the increased interest in the environment today testifies to the common interest and commitment in the promotion and the protection of this heritage. This is particularly in view of the past years of drought when many came to realize the importance of conservation in the socioeconomic and political well being of our society. As the result of increased awareness of environmental problems and the recent considerations, the new Federal Ministry of Environment (FMEN) now takes precedence over the Environmental Protection Agency (FEPA) which is being integrated into FMEN. Ecological Disaster Fund, Nigeria Conservation Foundation, and the National Committee on Drought and Desertification Control have now consolidated their mandates on environmental problems. In this regard, the formation of environmental clubs adds to the growing number of groups playing the necessary leadership roles in this important endeavour. Indeed the conservation issue should presently be the preoccupation of Nigerians.

Conservation of degraded natural resources is basic to the principles of ecology that, in the energy stratification phenomenon of the world's total standing biomes, the primary producers, the green plants, are the foundation of the food chain. When this foundation is threatened, all of us are threatened as vividly seen during periods of drought. The priority action required now is for us to embark on effective planning and management of the natural resources so as to secure their prudent use and continuity of supply, while maintaining and enhancing their quality, value, and diversity of the flora, fauna and the physio-geographical features of our environment.

Natural resources, of course consist of more than forest, vegetation and wildlife. According to Gerasimov et al (1971), "natural resources are those varied raw materials that man derives directly from nature and by means of which he sustains his livelihood. These resources are the natural vegetation and animal life that provide man with food and industrial raw materials; the

air he breathes; the soil that nurtures his crops; the water he drinks and uses in agriculture, industry and power production; the ores he smelts; the rocks with which he builds his houses; the coal and oil that serve as domestic fuel and provide energy for his machines; and much more."

Broadly, and according to Gerasimov, natural resources could be categorized into three groups: non-renewable, renewable, and inexhaustible. Among non- renewable ones are a large number of valuable minerals such as gold, iron ore, coal, oil, etc. Their use will lead to exhaustion unless new deposits and reserves are worked. Salt is an exception in this case, as it could be precipitated out of lakes and lagoons of salty water. Renewable resources include soil, natural vegetation, and animal life. They are continuously replaced by nature as they are utilized; their use may however exceed supply. The inexhaustible natural resources include water and climate (solar radiation and wind). Their use may not lead to depletion but unskilled or careless use of these resources may lead to their pollution, lowering of quality and undesirable distribution. In the case of water, it may lead to exhaustion.

2.0 Environmental Degradation Means Loss of Asset

By the effect of the recent changes in climate, inhabitants of the Sahel, for example, should be very understanding of the urgent need for conservation since we live in constant danger of drought and desertification. The Sahelian ecosystem, in which much of Nigeria north of 12° N latitude is now located, is considered one of the world's most fragile environments, constantly being claimed by the southward movement of the great Sahara desert. Nigeria is known to be losing about 351,000 square kilometres to the desert, representing 38% of its total landmass. The rate of desertification however, is subjective and is estimated at 1.0 to 38 kilometres per year. This spread in value is acceptable in view of the fact that desert movement is erratic and depends on the variable factors and the locations measured.

The causal factors for the continued degradation of our environment are man-made, natural, and multifarious. In this context, desertification is one of the major agents which, although aggravated by natural phenomenon such as drought, is primarily caused by the activities of man in the environment. More than 30 million people (which is about 32% of the total population of the country) live in the Sahel under the hardship of desertification. This has not however, featured prominently in international circles perhaps because of Nigeria's size, geography, and relative wealth. It may also be due to lack of publicity at the international level or due to the resilience of the enduring and determined people of the affected area. Nevertheless, three-quarters of the land area of the Sahelian states of the nation, for example Borno, Yobe, Bauchi, Jigawa, Kano, Katsina, Zamfara, Kebbi and Sokoto States are severely threatened by desertification. Nationally, however, soil erosion and coastal erosion are rampant in the South- South, East-Central and Southwest States; while environmental pollution is a major threat in the South-South, causing social unrest. Population pressure in Sahelian Nigeria, as elsewhere in the country, is also on the increase.

The scenario is that, with increase in scientific awareness, the problem of death decreases due

to improved medical services; improved law enforcement should reduce crime and warfare; consequently, increase in population growth requires increase in both quantity and quality of food, forcing farmers to clear virgin lands for crop cultivation and for domestic and commercial fuel. The pressure also induces increasingly intensified use of fragile land resources leading to their degradation and destruction. In this situation desertification and land degradation process continues to occur resulting in unproductive agriculture, even in normal to good rainfall years. With no major breakthrough in the development of appropriate and acceptable alternative sources of energy, fuel wood continues to be in great demand by the increasing population in urban centres despite the existence of Felling of Tree (Control) Edicts in the various states. In fact, the United Nations Sudan-Sahel Office (UNSO) ranks forest depletion as the major agent of desertification in Nigeria (Table 1). Therefore, due to demand for construction, building, fuel, fishing industry and other uses, removal of trees, shrubs, herbaceous plants, and grass cover from the fragile land of the Sahel, indeed in all parts of Nigeria, will continue to accelerate the degradation of the soil to poor conditions, thereby reducing sustainable agricultural production.

Livestock is another important agent of desertification and yet very little is at present known on the changing distribution and numbers of livestock in Nigeria. There are no reliable and up-to-date data on the populations and production systems in the country, particularly in the Sahelian states that are known to produce over 50% of all the livestock of Nigeria. This is despite the recent extensive area survey conducted by the Livestock Department of the Federal Ministry of Agriculture and Natural Resources. It is actually paradoxical that, livestock which requires good grass fodder and browse, is the main destructive force of the range lands. Of special concern also is the rapid population increase of goats in the country, particularly in the Sahel. These are known to inflict considerable effects in overgrazing and the degradation process of the range and browse, thereby accelerating desertification (Table 2).

Bush burning, which is a very frequent phenomenon in the range lands, may occur as hunters set fire to the bush, farmers clear farming lands, or herders annually burn the vegetation in order to stimulate early growth of shoots for livestock grazing. These practices are not systematically controlled and invariably constitute great damage to the environment. Bush burning is known to cause loss of soil minerals because of loss of organic materials; sun drying and rain splashing, thereby favouring laterization; reduction in rain water infiltration rates and higher run off; preponderance of laterite gravel as a result of reduced organic matter; and increase in erosion. In all the above cases, the activity of man is central to the processes of degradation.

As stated earlier, the recent drought of more than twenty years (1968-1990) in the Sahel of Africa has accentuated the process of debilitating desertification in the region. Also as defined elsewhere, drought is a condition of below normal rainfall insufficient to meet the moisture requirements of living organisms and agricultural production which is brought about by abnormal climate, leading to disastrous economic and social consequences. Furthermore, hydrological drought is a condition of sustained deficit in surface runoff below normal condition and

depletion of groundwater levels. The three types of drought: meteorological, hydrological, and agricultural have been manifested in Nigeria during the past years with the hydrological one persisting around urban centres due to over population; and in the river systems, due to over utility and the uncoordinated development of upstream dams in the region. All these directly or indirectly result in the lowering of biological productive potential of the land. From past experience however, it is now becoming quite clear that drought must be looked upon in the Sahel as part of the region's climate and a recurring phenomenon which should be taken into full account in developmental planning for agriculture, agroforestry and land use. It is now clear that water resources and its conservation and management are the key to desertification control in Nigeria and should be seriously assessed in greater detail.

Because of the express interest in the agents of aridity by the community, we have so far emphasized conditions of threat by desertification and drought. However, Nigeria as a whole should now be considered an ecological disaster area and that priority discussion should be on environmental protection. We find present in the country a wide range of climate and vegetation zones, but that the biotic zones are continually under some forms of threat. The ocean is eating up the coastal zone with the associated processes of coastal erosion. Our forests, both in the north and the south are fast disappearing. The middle belt of Nigeria is being decimated by wood harvesting and now overgrazing as this is opened up for more livestock. Gully and sheet erosions are rampant in the whole of the country. Urban solid waste pollution are rampant, with cases of petroleum pollution reported in the South-South. There is therefore no doubt that these ecological disasters with their consequential negative economic effects have aroused the concern of the generality of the people to the dangers of environmental degradation.

It is now clear that the extent of ecological disaster in Nigeria is beyond any one tier of government to cope with the problem, in addition to the normal requirements of governance and the provision of basic amenities for its citizens. Action for the attenuation of these problems must also be approached with cooperation at multi-sectoral and multidisciplinary levels with determined inputs by federal, state and local governments in collaboration with non-governmental organizations (NGOs) and various conservation clubs. Priority mobilization of the masses as by the defunct Mass Mobilization for Social and Economic Recovery (MAMSER) and/or other relevant government agencies, is an absolute necessity for long-term planning in view of the geographical expanse that is affected.

The youth must fully and actively participate through social activities such as conservation clubs. In my years in the university system in Nigeria, I have observed that in the decades 1960, 1970, and 1980, much of the energies of the youth had appropriately been invested in activities concerned with liberation and freedom for Africa. In this regard, I salute the youth of Africa, as the battle has effectively been won. We now salute the Nigerian youth with fresh anticipation for taking on a new battle, a new war, against ecological and environmental degradation in Nigeria in the new millennium 2000. I salute the youth of this nation for the early realization that the conservation of our valuable natural resources is survival itself

3.0 Threat to Biodiversity

The need to conserve the diverse biological diversity (biodiversity) of Nigeria is without any question very timely as it is now a matter for global concern, deserving a United Nations Convention. Nigeria is a signatory to the Convention. As shown in the ecological zones distribution map of Nigeria (Figure 1), it is a feat that the country is blessed with communities replete in richness of diversity. Each stock of species could however be threatened at any time. According to Huggett (1997), species would naturally have survival crisis, and a biotic crisis occurs when the species biodiversity reaches a point and falls to a lower level. In a mid crisis situation, it involves an elevated turnover of species. In a severe crisis situation however, it involves a loss of 20% or more of all the species. This reaches a mass extinction level when the crisis acts globally.

Causes that would reduce biodiversity include climate change, reduced productivity due to the deterioration of the environment, or disaster in the biosphere due to an impact event, usually cosmic in nature. Many other causes are due to earth movements such as continental drift, volcanism, sea level change, etc. Although extinction is to be taken as part of life for the species (Moore et al, 1996), the advanced knowledge of the humans must be used to ameliorate some of the problems. In Germany, for instance, much of the countryside was denuded of much of the forest cover not more than 100 years ago; today uncultivated public lands are covered by forests or vegetation due to the determined efforts of the people and their governments.

In Nigeria, the recent studies of the Forest Management Evaluation and Coordination Unit (FORMECU) on land use and vegetation cover of 1976/78 with a repeat in 1993/95, revealed an alarming rate of environmental degradation in this country (Figure 2). It was suspected since the early 1990s that the benigned neglect of forestry development matters during the period of the military rule in Nigeria has had negative effects on the vegetation cover of the nation. Therefore, the timely land use and vegetation cover studies of Nigeria for the periods 1976/78 and 1993/1995 by the Forestry Management Evaluation and Coordination Unit (FORMECU) of Federal Department of Forestry, offers the most tangible data on the state of the forest and vegetation cover of the country. As earlier stated, it must be mentioned here again that by 1975, the vegetation cover of the nation was already in a devastated state of destruction. According to FORMECU, the change recorded during an interval period of 15 years (1978 to 1995) is staggering, with 32% of the 1978 reparian vegetation cover removed by 1995 (Figure 3 (a) and (b). In respect to actual forest cover changes, 20% of that of 1978 was lost within the 15 year-period (Figure 4 (a) and (b); this is equivalent to about 10,000 square km which, according to Huggett (1997), should be considered a severe biotic crisis. So far, the replenishing effect of forest plantations, which was about 2000 km square for the same period, had negligible impact.

It is important to emphasize here, the significant effect of forest on climate. According to Worell (1959), a 20% forest cover would replenish 40% to 50% of stable water runoff supply of a river. A 40% forest cover will contribute 80% to 90% of the water runoff. This means that 1% of forested area provides 2% to 2.5% of the stable water supply of the river basin. It is also stated that for every additional 10% forested area in the windward portion of the region causes a 10%

increase in precipitation.

The loss in woodland/shrub/grassland of the Savannas is equally staggering. In the 15 years, about 29% of such cover was lost (Figure 5 (a) and (b). Interestingly, increase in agricultural land use is only 15% during the same period. A big factor may be constraints associated with the availability of arable lands as these changes must be viewed against other factors such as increase in population (both human and livestock), land tenure, and the general degradation of the environment. The population of Nigeria was about 50 million people in 1963; it increased to over 80 million in 1975 when the effects of the devastating drought of 1968/73 were still very much being felt.

It is in the light of the above general environmental degradation that Figure 6 must be viewed with very serious concern. Although the increase in the distribution of alluvial and rock outcrops degradation was slight, those of gullies and sand dunes increased tremendously by 1200% and 530% respectively. These are very serious and unprecedented environmental changes and FORMECU indeed deserves commendation for a job well done in documenting and providing data on this disaster of serious magnitude for the nation. The grim picture provided supports the views of Adewoye (1998) that the nation's biodiversity was fast decreasing and that 484 plant types of the 4,600 species recorded in Nigeria are threatened with extinction primarily due to desertification. Forest cover for Nigeria now is less than 10%; whereas the United Nations recommends a minimum of 20%.

What is of paramount importance now is for the newly established Federal Ministry of Environment to be given all the support by the governments and the people of Nigeria to carry out its important responsibilities of environmental policy consolidation, repairs, protection and development. In this regard, this is the time for the review and the implementation of the stale environmental laws of Nigeria. The planned review of the existing forestry laws by the Federal Ministry of Environment or by the Nigerian Conservation Foundation is welcome. The final document, when ready, should be submitted to the Committee on Environment, House of Representatives as a memorandum for legislation at the earliest opportunity.

4.0 Loss of Economic Base

From the economic point of view, it was stated that forests contribute between 1.3% to 3.0% of the GDP and over 10% of the food supply of the rural population of Nigeria. Timber is a valuable asset, bringing in millions of naira each year and yet such a resource is presently under difficult ecological predicament. Perhaps the research and observation of Vasilyev (1971) on the use of forest resource under well managed conditions as seen from his work in Russia, illustrates this point. To him, forest cover should match resources utility as follows:

Forest Cover Percentage Resources	*Possible Use of Forest*
(1) Under 5% to 6% forest cover	Usually sufficient tb protect fields from dust

	storms and erosion in an area where desiccation is not a severe problems; such cover does not provide significant local source of timber.
(2) Cover of 8% to 10%	Protects fields as in (1) and possible timber supply farms of the community.
(3) Cover of 10% to 15%	Will serve the purpose of (1) and (2) and sufficient to satisfy regional needs and some construction materials
(4) Cover of 20% to 25%	Will have the foregoing function as in (1) to (3) and support some forest processing industry.
(5) Cover of more than 25%	Will provide the possibility of exporting raw materials or some processed forest products.

Although the indicators were based on Russian experience, it is applicable internationally. It may however vary with natural conditions, productivity and quality of the forest, the demand and the specialization of the economy, and the local availability of other necessary supplies such as different types of fuels. By the standards recommended above however, Nigeria has no business exporting timber at the present or in the near future until the situation is greatly improved.

As for wildlife as products of the forest, the traditional use of this resource as food delicacy is long rooted with high consumption of "bush" meat throughout the country. It is estimated that game meat constitutes 25% of all the meat annual consumption of animal products in rural areas (Ajayi, 1971). Mead (1970) also estimated that bush meat (including fish) worth US 35 million (N3.5 billion) per year constituted about 85% of all the animal products consumed in the southern states.

Reports had however indicated as early as the 1960s that about 20-25% of all meat consumed in the northern part of Nigeria comes from wild animals compared to 30-85% in the Eastern part of the country. It is clear from the above that forest and wildlife resources contribute immensely to the economic well being of the nation, generating billions of naira of business. It must also be mentioned here that ethno/cultural-botany thrives in Nigeria, as plant derivatives as well as wildlife parts, are widely used medicinally. The importance of this is documented by the recent activities of the National Institute for Pharmaceutical Research and Development at Abuja on medicinal plants.

5.0 Threat to Cultural Heritage

Another very important reason why we must conserve natural resources is because of the long standing intimate folklore interaction between the African and the wildlife in his traditional

forest environment as an important aspect of our cultural set up. From superficial argument, it may not seem appropriate to include this section as contributory factor to the preservation of wildlife. It is nonetheless interesting to note that the period of most rapid wildlife development in Nigeria coincides with exchanges in cultural activities in Africa with the Black Arts and Cultural Festivals in Senegal (1966) and Nigeria (1977). It is indeed because of the increasing awareness of the significant contribution of animals to the African culture that, but for the inadequacy of funds, an exhibition of selected mounted animals would have been staged at the 2nd World Black and African Festival of Arts and Culture held in Lagos, Nigeria.

It is recognized that in this era of cultural renaissance in African heritage, the projection of the long-standing impact of animal impersonation and characterization, which are deeply rooted in African folklore, proverbs, and myths, is justifiable. It is not in the scope of this lecture that we discuss how the art of impersonation originated, but perhaps one of the most important underlying factors is that Africans are close and ardent observers of natural phenomena. Naturally, we have easily incorporated the mystiques and habits of wild animals into local legends and beliefs and time has been kind to this process. Furthermore, through anthropological and archeological studies of fossils, it has been indisputably demonstrated that man has evolved in tropical Africa. He has been an integral part of this special fauna interacting with the unique wealth of plants and animals over thousands of years. In fact, no continent is so blessed with such abundance and variety; the slants of large mammals of Africa are just unique.

These animals possess intriguing behaviours, which are specialization that enable them to utilize fully the resources available in various habitats. Consequently, multitudes of "personalities" displayed in the animal kingdom have generously been tapped to create African folklore. We easily interpret their demeanor in terms of human attributes and emotions: goodness, sadness, joy, beauty, mischief delight, mockery, greed, trust, etc. Some of the more common animals are typically characterized through fables of some Nigerian community Recurrently for example, baboon is childish, forceful, ugly tempered imitative. But antelopes (Impala, Thomson's and Dorcas gazelles) embody beauty, grace, speed, and the quintessence of beautiful women. Lions are strong, majestic, and brave and the lioness affectionate, evenhanded, generous. For leopards and cheetah, slyness and shyness, complete descriptions of those they characterized and such people are easily trusted. It is also interesting to note that as sly as they are, these animals are still outwit table.

The elephant represents those that are fat, gluttonous, powerful, imposing and overconfident: attributes that render them vulnerable. Typically, the hyena is always accepted among other animals as adventurous for a nice bone, but the stupid fellow who offers J laughs at cheap jokes, easy to please and/or convince; a rural and municipal sanitary inspector of good standing. In fact the saying goes that "if the vulture speaks to the hyena in proverbs, he understands."

The python is seen as quiet, kindly, slow to judge, and certain actions (such as biting), unbefitting its esteem. In other cultures, strong men are praised by being called "crocodile". Good

wrestlers are also associated with the reptile. Because it lives in water and occasionally found on land, its versatility is linked to a shifty woman who goes to one friend today and seen with another the next day.

Warthogs are of course the great diggers - the farmers who work hard but live good life. Buffaloes are labeled as fierce, strong, untamable and constantly picking a quarrel; they represent people who are naturally wild; the cousin of the rhino. Squirrels and hares have played the parts of very clever deeds but occasionally pay for fooling others. Dogs are born messengers who make side business while on duty or who are "robbed" of the message on the way. The tortoise too features prominently in Africa folklore; its slow but steady personality emits security and wisdom.

The above impersonation and characterizations are but just a few instances to which the reader, particularly African, can add a lot more. The interchangeability of human and animal characters and behaviours, as expressed, in folklore have directly or indirectly influenced our attitudes. Some old day myths even suggest that certain people are possessed of particular sorts of animals which they have no choice but to emulate whether in performing masquerades or in daily life. Such totems would not be killed or eaten by the particular tribe or clan concerned. If one is possessed of a leopard for example, and he is angered, he would tend to act like this personified animal. Indeed, known cases do exist where parents would tie pieces of animal bones around the necks and waists of their children to ensure character development emulating the attributes of the characteristic behaviour of the animals chosen. The legendary relationship that exists between lions and hunters is of course more obvious. It represents professional respect and cooperation, which we might call "labour union". But more mythical situation expressed through stories do exist in that situations did arise when the most beautiful daughters of gods and human kings were given in marriage to animals to honour a promise earlier made, or in appreciation of a difficult job well done. The breaking of the word of honour of those who offered the promise is calamitous upon them.

It could safely be said that there is no African culture without particular myths or fables. Unfortunately, many of the wild animals that share and co-exist in our countries and that have immensely contributed in our legends are nowadays dwindling in population. The state of scarcity of these legendary animals coupled with the cultural reawakening must surely be viewed as a significant factor in the increasing desire to rehabilitate wildlife. The popularity of the recently created zoos at Jos, Kano, Maiduguri, Enugu and Ibadan and the number of Nigerians that annually patronize the more developed parks such as Yankari and Kainji Lake National Parks clearly point to this optimistic direction.

6.0 Prospects of Environmental Conservation for a Sustainable Future

It was in the mid-1970s that the problems of degradation of the environment were seriously appreciated. This was heightened by the drought of 1968 to 1973. By that time the value of the naira, although considered a strong currency internationally, had began to slip. Since then, the

country has not been able to stabilize the naira (N) to reflect its real value. Operating an economy under such a value fluctuating currency condition is difficult. One US dollar ($) is now equivalent to about one hundred naira; it is higher in the parallel market. Whereas one US$ was 0.5 Naira in 1973! Although it is reported that inflation has been stabilised, cost of services is considerably much higher than in 1973. This has subsequently slowed down important conservation programmes. However, despite the mentioned drawbacks, considerable progress has been achieved, particularly in fauna conservation in the 1970s.

Credit must be given to many state governments that had shown determination by investing the available funds in environmental conservation, especially during the Gowon regime. The very impressive shelter belts development in Kano (now Kano and Jigawa States), is a commendable example; in fact, it is said that this has become a satellite beacon because of its prominence. A visit to this amazing achievement, as I did in 1987, leaves one in no doubt that the states are capable of performing and that the present policy that leaves forestry programme implementation to the states is correct and appropriate. In fact, the local government level should be made responsible for the progress of all the environmental projects in their domain. Elsewhere, it is the countries that ensure that projects are carried out for the progress and environmental quality of their communities. As it is, states are too over dependent on the central government for funds; states should do more to generate their financial resources.

The present Federal Government has put environment at the highest level by recently creating a Federal Ministry of Environment. With a dynamic leader in the person of Alhaji (Dr.) Hassan Adamu (Wakilin Adamawa) as the first Honourable Minister of Environment, with the very dedicated Minister of State in the person of Chief (Dr.) I.J. Okopido, there is an excellent prospect for rapid and holistic consolidation of the environmental programmes of the country. The Federal Ministry of Environment may also hasten to ensure the greater participation of international agencies that have immensely contributed in areas of positive activities in sustaining quality environment.

6.1 Partnership in Environmental Conservation

With Nigeria's dynamic leadership at regional and international levels, it is indeed expected that Nigeria would have many bilateral partners including the UN agencies. The country played a major role at the Rio 92 Conference on Environment and Development and in fact facilitated the only Convention to Combat Desertification (CCD) at the Conference. Nigeria has ratified all the environmentally-related conventions of the UN, ie the CCD, the Convention on Biodiversity (C3D) and the one on Climate Change. Unfortunately however, there has been some delays in effecting the National Action Programme which is very important for sourcing external funds, through the UN, for implementing National Action Plan projects. It is in the light of this that the recent Rural Participatory Appraisal Workshop, held in Kano in this regard, is very encouraging. It should be noted that the objective of the National Action Programme (NAP) to Combat Desertification for the country is to develop 'long-term, integrated strategies that focus simultaneously, in affected areas, on improved productivity of land, and the rehabilitation, con-

servation, and sustainable management of land and other resources, leading to improved living conditions, in particular at community level.

In Nigeria, the United Nations Development Programme (UNDP) is the central planning, funding, and coordinating agency for all forms of technical and scientific cooperation on behalf of the UN. The UNDP is a leading agency in promoting environmental quality and development and had sent a team of specialists from Nigeria in 1998 to visit the successful sand dune fixation in the Republic of Mauritania. Other UN agencies that are environmentally-mandated and have, in the past, assisted Nigeria are the United Nations Environmental Programme (UNEP), the United Nations Sudano-Sahelian Office (UNSO) and the United Nations Educational, Scientific and Cultural Organization (UNESCO). The UNESCO has funded Nigeria's National Committee on Man and Biosphere (MAB) over the years and had sponsored workshops and conferences on forestry-related projects. The National Committee has sustained research on the protection of high forest Biosphere Reserve located at Owo in Ondo State through the support of UNESCO.

The World Bank (WB) provides, among others, loan for environmental improvement projects. In the past, the loans obtained for forestry projects, through the Federal Ministry of Agriculture and Natural Resources, have benefited the nation. The Bank's support for Forestry I and II Projects, for instance, had tremendous impact on forestry development in the states. Good examples are the Sokoto State shelter belts development, highway tree protection belts, and the urban tree plantation projects. In all these projects, and to provide proper support, there was adequate development of plant nurseries (of both local and exotic seedlings) in all the states. The Bank has also given support to FEPA (now integrated into the Federal Ministry of Environment) on its important Environmental Monitoring Programme. Through this, all the states in the federation have established their State Environmental Protection Agencies (SEPA) and that, through the defunct FEPA, State Environmental Action Plans (SEAP) have been completed for the states. The significance of this is that every state in the federation now has a set of prioritised environmental programmes for development, awaiting appropriate matching action plans. It must be stated here that the already mentioned successful work of FORMECU on land use and vegetation cover of the country was supported by the African Development Bank.

Other external agencies and governments that have supported environmental projects in the country are the European Union (EU), the governments of Japan, Canada, and the United Kingdom. The Katsina Rural Afforestation Project supported by the EU has been a major success worthy of mention. It is comparable in quality to the EU's most successful project in the country so far - the North-East Arid Zone Development Programme. The Kafaka Forest Development Project in Kaduna State has earned the Japanese some respect but they have not ventured to go further north to tackle the real challenges of desertification. The Canadians have so far concentrated on NGO support and research linkage programmes. They are noted for the sustained support given to the Nigerian Environmental Study/Action Team (NEST) which has been successful in public enlightenment and workshops on various environmental problems of

Nigeria. The British generally supported small but very meaningful projects, research linkages, and training.

Internally, many new NGOs have been established and are active in environmental issues in the nation. One such NGO based in Kaduna, is the National Forests Conservation Council of Nigeria (NAFCCON) that seeks to promote the use of coal and coal briquettes in order to attenuate the present overdependence on fuel wood. This and all other Nigeria-based NGOs should seek to register with the FMEN in order to facilitate information networking. It is strongly recommended that the FMEN should create a special desk for environmental NGOs in the Ministry.

6.2 Vegetation Cover Sustenance

As shown earlier, the vegetation cover of Nigeria, particularly in the guinea savanna, is being decimated and that no sustained concerted effort had been made to stabilize or rehabilitate vegetation cover nationally. Nigeria occupies a total area of about 933,213km square extending from latitude 4° to 14° north and from latitude 2° to 14o east. The human population is about 120 million with average population density of 450 people per square km. The natural vegetation (Figure 2) has been altered by man through various activities including agriculture, bush burning, and logging. Over the years, the forest areas had decreased from 14.9 million ha. in 1980 to 10 million ha. in 1990, and to about 9.5 million ha. in 1996. This is far below the 10 million ha. certified by the World Wide Fund for Nature (WWF) in 1998 and for which it would target 25 million ha. by the year 2001.

6.3 Forest Reservation

Recently, there are about 1,275 registered forest reserves covering over 9.3 million hectares occurring in all the vegetation belts of Nigeria (Figure 8). The protection and management of the forest reserves fall under the authority of state departments of forestry, except the national parks, which are managed by the federal government under the auspices of the National Parks Board. Over 469,422 ha. of forest estates were de-reserved by 1994 for agriculture and public infrastructures. The area occupied by forest plantations is about 278,600 ha. Both the natural forests and plantations are expected to supply about 76.6 million m3 for fuel wood, poles, saw logs, veneer logs and pulpwood by the year 2000. Along with wildlife and bio-diversity conservation, plantations of indigenous and exotic species of trees are established to meet the expected demands for forest products as food, medicine, fuel wood, timber, gum, oil and environmental conservation. The forests contribute between 1.3% and 3% to the GDP and over 10% of the food supply of the rural population of Nigeria.

The colonial administration considered it necessary, around 1904, to reserve some of the good quality forests to stop their destruction. A target of 25% of the country's land area was earmarked for reservation. Although Mr Thompson (the first Conservator of Forest in Nigeria) successfully organised the forestry department, he achieved little on forest reservation because of widespread stiff resistance of local communities who rightly established their claims to the

land. When Thompson finally left Nigeria in 1915, only 9% of the country's land area had been put under forest reservation. Between then and now, only an additional 1% reservation areas was achieved, bringing the proportion of forest reserve to 10% of Nigeria's land area. Apart from the crucial role which forestry is playing in the economic development of Nigeria as a whole, the sub-sector has high potentials for accelerating development in rural Nigeria. With adequate funding, the under-utilized land and manpower resources of the rural sector could be put into economic production through forestry.

6.4 The Role of the Federal Department of Forestry

The Federal Department of Forestry (FDF) was created in 1970 as an arm of the Federal Ministry of Agriculture and Natural Resources recently transferred to the Federal Ministry of Environment. It co-ordinates forestry activities in Nigeria. The specific functions are to:

(1) Advise the Federal Government on forestry development and liaise with the state Forestry Services;
(2) Ensure the sound and efficient management of forests for sustainable production of forest goods and services;
(3) Co-ordinate all forest matters as they relate to conservation, protection, environment, exploitation, utilization and renewal of forest resources;
(4) Co-ordinate Nigeria's collaboration with international organizations on forestry matters;
(5) Institute forest policy formulation;
(6) Provide extension and advisory services to the states for the improvement and promotion of forestry practice;
(7) Assist in monitoring, evaluation, and appraisal of forestry projects;
(8) Promote and enhance the development of forest management capability;
(9) Promote manpower development and institutional capacity building.

Each state of the federation operates a forestry department within the appropriate Ministry. Most of the work in forestry is carried out at the state and local government levels. The Federal Department of Forestry co-ordinates forestry activities while the Forestry Research Institute of Nigeria (FRIN) is responsible for research and training of technical and vocational staff. Professional courses are offered in various universities located at Ibadan, Benin, Abeokuta, Maiduguri, Makurdi, Umudike, Akure, Calabar, Sokoto, Port Harcourt, etc.

6.5 Wildlife Conservation Prospects

The policy and programmes for conserving wildlife presently differs from that of forestry in that the federal government's current policy tends to favour a centralised approach to fauna conservation. Perhaps this is influenced by recent activities, especially of the Nigerian Conservation Foundation and the subsequent creation of the National Parks Board.

In view of the obviously threatened status of forest resources in Nigeria, there has been, no

doubt, a state of uncertainty concerning fauna and wildlife conservation and development due largely to ecological changes, the dwindling financial resources and the dearth of specialist manpower in this area. Occasional creation of additional states for the country further compounds the problem in that no one state has the financial and managerial capacity to adequately maintain the forest reserves, game reserves, and animal sanctuaries under their protection and care at minimum acceptable standards. Future prospects have however been made to appear promising and or favourable by the federal government in establishing the Nigeria National Parks Board in 1991 with its Headquarters in Abuja. This Board, of course, will be performing its duties in conjunction with the mandated government establishments such as Department of Forestry in the Ministry of Agriculture (federal and states), appropriate departments under the new Federal Ministry of Environment, Nigerian Educational Research and Development Council for environmental education curricula development, and many NGOs, other parastatals and private companies too numerous to mention here.

6.6 The Nigerian Conservation Foundation

This organisation was established in 1982 with legal instrument of operations by Decree No. 11 of 1985. The Headquarters of this non-governmental organisation (NGO) is sited at Lekki Conservation Centre on the Lekki Peninsula (Kilometre 19, Lagos-Epe Expressway) for partnership with government and other agencies. The main objective of the Foundation is to ensure entrenchment of a conservation ethic in the citizens of Nigeria, thereby arousing the necessity for prudent management of the rich natural resources heritage of the land. Its national reach has been possible and successful through public awareness campaigns mounted by the Foundation since 1984. The remarkable achievements in the short period of its existence is surely attributed to the able leadership of Chief S.L. Edu (President of the Foundation), Izoma P.C. Asiodu (Chairman), past and present Executive Directors, and the able staff of the Foundation (NCF Annual Report 1997).

At the policy level, this unique non-governmental organisation (NGO), in collaboration with other agencies, has been a moving force in the realisation of the following:

(1) The promulgation of Decree No. 11 of 1985 prohibiting hunting, capture and trade in chimpanzee, gorilla, crocodile, monitor, leopard, python, parrot and others;
(2) Creation of Natural Resources Conservation Council, 1996;
(3) Establishment of Federal Environmental Protection Agency, 1988;
(4) Establishment of National Parks Services and the creation of six National Parks of Nigeria in 1991;
(5) Pre-conference national meetings in preparation for the United Nations; Conference on Environment and Development (UNCED) in Rio, 1992;
(6) Decision on the stoppage of Kaffein - Zaki Dam construction, 1993
(7) Selection of RAMSAR sites; and
(8) Revision of National Forestry Laws

Also, the conservation activities of the NCF have been commendable. In particular, the feder-

al government adoption of the National Conservation Education Strategy in 1988 proposed by the NCF was a milestone in the development of environmental education in Nigeria. The Foundation actively and fully participated in training workshops and awareness seminars organised for school pre-service teachers, in-service teachers, and administrators in view of their key roles in the programme. The belief of the organisation that education in environment is essential for a sustainable Nigerian environment, is manifested in the consistent manner they have ensured the production of their valuable proceedings on these activities (Lawal and Mohammed 1990-91 & 1992-1993). Through this diligent partnership effort, the Nigerian Educational Research and Development Council (NERDC) is able to develop the environmental education syllabi for primary school, junior secondary school, and senior secondary school levels. The National Council on Education in July 1998 approved these, along with the non-formal education one.

Another source of visible activity and impact in partnership, with Worldwide fund for Nature (WWW), is in conservation field work which is aimed at preserving Nigeria's rich biological diversity. Some of these include:

(1) Restoration and maintenance of the ecological values and functions of the flood plains ecosystem of Hadejia-Nguru wetlands as a special habitation for birds and their conservation.
(2) Sustenance of the Lekki Conservation Centre - an Environmental Education Resource Centre in special habitat protection and maintenance, research, education and community awareness programmes as example of unique mixture of coastal swamp forest and derived grassland.
(3) Participating in conservation effort with regard to Okomu wildlife sanctuary (Edate), home of the endangered white throated monkey (Cercopithecus erythrogaster) and many tropical forest economic trees.
(4) Improved management at Gashaka Gumti National Park through strengthening national park management systems of the National Parks Service to enhance habitat protection in this rugged but beautiful Park, harbouring some of the rarest primate species in Africa.
(5) Effort (in collaboration with WWF) towards having Cross River National Park recognized as a World Heritage site for its internationally acclaimed biological diversity.
(6) Integrated conservation and rural development at Stubbs Creek Forest Reserve for the sustainable utilization of coastal mangrove and rain forest resources.

NCF maintains publication of a conservation magazine, *TORTOISE* for the readership of the youth but also it is to be instructive reading for the adult. Its youth and environment essay competition is nationally acclaimed. The chairman of the Foundation (Chief P.C. Asiodu) sponsors this in collaboration with many private companies (Mohammed and Oyewole, 1997). These commendable efforts have further popularized the cause of environmental conservation with the potential of encouraging formation of conservation clubs in schools. It is gratifying to also note that the attention of NCF is now focused on the tertiary institution level (Lawal and

Mohammed, 1997) for curriculum development. Because of its tremendous success in implementing its project and generating national and international funds to support its mandates, NCF is now an Associate of Worldwide Fund for Nature of Britain for fund raising, awareness programmes and conservation project. NCF has since collaborated with many other international friendly agencies and bodies. It is however proper at this point to mention AG. Leventis Foundation for its assistance at the early stage of the establishment of NCF. Also the beautiful headquarters of the NCF at Lekki Peninsula was built and donated by Chevron.

6.7 The Game Reserves and National Parks of Nigeria

Lawan Marguba, the Director and Chief Executive of National Parks of Nigeria describes national parks as large natural areas of land/or sea (water) set aside to protect the ecological integrity of one or more ecosystems for present and future generations (Marguba, 1997). A national park should be free from exploitation or occupation inimical to the purpose for which it was created. It is also to provide scientific educational, recreational and spiritual wellbeing for all concerned in an environmentally friendly and culturally compatible manner. Besides the Lake Kainji National Park which came into being in 1975, five other national parks were created in ‘ °9 \ in Nigeria and legally backed by the promulgation of Decree No. 36 in the same year. This positively confirmed the seriousness of the Federal Government in purposeful nature conservation especially in areas of special and threatened flora and fauna. The objectives of the Nigeria National Parks are to:

(1) Conserve, preserve and protect the indigenous Nigerian flora and fauna resources in selected ecological enclaves for the benefit of the present and future generations;
(2) Enhance the regeneration of the unique natural heritage, some of which are already endangered and threatened with extinction;
(3) Stabilize the environment and forestall adverse effects of climate and changes brought about by modernisation;
(4) Cultivate the recreation culture amongst Nigerians and promote aesthetic and tourism values of our unique natural heritage for sound economic, social, and cultural development. Boost ecotourism; and,
(5) Generally, fulfill the terms of international conventions in the conservation of natural resources to which Nigeria is a signatory.

This is indeed in line with the several global protection conventions signed by Nigeria. The rich biological diversity (biodiversity) in Nigeria's ecosystem deserves this attention as the country is blessed with a wide variety of habitats due to its broad climatic variations earlier shown in Figure 2. Nigeria, therefore, has one of the richest biodiversity in the world. According to Marguba, the varied habitats support about 4600 plant species; more than 1,340 species of animals (at least 274 of these are mammals); and 831 bird species.

The six initial National Parks are: - Kainji Lake complex (Borgu, Zugurma); Yankari; Chad Basin complex (Bulatura Oasis, Chingurmi-Duguma, Dagona/Bade Nguru Wetlands); Gasha-

ka - Gumti; Cross River complex (Oban Hills, Okwango); and Old Oyo. Each of these would be at its peculiar developmental stage but a closer examination reveals commonality of purpose.

Other new developments deserving mention here are the NCF's Lekki Conservation Centre built in 1993 as its headquarters and a 78-hectare reserve created by NCF near the centre. This is for the conservation of flora and fauna in wetland threatened by land development on Lekki Peninsula.

6.8 Education and Public Enlightenment

Protection of game by written law is not good enough. Therefore efforts should be made to extensively educate and enlighten the general public on the usefulness of creating reserve areas for our wildlife heritage through pamphlets, as well as radio and television programmes translated into several Nigerian languages as the NCF has already done. In planning of reservation areas, those citizens affected should not only be compensated for properties lost, but should be integrated and utilized in the conservation scheme as labourers, technicians, law enforcement agents, rangers, etc (Gadzama et al, 1974; Gadzama, 1976). With careful planning, their meat requirements should be supplemented by seasonal cropping so that the temptation to poach the existing animals is minimized. Establishment of museums of national history will greatly assist in the process of enlightening the public on this topic.

6.9 Ranching and Cropping

It is conceivable that with time, the carrying capacity of some of the game reserves such as Borgu, Yankari, Pai and other wilderness reservation areas will have reached population level that cropping may be a reality, considering meat demands and the effect of overcrowding on the environment. A good example of a cropping scheme is that of the old Russian native Saiga antelope (Saiga tatation) which was allowed to graze a piece of land in Kazakhstan steppe and where hunting was prohibited and research into its biology and husbandry was instituted. From an almost extinct stock of only 300 individuals in 1919 about 12 million animals yielding 7,000 tons of meat yearly was generated (Fry and Callender, 1974). Nigeria has the land, resources, and the right type of wildlife (Resevear, 1953) to institute a cropping scheme since such antelopes as hartebeest, roan, kob and other ungulates such as buffalo, are still well distributed in the Savanna zones and are observed to be on the increase in population in the game reserves.

Because of the land tenure system, the government may initially be in the best position to perhaps initiate carrying out game ranching. In Zimbabwe, over 100 licenses have been granted to individuals for wildlife game ranching (Kay, 19/0) and good possibilities do exist for stock improvement once the programmes are well established. For example, the Nigerian cattle suffers heavily from nagana in the Sudan and Guinea Savannas but one only needs to visit Yankari in Bauchi State and marvel at the health of the buffaloes that dominate the conservation area. Certainly, buffaloes have, through evolution, adapted very well to the environment and therefore resist the tsetse problem. It would be of economic interest not only to research into the biology of this bush cow but to investigate possibilities of the hybridization of cattle with buffaloes as to

develop a stock that may yield good carcass and yet resist nagana. Such a programme however requires full co-operations of interdisciplinary specialists in animal production, veterinary science, entomology, parasitology and others.

6.10 Domestication

In view of the significant contribution of wildlife to the national economy, research workers in various institutions have begun serious thinking into ways and possibilities of domesticating some of the game animals. Strategically, perhaps it is in the right direction to start research of this sort on smaller, more manageable, and on high fecundity animals. To this effect, the domestication possibilities of the African giant rat (Cricetomvs gambianus) water jouse, the grass cutter (Thryonomys swinderianus Teeminck), the African giant snail (Archachatina marginata), and the bush fowl (Francolinus bicalcaratus) are being carried out at the University of Ibadan, Nigeria (Roche, 1875; Ajayi, 1976). Similar research also being conducted by Asibey (1975) on the grasscutter in Ghana. Results of such research should be patented and widely publicised for general public information.

Of the larger ungulates, the eland (Tourotragus derbianus). Africa's largest antelope, has so far offered a promising venture and is being raised along with domestic cattle in Zambia and other East African countries (Surujbally, 1978). Weighing 80 kg (1,500 pounds), the eland has indiscriminate food habits and yields good carcass of 63 dressing percentage. The physiology of this antelope is of added advantage in that it appears to thrive well in arid zones but converts food eaten more efficiently than cattle. The meat and milk produced are said to be of low cholesterol quality, which should provide good export products (Fry and Callendcr, 1974). Restocking of elands in Nigeria is a good possibility especially as they are still found in Gashaka-Gumti National Park of Adamawa and Taraba States. The low-level population of manatee has been attributed to environmental use and excessive hunting for its meat which has been described as delicate and liked by all those who tried it. Beal (1939) believes this animal can be reared and domesticated. The recent success with manatee in Jos Wildlife Park supports this idea.

With a view to improving the carcass value of the herbivorous game on long term bases, various workers are now investigating the fodder and grass qualities of some Nigerian game reserves (Afolayan 1975 (a) and (b); Geerling, 1975; Kapu 1975; de Leeuw, 1975; Lassan, 1975; Mbaclele, 1978). The research on the food preference of the ungulates (Petrides, 1976) provide an environmental planning base for the suitable locations of wildlife ranches and domestication centres.

6.11 Centre for Wildlife Research and Management

There are only two places of international repute where wildlife studies are freely carried out in Africa, i.e. the College of African Wildlife Management, Moshi, Tanzania and Ecole de Fauna, Garoua, Cameroon. Nigeria sends most of her high-level manpower trainees to the College in Tanzania, being an English speaking country. But this does not, at present, satisfy the demand of this country in terms of trained wildlife specialists, particularly the middle level technical

staff. Considering the diverse ecosystems of Nigeria, it is practicable that the National Parks Board and the Federal Department of Forestry, should establish a centre for training middle level manpower to attempt satisfying this special gap, especially in extension work in educating the community and the public. It is strongly recommended that in executing such a course the various national parks and game reserves of the country be taken into account to emphasize the applied field aspect of the programme. Locally experienced ecologists, such as the traditional hunters, should fully be integrated into this programme.

6.12 Decree No. 11 of 1985 on Endangered Species Control on International Trade Traffic Wildlife

According to a publication by NCF, the decree No. 11, which was promulgated in 1985, was in line with the Convention on International Trade in Endangered Wild Species of the Fauna and Flora, which Nigeria signed in 1977. The country also ratified the Agreement on the Joint Regulation of Fauna and Flora in the Chad Basin with the Republics of Cameroun, Niger, and Chad on measures to ensure conservation, utilization, and the development of soil, water, floral and faunal resources. Nigeria is a party to the ratified Article II of the African Convention on Nature and Natural Resources in her right as a member of the Organization of African Unity (OAU).

The position of the above decree stipulates that, as from the day the decree was promulgated (20th April 1985), the hunting, capture of, or trade in the animal species specified in its (Schedule I) had been absolutely prohibited. These animals are listed in Schedule I as described elsewhere.

In Schedule II, the decree stipulates that no import permit be issued unless the Minister is satisfied that:

(1) the export will not be for the purpose detrimental to the survival of the specimen;
(2) the specimen is not to be used for a primarily commercial purpose, and
(3) the proposed recipient of a living specimen is suitably equipped to house and care for it.

Obviously appropriate fines or punishments are stipulated for those who contravene the provisions. It is our opinion that the penalty of one thousand naira (1000) and five hundred naira (N500) are not deterrent enough under the present low value of the naira. The penalty d fines should accordingly be reviewed.

7 0 Biodiversity, Biosafety and Conservation

Under the able leadership of the Honourable Minister of State for Environment, Chief (Dr.) I.J. Okopido, the Nigerian delegation made impressive contributions at the Conference of Parties No.5 of Convention on Biological Diversity CBD recently held in Nairobi, Kenya, where 66 nations (including Nigeria) signed the Protocol on Biosafety (the Cartagena Protocol). Nigeria is the current Chairman of Group of 77 and China. This block of nations, in association with the Africa Group, worked hard to ensure the precautionary principle in the Protocol on the issue of Biosafety as it concerns policy on trans-boundary transfer of living modified organisms

(LMOs). Therefore, parties are expected to take preventive (protective) action on the risks or no risks that the LMOs may generate (Mugabe, 2000).

This, it is hoped, will pave the way to the renewed search for strategic ways and measures of promoting the safe development of Biotechnology in general, and LMOs in particular. The Cartagena Protocol provides the African countries the opportunity to assess and prioritize building of their technological capabilities in biotechnology of their choice. They may also consider adoption of a regional common policy on biosafety and a programme that would promote training and research in biotechnology, training in risk assessment and creation of a regional facility for risk assessment. They need to fully utilize the Biosafety Clearing House (BCH) of the United Nations. Unfortunately, Nigeria has not kept pace with biotechnological development which will have significant environmental impact globally in the near future.

Basically and according to Mugabe (2000), biotechnology is a charter of technologies that are used to transform and or produce goods and services from living organizations. It involves the "application of in vitro nucleic acid technologies, including recombinant deoxyribonucleic acid (DNA) and direct injection of nucleic acid into cells or organelle".

Presently, the technology and its increasing application are transforming agricultural, pharmaceutical, medical and other sectors or national and global economies in profound ways. Agriculturally, variety of crops can now be grown in environments that were perceived of no productive potential for example growing tropical crops in temperate lands. The promising view is that new varieties of plants resistant to drought have been developed through biotechnological methods. However there is still uncertainty about socio-economic and ecological benefits and risks from the technology because of lack of scientific knowledge on the nature of the risks. Thus, the precautionary principle mentioned earlier.

Take, for example, the high quality yielding maize tagged with terminator gene. The farmer obtaining such a seed will be able to harvest good crops for one to two years and thereafter the seed from such a stock will not germinate after the second year because of the action of the terminator gene. The farmer is therefore at the mercy of the owner or producer of the patent stock. Such is the anxiety of introducing an LMO into the environment without further knowledge of its status.

Nigeria has the political will and the human (scientific) resources to establish laboratories for capability development in this new technology. It may be that a partnership with the main commercial actors such as Monsanto be initiated for this purpose, as this technology can no longer be ignored particularly by the developing countries that are at the receiving end.

African countries like Egypt and South Africa have made good strides in biotechnology research and development (R and D). South Africa has a focus on genetic engineering of cereals: maize, wheat, barley, sorghum, millet, soybean, sugarcane and sunflower; while Egypt has in-

vested in genetic engineering of potatoes, maize and tomatoes, and is at the stage of field tests for LMO potatoes.

It is reported that other countries in Africa that possess good agricultural research base for this technology include, Nigeria, Zimbabwe, Kenya, Uganda, Ghana, and Tanzania but at different levels of capacity development. While we, in Africa, are starting the biotechnology R and D, the developed world has gone far. One only wonders with awe and concern on the global environmental ramification of this technology at the end of this millennium, even with the Cartagena Protocol on Biosafety in place. With all considerations on the subject, the lecturer is inclined to support those who encourage regional agenda to enlarge Africa's technological capabilities in this matter.

8.0 Conclusions and Recommendations

With continued environmental degradation in Nigeria, conserving our natural resources is our priority responsibility. The major reason in support are conservation of valuable natural resources and biodiversity, economic, cultural and the prevention of ecological disaster in the country. The marked increased in the population of the nation requires that much attention should be given to Nigeria's environmental problems, particularly the conditions brought about by the discernible changes in the climate.

Key factors in ecological degradation are human activities and climate change. Bad farming practices, deforestation, inappropriate land use, livestock overgrazing, and bush burning are all anthropogenic activities that bring about land degradation, the control of which must take into serious account population management and extensive environmental education. Research activities should be encouraged along with the development of botanical gardens (including ethno-cultural botany), wildlife parks, and natural history museums in all the ecological zones of Nigeria.

As for the problems brought about by climate change, early warning system should be developed as a priority for the monitoring of important indicators of ecological problems. In this regard, research must be strengthened in order to facilitate the choice of appropriate control strategy options. Also the existing laws on environment should be reviewed and new ones appropriately legislated on environmental protection. With the timely establishment of the Federal Ministry of Environment, this should be the pivotal coordinating point of all environmental programmes in the Federation.

There has been tremendous stress on Nigeria forest resources since the late 1950s. This has been due to increase in demand for forest products, land for food and livestock production, arising from the growing population, creation of more states (from 21 to 37), expansion for right of way for placement of infrastructure! (development of roads, state capital and local government etc). The rate of exploitation of forest resources has not been matched by afforestation.

Rural communities should be organized for social forestry and encouraged to grow their own woodlots, shelterbelts, fruit trees, and to develop non-timber forest products for enhancing their income. The private sector should also be requested to forge effective partnership with government in order to produce raw materials for industry to meet domestic needs.

Many states in the country have created forestry trust funds to provide money for critical forest operation irrespective of the status of the fiscal calendar. Several states have also enacted anti-bush burning legislation to minimize indiscriminate forest fires, which have led to considerable environmental degradation. There is, at present, no national forest law and the state laws are obsolete and not sufficiently deterrent. These should be reviewed.

The history of fauna protection in Nigeria is related with the development of forest reserves. Despite the relative safety in the protected forest however, there was the need to have a delineated area specifically designated for the protection of wild animal life. Tremendous success was achieved in terms of policy formulation, planning, and implementation in the creation of wildlife reserves in the late 1960s and early 1970s. This was sequel to the favourable recommendation contained in the special report of Petrides who was commissioned to look into the establishment of forest reserves in the country. By mid-1970, about 40 game reserves were slated for establishment across the breath and length of Nigeria in all the ecological zones. The good economic standing of Nigeria at that time ensured such expensive and rapid development in biodiversity conservation. This in turn stimulated economic growth in tourist's ventures. Also the game reserves were used extensively for educational purposes providing excellent opportunities for student field trips.

A majority of the large game reserves are located in Sudan and Guinea Savannas where competition for land was severe but that enabling logistics were favourable. It was encouraging to note that commendable efforts were also made to establish game reserves in the more difficult terrains in the forested zones of the south, albeit these are comparatively much smaller in size. This was a commendable policy as it has facilitated the preservation of special biotic areas in the south where threatened animals such as gorilla, mandrill, white-throated monkeys and buffaloes are found.

Because of proliferation of states and the dramatic devaluation of the naira, it is increasingly becoming difficult for the states to maintain the game reserves at quality level. The demand for farming and grazing lands has increased with increase in human and livestock population. It is therefore necessary, as the NCF has initiated, that external and NGO aid be sought for the protection of this wildlife heritage. The use of Ecological Fund for this purpose is therefore very appropriate.

It is timely that Nigeria develops capability in Biotechnology in order to ensure progressive research in issues of living modified organism (LMOs) and genetic modified organism (GMOs) for the purpose of advancing developments in agriculture and medicine. The issue of environ-

mental concern here cannot be ignored.

9.0 Acknowledgement

I wish to express my sincere gratitude to the Nigerian Academy, of Science, especially to the President and Honorary Secretary] Professors Anya O. Anya and Sulaiman A. Adekola respectively for the) honour extended to me to present the Fourth Sir Kashim Lecture. I wish also to thank Professors Kenneth Foster and Charles Hutchison both of the office of Arid Lands Studies, University of Arizona, USA and Professor Nagel of the University of Frankfurt who assisted me with facilities in developing this lecture, during my sabbatical leave visits. Our respected Professor Emeritus Umaru Shehu, the first Sir Kashim Ibrahim lecturer, and Professor J. Osuntokun who provided me with special pieces of information on the biography of the late Excellency, Sir Kashim Ibrahim, for which I am most grateful. I am also grateful to my children - Zara, Bukar, Ibrahim and Nubwa for their understanding and support. I thank Samuel Kwarantang of Kwari Computers for typing the lecture manuscript.

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Table 1: DESERTIFICATION SPREADING Four-fifths of the indicators show increasing desertification.

COUNTRY	SAND DUNE ENCROACHMENT	DETERIORATION IN RANGELANDS	FOREST DEPLETION	DETERIORATION OF IRRIGATION	RAINFED AGRICULTURE PROBLEMS	GENERAL ASSESSMENT
BENIN	■	■■	■■	■	■■	■■
BURKINA FASO	■	■■	■■	■■	■■■	■■
CAMEROON	■	■■	■■	■	■■	■■
CAPE VERDE	■■	■■	■	■■	■■■	■■
CHAD	■■■	■■■	■■	■■■	■■■	■■■
DJIBOUTI	■■	■■■	■■	■■	■■	■■/■■■
ETHIOPIA	■■	■■■	■■	■■	■■	■■/■■■
GAMBIA	■■	■■	■■■	■■■	■■	■■
GUINEA	■	■	■■	■■	■■■	■■
GUINEA-BISSAU	■	■	■■	■■	■■	■■
KENYA	■	■■■	■■	■	■■	■■
MALI	■■	■■■	■■■	■■	■■	■■/■■■
MAURITANIA	■■	■■■	■■■	■■	■■	■■■
NIGER	■■	■■■	■■	■■■	■■	■■/■■■
NIGERIA	■	■■	■■■	■	■■	■■
SENEGAL	■■	■■■	■■	■■	■■■	■■
SOMALIA	■■	■■	■■	■■■	■■	■■
SUDAN	■■■	■■	■■	■■	■	■■
UGANDA	■	■■■	■	■	■■	■■

KEY: stable, ■■ some increase, ■■■ significant increase

SOURCE: Leonard Berry, Clark University, with CUSO

Table 2: Population Estimates for Livestock in Borno State in 1983 at Local Government level

Local Government Area	Cattle	Sheep	Goats
Askira/Uba	40,981	50,000	57,800
Bedde	252,000	200,000	241,400
Bama	78,757	112,000	122,400
Biu	264,416	188,000	91,800
Damaturu	180,000	270,000	282,200
Damboa	122,377	90,000	70,200
Fika	211,555	290,000	285,600
Fune	240,000	100,000	180,200
Geidam	54,146	140,000	175,400
Gujba	180,000	122,000	105,000
Gwoza	19,694	112,000	122,000
Kaga	186,247	102,000	935,000
Konduga	177,300	108,000	244,500
Kukawa	440,110	563,000	210,800
Maiduguri	72,074	72,000	217,800
Monguno	280,531	150,000	105,400
Ngala	396,856	140,000	176,700
Nguru	125,987	125,000	57,000
TOTAL	3,331,000	2,814,000	3,688,000

Source: Borno State Government

Figure 1: Map of Africa

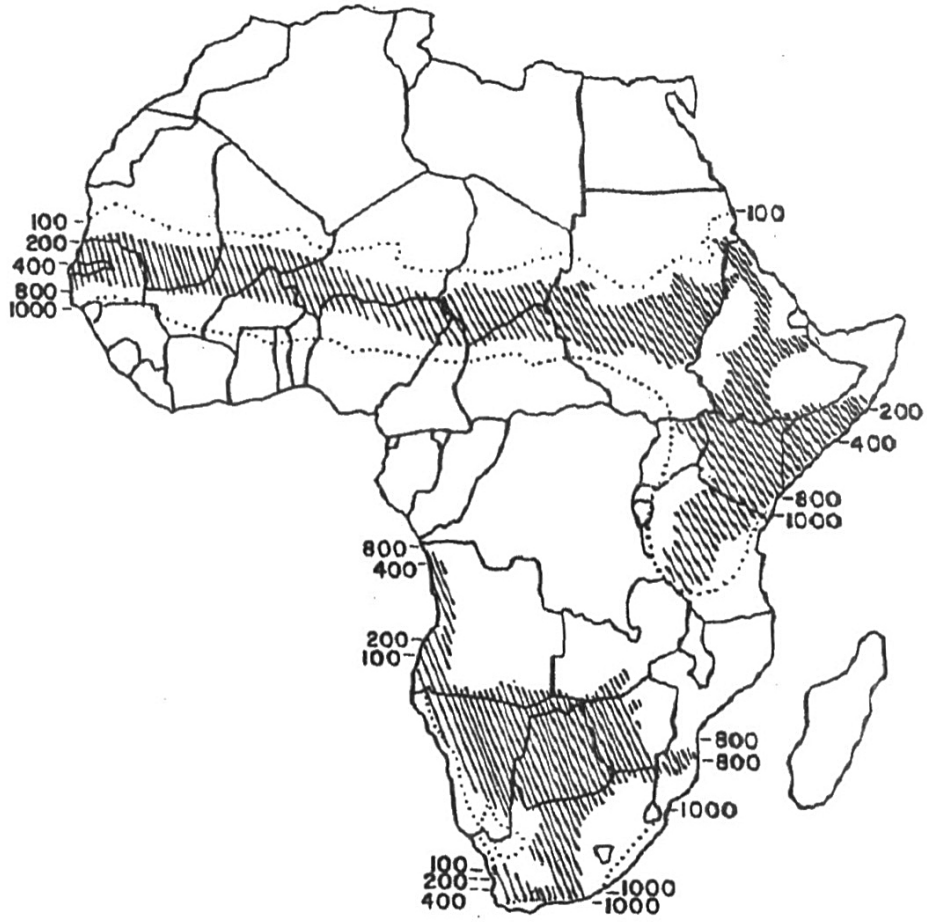

FIGURE 1: A map of the African continent, showing areas that receive between 200mm and 800mm per year of rainfall (90 per cent isohyol probability). Adapted from Atlas for African Editions Jeune Afrique, 1973).

In the IUCN Sahel Studies, 1989 the ten countries of the Sahel Programme are generally grouped into three regions on the basis of their climate patterns:

Western region : Senegal, Mauritania, Mali, Niger :

Central region : Burkina Faso, Chad, Sudan :

Eastern region : Ethiopia, Somalia, Djibouti .

SOURCE: IIED (International Institute for Environment and Development) Paper No. 14: SAHEL INFORMATION KIT

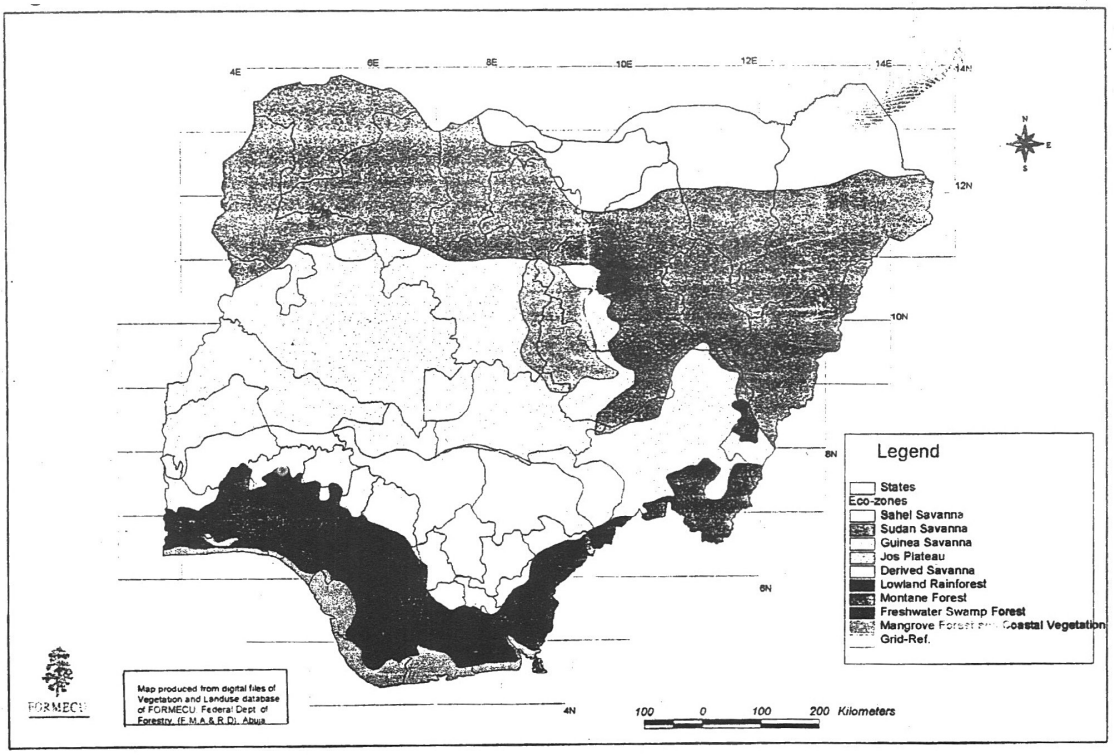

Figure 2 *NIGERIA ECOLOGICAL ZONES*

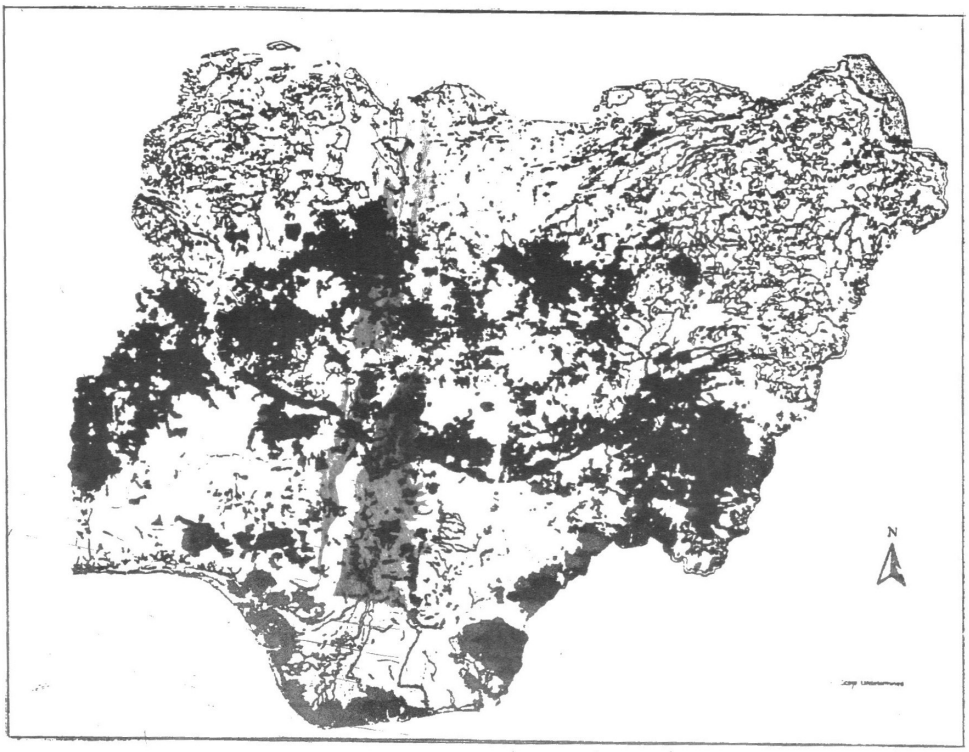

Figure 3(a): 1976/78 Vegetation Cover

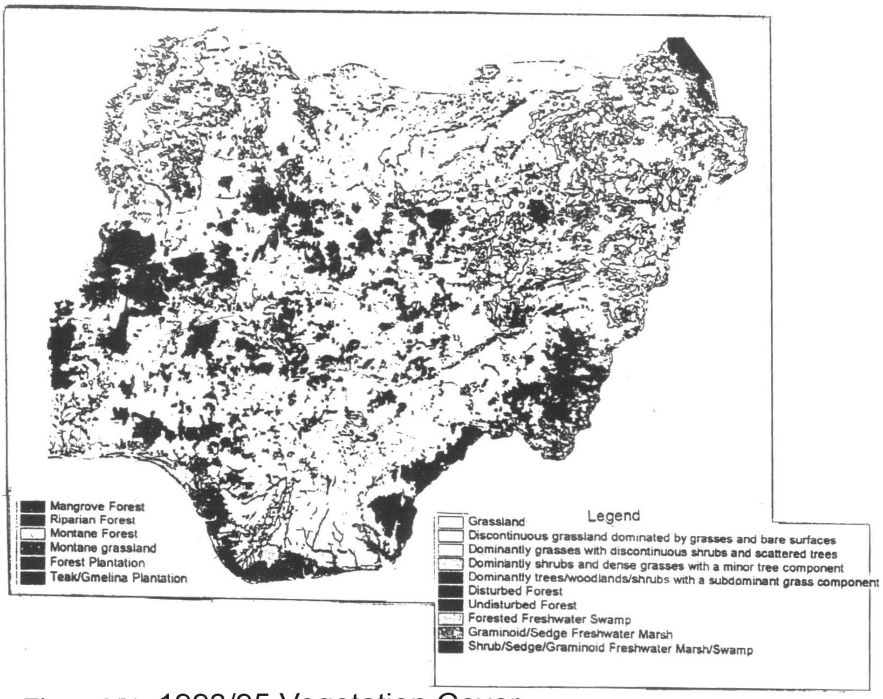

Figure 3(b): 1993/95 Vegetation Cover

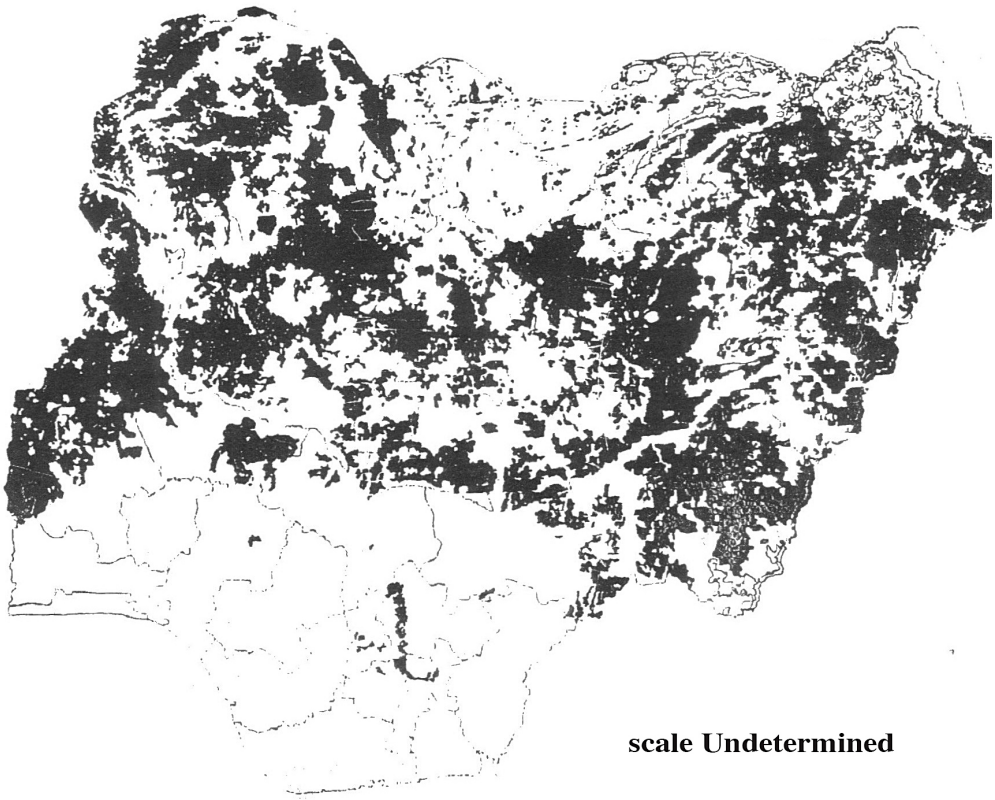

Figure 4(a) : 1976/78 Woodland/Shrub/Grassland

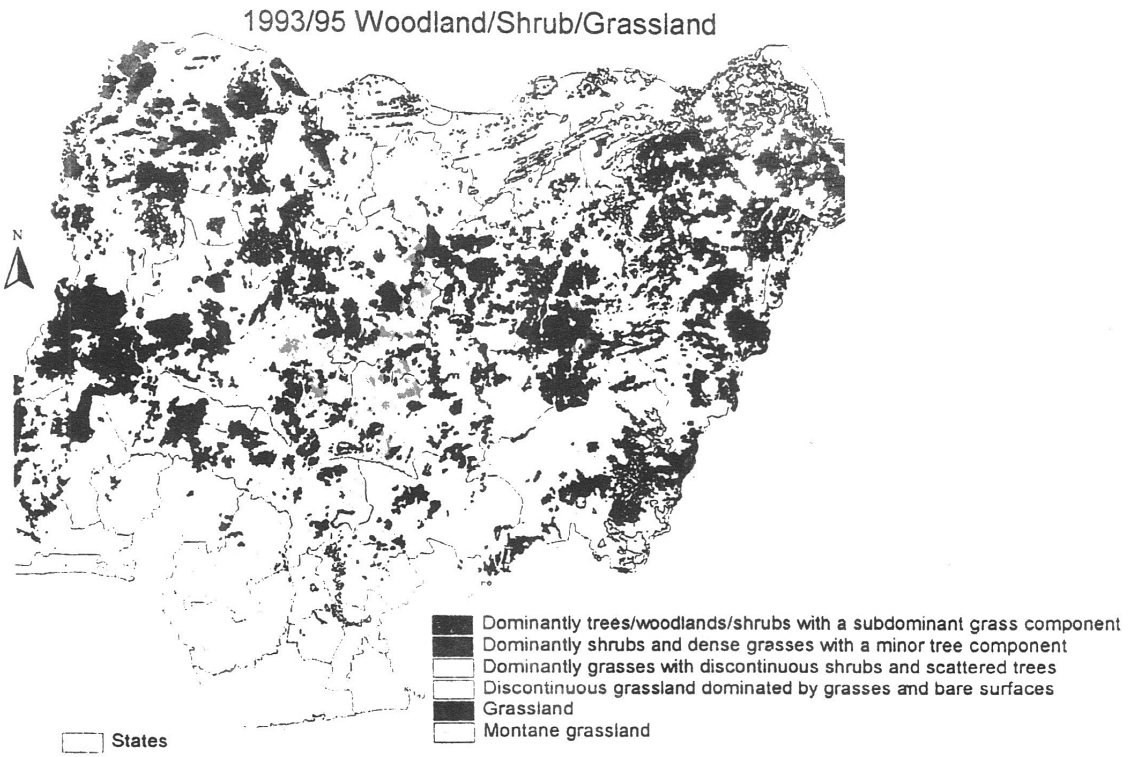

Figure 4(b) Scale Undetermined

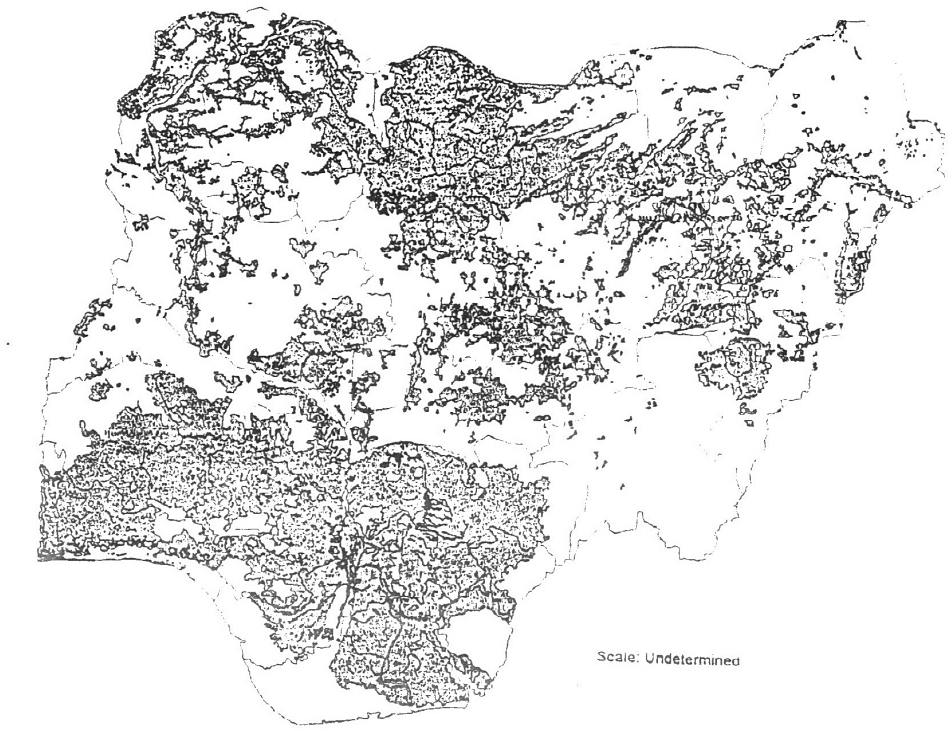

Figure 5(a) : 1976/78 Intensive Agric Landuse

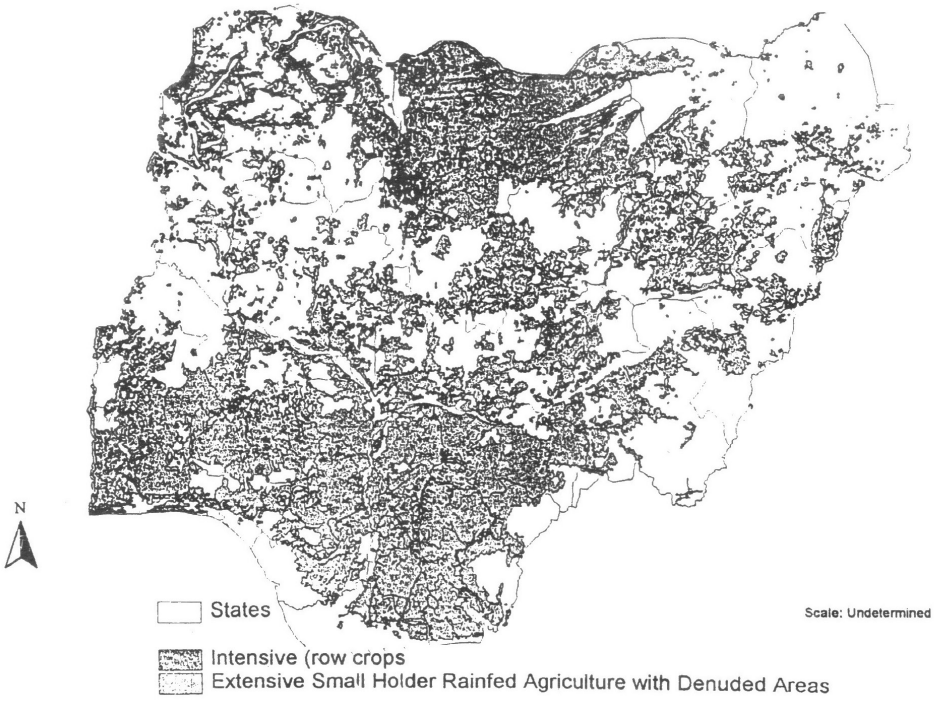

Figure 5(b): 1993/95 Vegetation Cover

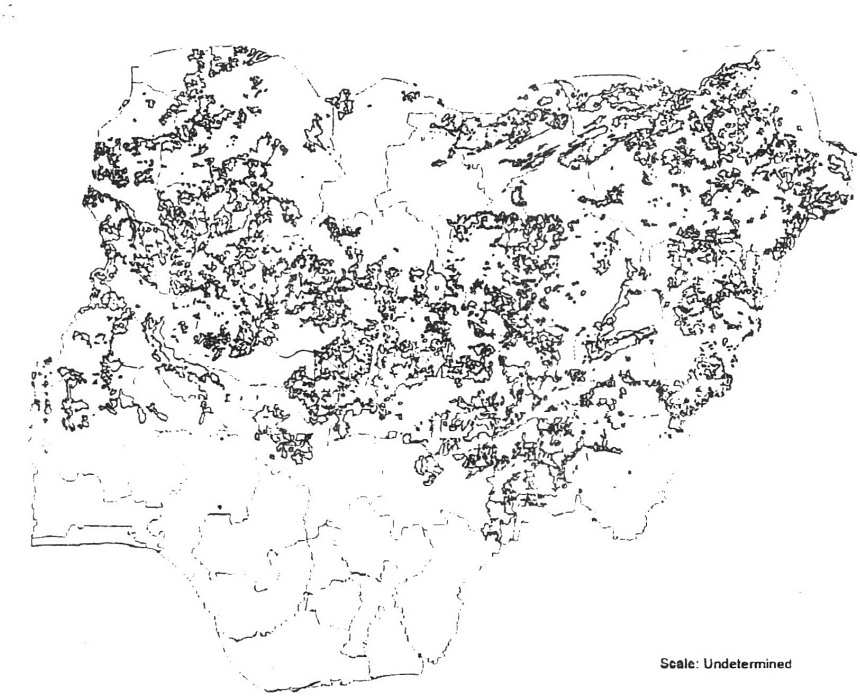

Figure 6(a): 1976/78 Grazing Landuse & Livestock Projects

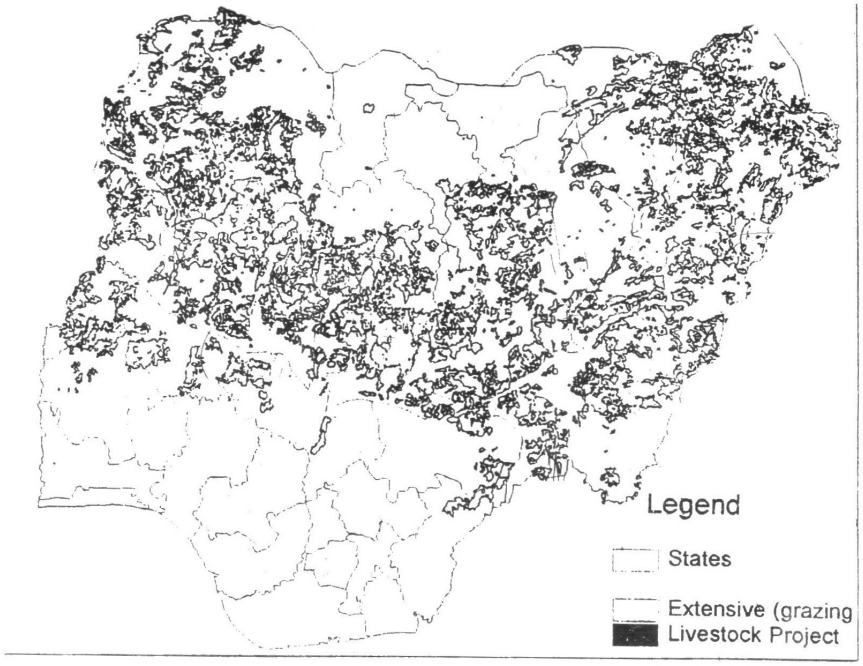

Figure 6(b): 1993/95 Grazing Landuse & Livestock Projects

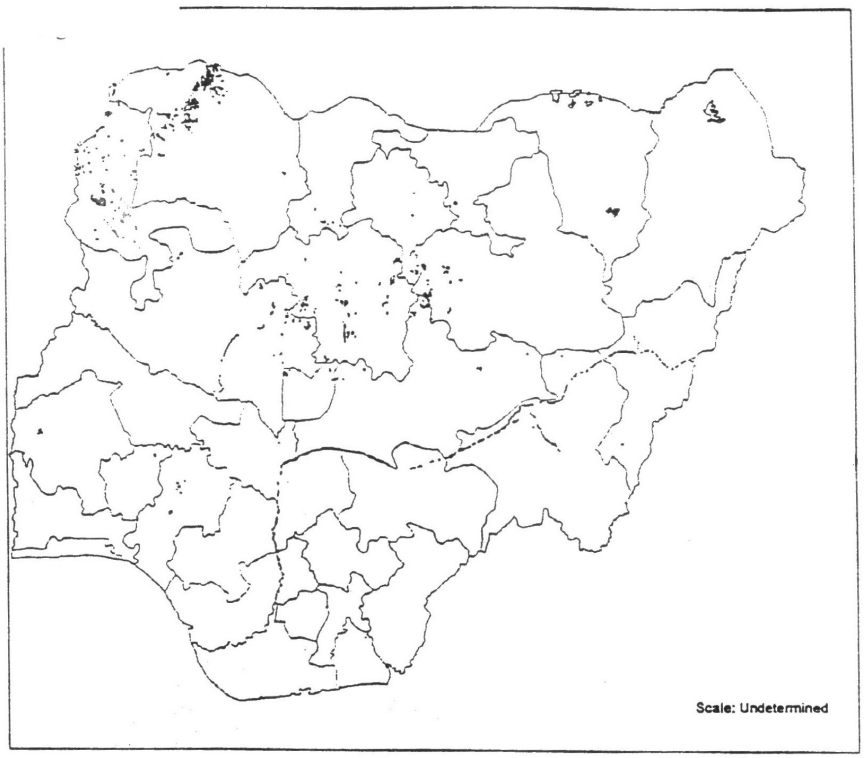

Figure 7(a): 1976/78 Bare Surfaces

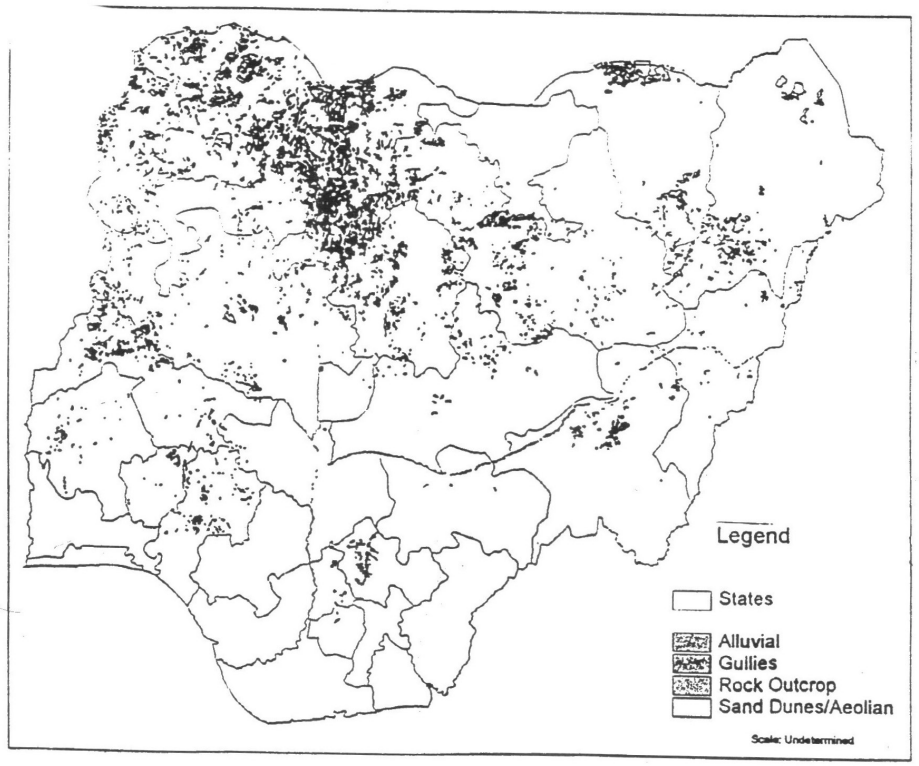

Figure 7(b): 1993/95 Bare Surfaces

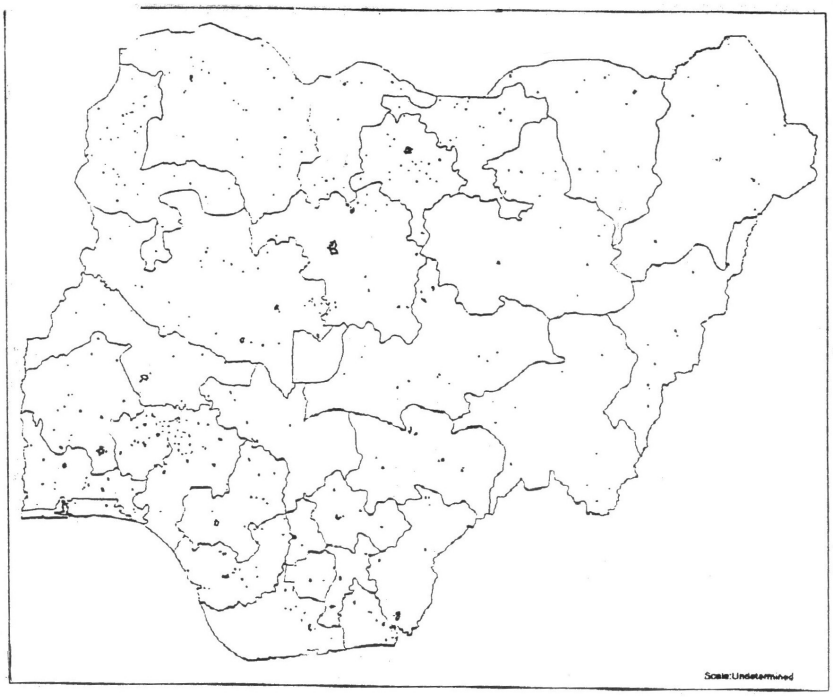

Figure 7(c): 1976/78 Urban Areas

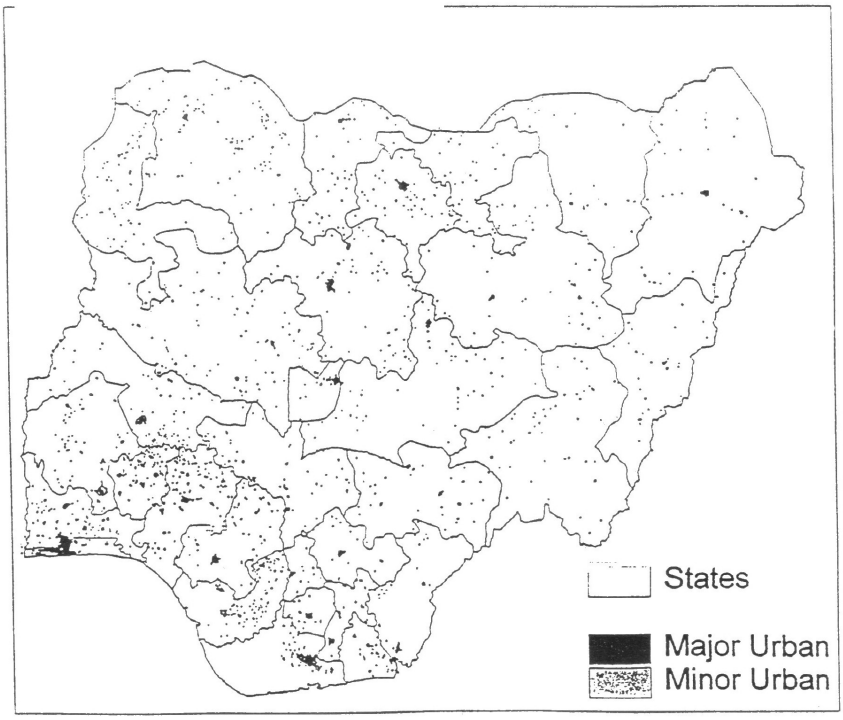

Figure 7(d) 1993/95 Urban Areas

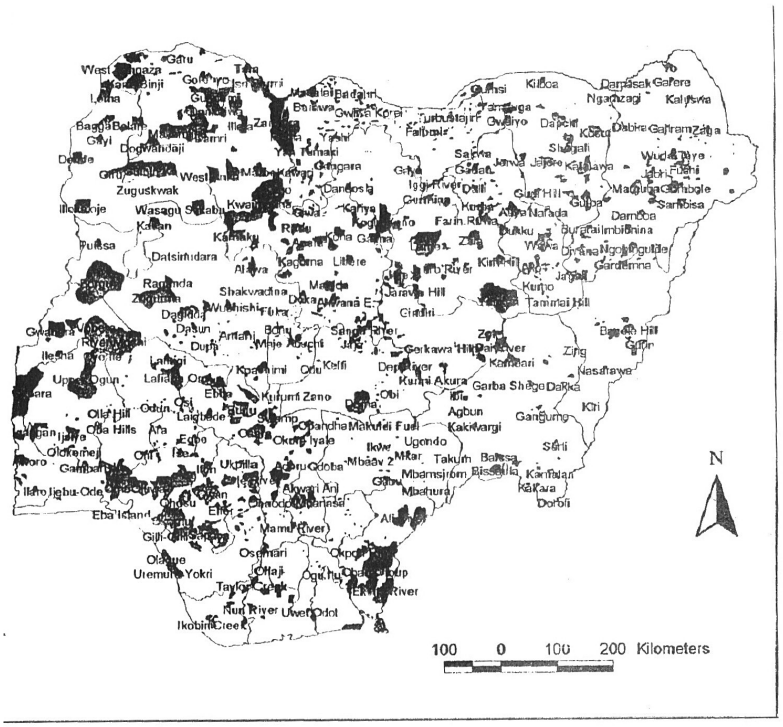

Figure 8

Legend

States Boundaries
Forest Reserves

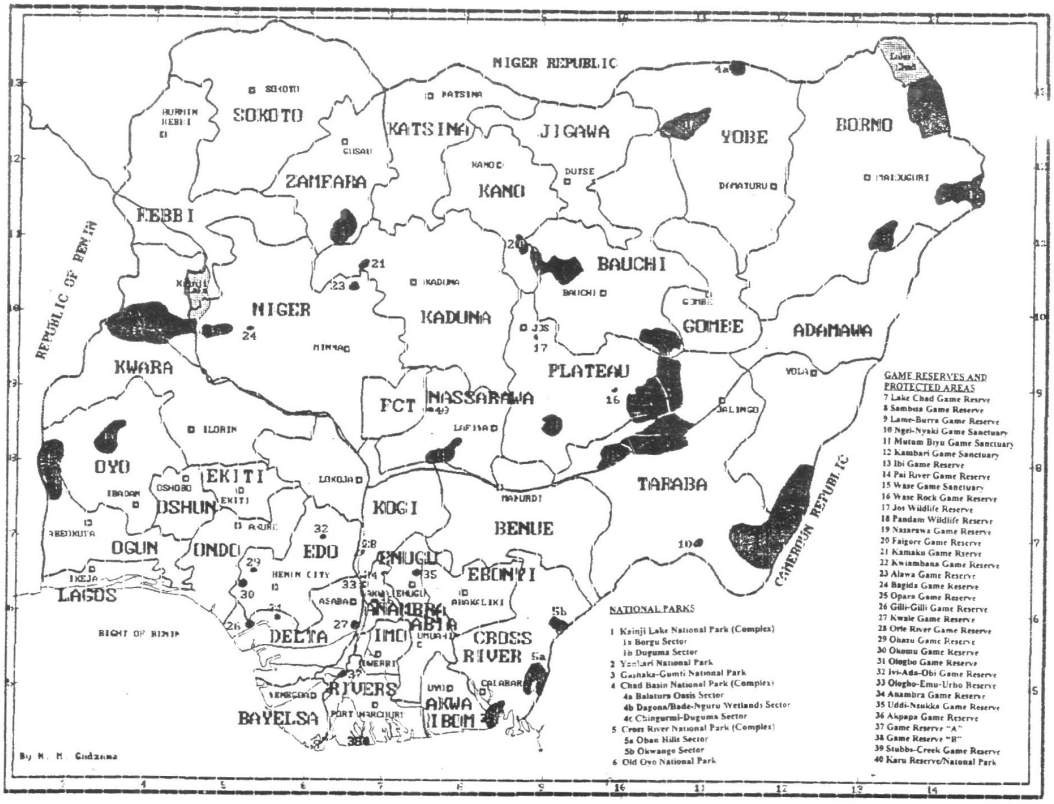

Figure 9 NATIONAL PARKS AND GAME RESERVES OF NIGERIA

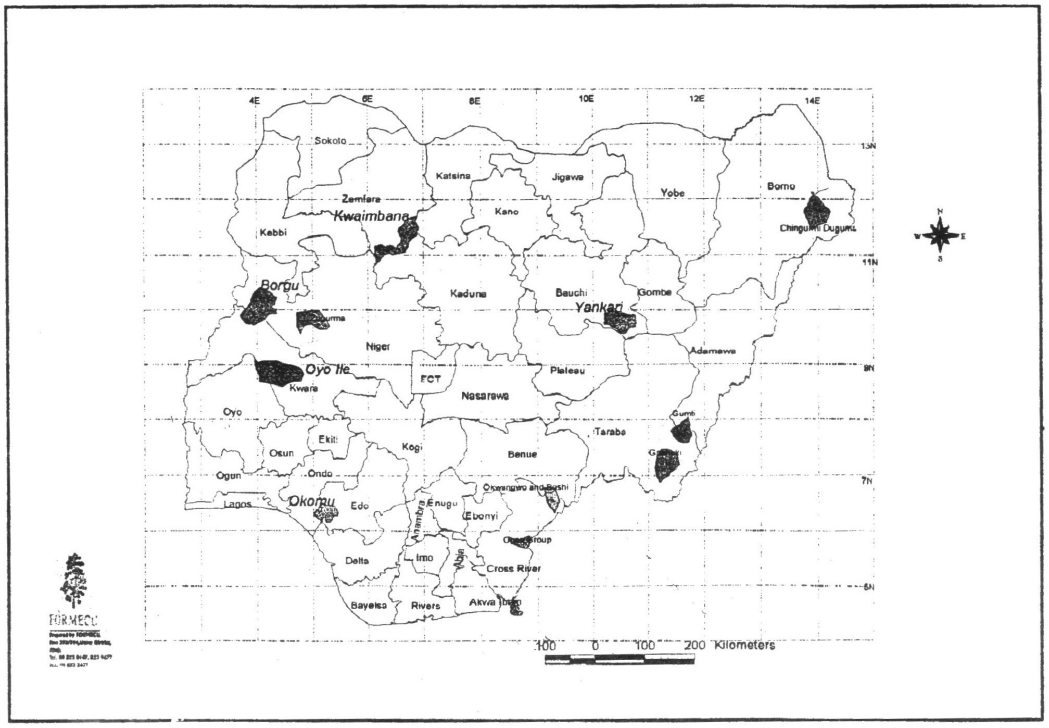

Figure 10 *NIGERIA NATIONAL PARKS*

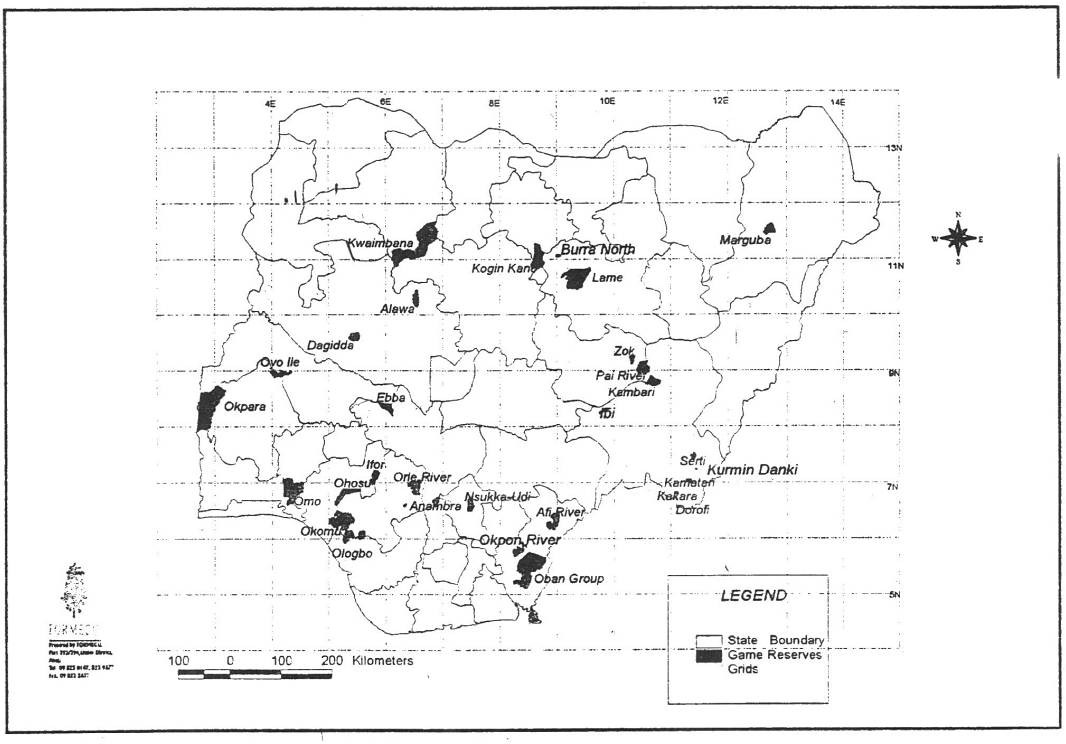

Figure 11 ***NIGERIA GAME RESERVES***

NIGERIA'S MINERAL RESOURCES FOR WEALTH, INDUSTRY, INFRASTRUCTURE AND LIFE PUBLIC LECTURE DELIVERED

Siyan Malomo FAS
A NAS public lecture delivered January 2011

PREAMBLE

I would like to begin by thanking the Chairman of the occasion, a former academic renowned geologists in its own right who has found time, within thereally buy period, and we all know that it is very busy, to accept to Chair thisevent.

The Special Guest of Honour, Arc Musa Sada is equally, if not more, a very busy man and has shown his commitment to the development of science (including the environmental science) by travelling from Abuja, to honour this invitation.

I would also like to pay tribute and remember those great scientists and illustrious men of honour, the fellows of the Academy who passed away in the last twelve months i.e. since the last general meeting of the Academy. These are Prof Oyenuga, Prof Adesola, Dr Amenechi, Prof Oladapo and of course the Grand Patron of the Academy: Alhaji Umar Musa Yar'Adua, GCFR, the former President of the Federal Republic of Nigeria.

In preparing for this lecture, I was mindful of the charge that the audience will be both scientists and non-scientists. The challenge has therefore been to steer a middle course between high falluting equations or ideas in engineering geology or geotechnical engineering my special area of interest, which might interest the fellows. The alternative is something very bland for the wider public. Both have inherent risk of sending people to sleep. The one can bore the fellows to a deserved sleep after the retreat in Cotonou for Council member (and some fellows) and lunch, the other to a less deserved sleep but that which will come from a boring afternoon lecture.

In the consideration I am easily reminded of the famous statement by Lord Rutherford about the point of a good physicist being able to explain quantum physics to his char woman (i.e. the housed cleaner). I hope there will be enough spice in the lecture that will capture your attention and keep you awake for its duration.

INTRODUCTION

This lecture is divided into two parts. The first is of general nature and provides the background to Nigeria's minerals and the second describes hat we have done about the impact of these minerals on Nigeria's development.

PART 1: SETTING THE SCENCE

What are Minerals?

1. Minerals are solid substances found within the crust of the earth with fixed chemical compositions formed by the inorganic processes of nature. They constitute the building blocks of rocks; hence rocks are referred to as aggregates of minerals. Geology is the study of the earth, its composition and the processes that are shapening the earth as recorded in the rocks. Mineral deposits are associated with specific geological environments.

Solid Minerals – A Definition

2. Solid minerals (in the Nigerian context - Mining and Minerals Act 2007) are defined as all earth resources except for all oil, gas and water. They include fuel minerals of coal, lignite and bitumen as well as the geomaterials of sand, gravel and laterite.

Importance of Solid Minerals

3. Solid minerals are very important to every nation. The weapons with which we wage wars and defend our national territory are derived from minerals. Materials for housing, national and local infrastructure are derived from minerals. Technological machineries and inventions are made with minerals, the energy with which these machines are powered are derived from fuel minerals. Agricultural fertility is dependent on minerals and importantly human and animal health on the planet depends on solid minerals (either through requirement or toxicity).

4. Solid Minerals is one of the sectors that can respond at once to the need for economic growth through wealth creation and reduction in poverty. It helps to create wealth through encouragement of foreign direct investment into the mining sector as well as large investment into industrial minerals e.g. the processing of limestone into cement.

5. At the same time it responds to poverty reduction through the improvement in the lives of artisanal small scale miners and mining communities.

Minerals and National Wealth

6. Globally the mining sector of mineral-producing countries has been a major foreign exchange earner and a provider of job opportunities for their citizens and other stakeholders. For many years, the mining sector has remained a positive core contributor to the sustainable socio-economic development of mineral-producing countries.

7. Recent economic research findings indicate that earnings from solid minerals contribute

a reasonable share of the Gross Domestic Product (GDP) of such countries as Ghana, South Africa, Australia, Canada, and the USA, among others.

8. Data for 2007, for instance, show that the mining sector contributed 5% to Ghana's GDP, accounted for 12% of its government's revenue, comprised 41% of total export earnings and employed over 500,000 people. It contributed 7% to South Africa's GDP, accounted for 12.4% of its total company tax, provided 25.2% of the country's total foreign exchange earnings and employed slightly under a million workers. For Canada it contributed $42 billion or 3% to the GDP, with mining industry payments of $8 billion to its government, constituted 19% of total exports, and provided direct employment of 363,000 people.

9. The comparable information for Nigeria' is that solid minerals have contributed a paltry 0.3% or less over the last fifteen years. Certainly we need to do something about it and I will show later in the lecture the efforts that the have been made over the last five years.

Minerals and Infrastructure

10. Geology interfaces with infrastructure in directly in two areas.

i. The application of geological principles in the understanding of engineering phenomena- Engineering Geology
ii. The production and proper use of geomaterials

In addition there are indirect interfaces e.g. the link between mining infrastructures which has always been important.

Geology in Engineering Practice

11. Engineering Geology is the application of the geologic sciences to engineering practice for the purpose of assuring that the geologic factors affecting the location, design, construction, operation and maintenance of engineering works are recognized and adequately provided for.

12. Engineering geologists investigate and provide geologic and geotechnical recommendations, analysis, and design associated with human development. The realm of the engineering geologist is essentially in the area of earthstructure interactions, or investigation of how the earth or earth processes impact human made structures and human activities.

13. Engineering geological studies may be performed during the planning, environmental impact analysis, civil or structural engineering design, value engineering and construction phases of public and private works projects, and during post-construction and forensic phases of projects. Works completed by engineering geologists include; geological hazards, geotechnical, material properties, landslide and slope stability, erosion, flooding, dewatering, and seismic investigations, etc.

14. Engineering geological studies made major contribution to the major development of In-

frastructure (Federal capital, Dams, Airports and Highways) in Nigeria during the 1975-85.

Geomaterials

15. Geomaterials consists of crushed stone and sand and gravel and are among the most abundant natural resources and a major basic raw material used by construction, agriculture, and industries employing complex chemical and metallurgical processes. They are generally referred to as aggregates. Despite the low value of the basic products, natural aggregates are a major contributor to and an indicator of the economic wellbeing of the Nation.

16. They have a wide range of uses. These include roads, bridges, dams, airports, concrete etc. More than 90 percent of asphalt pavements and 80 percent of concrete are aggregates. Paint, paper, plastics, and glass also require sand, gravel, or crushed stone as a constituent.

17. Currently more than 80% of mining activities in Nigeria relates to the production of aggregates for infrastructure.

Mining Infrastructure

18. Mineral exploration and the search for new deposits are critical to the development of mining industry. Exploration is a major part of the industry and without it, mineral development would be impossible. Minerals occur in far flung places usually far from urban centres and developments. The building of mines that follow search and exploration of minerals require the development of supportive infrastructure: roads, railways, water transport, power etc to these places.

19. Mining specific infrastructure was developed in the past when mining was active. For example, the first power company in Nigeria was a private company (the Nigerian Electricity Supply Company (NESCO)) established to give electricity to the tin mines in Jos. At the same period there was the extension of the railway line to pass through Enugu to move coal to the ports for export. Such initiatives were stopped with the decline of the mining industry.

20. NESCO was established in 1928 and generated electricity from Kura Falls in Plateau State. The company developed other power stations in addition to the first one at Kura Falls. NESCO later extended its services to Bukuru, Jos townships and Kafanchan in Kaduna State. It ran as an independent company until the law establishing the Nigerian Electric Power Authority as a monopoly for the distribution of power was promulgated in 1972. The company was noted for its efficiency as Jos and its environs enjoyed uninterrupted power supply.

Minerals and Life

a) Minerals and Human Health

21. Geological factors play key roles in a range of issues that impact the health and well-being of humans, animals and plants. With respect o humans, the emerging interdisciplinary field

of "medical geology" respond appropriately to the wide variety of the interaction of geological environment with man. It includes nut not limited to the following:

- Geological processes and health,
- Veterinary or animal health and geology.
- Health aspects of elements in ground water
- Chronic diseases (e.g. cardiovascular disease, diabetes etc.)
- Natural environment deficiency / toxicity problems
- Trace and Essential Elements

22. All living organisms require inorganic elements, or minerals, for their life processes. An element is defined essential when it is required to support adequate growth, reproduction, and health when all other nutrients are optimal.

23. Minerals are classified in a number of ways. Often minerals that are needed in relatively large amounts are referred to as macrominerals whereas minerals that are needed in very small amounts are denoted microminerals or trace elements. Seven minerals are macrominerals and twenty –two can be referred to as trace elements (McDowell, 2003).

Table 1: Elements and Recommended Daily Adult Allowances (RDA)

Table 1 Elements and Recommended Daily Adult Allowances (RD

Element	RDA
Boron	(1.7-7.0 mg)*
Bromine	0.3-7.0 mg
Calcium	800-1300mg
Cesium	0.1-17.5 µg
Chromium	130 µg
Cobalt	15-32 µg
Copper	1-2mg
Fluoride	1.5-4.0mg
Iodine	70-150 µg
Iron	10-18 µg
Lithium	730 µg
Magnesium	3.5mg
Manganese	3.5mg
Molybdenum	160 µg
Nickel	(35-700 µg)
Phosphorus	800-1300 µg
Potassium	3500mg
Selenium	70 µg
Silicon	(21-46ug)
Tin	0.13-12.69 µg
Vanadium	(12.4-30.0 µg)
Zinc	8-15mg

*Values in brackets are for non-essential elements that are without accepted biologic function but detected in body tissues. From C Skinner (2007).

Special clinical conditions: Ca – osteoporosis, Fe – iron deficiency anemia, I – iodine deficiency (goiter) Magnesium – 'hard water '– cardiovascular disease, (Selenium – cardiovascular disease?) Eating Clay - Geophagy

24. The habit of eating soil and the physiological effects of its ingestion can be considered as the use of chemical elements in the clay to provide appropriate relief a particular need. Geophagy is defined as the deliberate and regular consumption of earthy materials such as soils, clays, and mineral substances by humans and animals. Geophagy is practised in several parts of south eastern Nigeria

Lead Poisoning In Zamfara State

25. The unfortunate incident of lead poisoning affecting mostly children that occurred with artisanal mining activities in Anka and Bukkuyum Local Government areas of Zamfara State.

26. Gold commonly associates with Lead (Pb), Antimony (Sb), Arsenic (As) Bismuth (Bi) Mercury (Hg). Milling the ore reduces the host material to dust. While milling, the lead bearing dust is inhaled.

27. The pulverized material is also panned in the stream for gold. During panning the stream is again polluted with toxic elements from the powdered rock.

28. At times, the panning for the gold from the pulverized material is done in pools of water created within the villages. This leads to the contamination of ground water and soils around the villages. Waste material dumped carelessly in the village eventually gets blown into water wells.

Figure1. Hand milling of ore in a mortal that could be used for milling food.

Figure 2. Dust and scattering of polluted ore in a village

b) Minerals and Plant life

29. The soil is the primary source of trace elements for plants, animals and humans. The trace element content of a soil depends initially on the parent material from which it was formed but subsequent leaching and nutrient cycling through plants and animal excreta creates both depletion and enrichment often in specific soil horizons.

30. Agrogeology is the application of geology to agricultural needs. It is the study of geological materials and processes that contribute to the improvement and maintenance of agro-ecosystems.

31. The use of rocks and minerals as low-cost, locally available geological nutrient resources for agricultural development is not new. It has been tested over centuries. Agricultural research with finely ground and chemically unprocessed rocks and minerals, based on the concept of 'bread from stones,' started in the 19th century by Missoux (1853/54), Hensel (1890, 1894) and others.

32. Since rocks are made up of minerals, the primary interest is in the minerals which make up rocks. Therefore the real interest is in agrominerals.
These are naturally occurring geological resources for the production of fertilizers and soil amendments.

33. This multi-disciplinary approach combines the knowledge of several professionals viz. geologist, soils scientists, process engineers and farmers.

34. Soil scientists define the soil limitations and needs, geologists find, delineate and characterize the geological raw materials that address those needs and process engineers contribute by concentrating the agrominerals and transforming them into more plant available forms. Processing technology is to be kept at an appropriate level to reflect the size, grade, location and end use of the raw material.

35. Rocks and minerals are used in crop production for:
- improving soil fertility,
- correcting the pH of soil,
- conserving nutrients and water.

35. The best known agrominerals are:
- saltpeter, the only naturally occurring nitrate mineral that occurs in sizable deposits,
- phosphate rocks (PRs) with apatite as the principle phosphate mineral,
- guano minerals, complex P- and N-bearing compounds,
- potash, mainly sylvite (KC1), and complex K-bearing salts,

- K-silicates, such as K-micas, glauconites, and K-bearing volcanic rocks and K-zeolites,
- sulphur, sulphides (e.g. pyrite) and sulphates (e.g. gypsum),
- calcium and magnesium carbonates,
- various silicate minerals and rocks used to conserve nutrients (e.g.zeolite) or used to conserve soil
- moisture (e.g. scoria and pumice).

36. Studies on Nigerian agromineral resources have shown the potential of developing the known agrominerals and finding additional mineral resources for use in agriculture, horticulture, forestry and agroforestry.

37. The agrominerals found and tested suitable for direct application in Nigeria are:
- Feldspar
- Marble
- Gypsum
- Phosphatic Nodules
- Phosphatic Limestone
- Gypsum
- Peat/Lignite

Solid Minerals in Nigeria's Historical Economy and Development

38. Solid Minerals has played a long and important role in the in the industrial history of Nigeria. Solid minerals were very important prior to 1970. Before this period there was boom in the exploration, exploitation and exportation of solid minerals such as coal, tin, columbite and wolframite.

39. Organised mining in Nigeria began to crystallise between 1902 and 1923 following the commissioning in 1903 and 1904 of the Mineral Surveys of the southern and northern protectorates. Tin deposits had been located in Jos plateau and organised mining activities were initiated by the Royal Niger Company in 1905.

40. Apart from tin and other associated minerals, such as columbite, and tantalite, mining for gold began in 1914 in areas now known as Niger and Kogi states. Exploration for coal dates back to 1906 but production did not commence until 1916 in the area now known as Enugu state. By 1919, the Geological Survey of Nigeria was established as a department of government to take over and continue the work of the previously established survey teams.

41. The Minerals ordinance of 1946 and the Coal ordinance No. 29 of 1950 provided the legal basis for the development of solid minerals in Nigeria. Specifically the work of the Mineral Surveys of Nigeria (and later the Geological Survey of Nigeria) led directly to the establishment

of the tin mines in the Jos plateau and the coal Mines at Enugu. It also led to the development of mineral based industries and plants such as the thermal generating plant at Oji River Station and Ijora Lagos, steam powered transportation of the Railways and Inland Water Ways, the cement plants at Nkalagu, Ewekoro, and Calabar. It contributed greatly to foreign exchange earnings.

42. The economic focus however shifted during the oil boom of the 1970's. The nation evolved an economy (monolithic) based solely on revenues from oil. Little attention was given to other sectors such as agriculture and solid minerals.

Geology of Nigeria

43. The Geology of Nigeria is composed of four main groups known as the Basement Complex, the Younger Granites, the Sedimentary series and the Tertiary-Recent Volcanic rocks. The

Basement Complex

44. The Basement Complex of Nigeria occupies the central part of the Pan- African mobile belt, which lies between the West African and Congo cratons. It occupies about half the surface area of Nigeria. It is composed of three major rock packages:

i. The migmatite-gnesis complex.
ii. The schist belts composed of metasedimentary and metavolcanic rocks.

iii. The pan-African Granitoids comprising the Older Granites and associated charnockitic rocks

The Younger Granites

45. The Younger Granites are distinct from the Older Granites (Pan-African granitoids), and are high-level anorogenic volcanic and hypayssal rocks emplaced within the Precambrian basement complex. They are characterized by arcuate to circular intrusions and represent one of the classical occurrences of ring complexes in the world. They are form the southern extension of similar ring complexes in Air, Niger Republic. The Nigerian occurrences range in age from 313 to 141 million years.

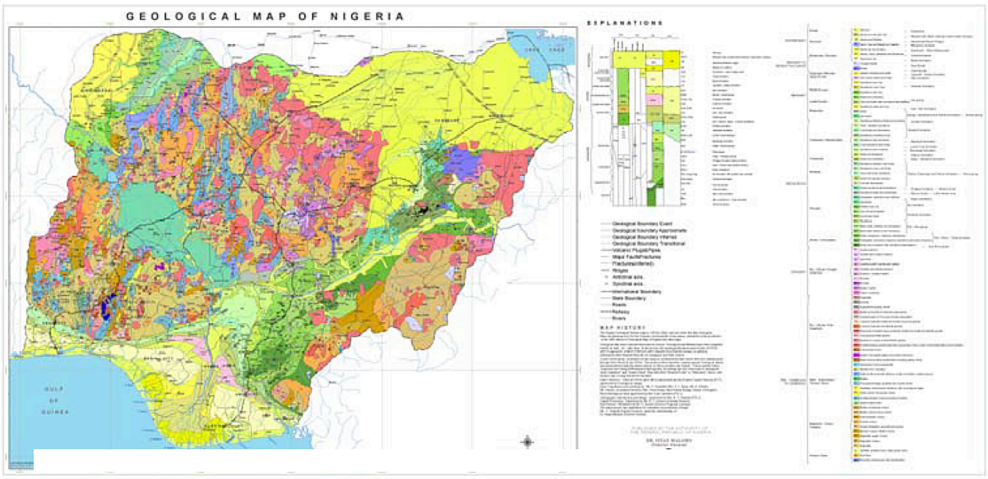

Figure 3 Geological map of Nigeria

The Sedimentary Series

46. The sedimentary rocks of Nigeria were deposited in seven basins surrounding the crystalline rocks. They outcrop over about half the surface of Nigeria. Five of them, the Niger Delta Bida, Benue and Anambra basins appear to have initiated in the Cretaceous and are related to the opening of the Gulf of the Guinea. The remaining two, the Sokoto and Chad basins are part of the Taodeni and lllumedden basins respectively, which outside Nigeria have histories dating back to the Palaeozoic.

The Tertiary - Recent Volcanic Rocks

47. Volcanic activity has taken place intermittently from tertiary to recent times. The most extensive outcrops are in the Biu and Longuda plateaux of north-eastern Nigeria and on the Jos Plateau and in the Benue Trough. The basalt ranges from 22 million years to 7 million years in age.

Nigeria's Solid Mineral Endowment

48. Nigeria is richly endowed with various mineral types that manifest inmultiple occurrences all over the country coupled with the presence of several vast mineral deposits of world class.

49. The solid mineral resources of the country may be categorised into three broad groups:

i) Metallic and Precious Minerals

Examples of these include cassiterite (tin ore) lead and zinc, iron ore, manganese, tantalite/columbite and gemstones.

ii) Energy Minerals

Examples of these include coal, lignite, bitumen (tar sands) and radio-active minerals.

iii) Industrial Minerals

Examples include barytes, gypsum, clays, limestone, marble, phosphate, silica sands and dimension stones.

50. Every state of Nigeria including the Federal Capital Territory has the presence of solid minerals. However many of these resources are still untapped.

More than 40 types of solid minerals have been identified in over 500 locations in the country.

51. The major minerals and the States of occurrence are shown below:

Gold: Cross River, Edo, FCT, Kaduna, Kano, Kebbi, Kogi, Kwara, Niger, Osun, Zamfara

Iron Ore:Edo, Enugu, Kaduna, Kogi, Taraba, Zamfara

Lead/Zinc: Kano, Ebonyi, Bauchi, FTC, Plateau, Nasarara, Taraba, Zamfara

Coal: Benue, Ebonyi, Enugu, Gombe, Kogi, Nasarawa, Plateau

Lignite:Abia, Anambra, Delta, Edo,Gombe, Imo

Bitumen:Edo, Enugu, Lagos, Ondo, Ogun

Limestone: Abia, Adamawa, Akwa Ibom, Benue, Cross River, Borno, Ebonyi,
Enugu, GombeKebbi, Ogun, Osun, Taraba, Yobe

Marble: Edo, FCT, Katsina, Kogi, Kawar, Niger, Oyo, Plateau, Zamfara

Barytes:Benue, Cross river, Nasarawa, Taraba, Adamawa

Cassiterite : Adamawa, bauchi, Ekiti, FCT, Jigawa, Kaduna, Kano, Katsina,
Kogi, Kwara, Ondo, Plateau

Manganese: Cross River, Kaduna, Kebbi

Tantalite/Colunmbite: FTC, Kaduna, Kwara, Kogi, Nasarawa, Niger, Osun, Oyo, Taraba, Zamfara

Columbite: Bauchi, Ekiti, Jigawa, Kaduna, Kano, Kogi, Kwara, Nasarawa,
Osun, Plateau, Taraba, Zamfara

Gypsum: Anambra, Bauchi, Bayelsa, Edo, Enugu, gombe, Ogun, Sokoto, Taraba, Yobe

Phosphate: Abia, Edo, Ogun, Sokoto

Silica Sand: Akwa Ibom, Anambra, Bayelsa, Delta, Edo, Enugu, Jigawa, Kano, Lagos, Ondo, Ogun, Rivers

Dimension Stones:Most of the States of the Federation and the FCT

52. Out of the list showing above, the following are the world class minerals are found in Nigeria. These minerals by definition are capable of attracting large foreign direct investment and can make important contribution to the GDP. They are:

- Bitumen – 27 billion barrels of oil equivalent
- Coal – 1.5 billion metric tonnes inferred
- Gold – 10 locations > 50,000 ounces inferred resources
- Barytes – 13 million metric tonnes inferred resources
- Iron Ore – 100million metric tonnes inferred resources

Reforms in the Mineral Development Sector in Nigeria

53. The Federal Government that has the singular responsibility of developing minerals has been mindful of the poor contribution to the economy to the mining sector for sometime.

54. A dedicated Ministry of Solid Minerals was established in 1995. Despite the establishment no major change was recorded in the contribution to national economy. The annual contribution to the GDP between 1999- 2006 was below.

55. The identified factors that hindered the development of the sector include:
i. Opaque licensing procedures leading to speculative holding of mineral titles
ii. Low revenue generating capability
iii. Prevalence of illegal and artisanal miners
iv. Conflict between Federal/State governments over ownership of mineral rights
v. Existence of too much discretion granted by the Minerals and Mining Act 1999, which was not private sector friendly.

56. To improve on the situation, and attract large direct foreign investments, root and branch sector reforms were carried out during 2005-2008. The reforms include:
i. Development of a National Policy with clear direction of future activity in the sector.
ii. Review of the 1999 Minerals and Mining Act to provide incentives for private sector participation. This is to the promulgation of a new Minerals and Mining Act.
iii. Restructuring of the Ministry for enhanced performance and better administration/regulation of the sector.
iv. Privatisation/Deregulation of some of the parastatals.
v. Curbing of illegal mining.
vi. Strengthening geological data generation.
vii.Promotion and marketing of investment opportunities.

57. The elements of the reforms are similar to the broad reform categories adopted by countries that have experienced resurgence in mining activity in the 1990's. These include countries as Tanzania, Mali, Bolivia, Peru, Madagascar, Mongolia and Burkina Faso.

58. These reforms are now been stabilised by the current Minister of Mines and Steel Development who is our Special Guest of Honour today. We will demonstrate later in the lecture some of the impact of these reforms in the second part of this lecture. This is built on Item vi of the list above i.e. the strengthening of geological data generation and the infusion of science.

PART 2: MINERAL RESOURCES DEVELOPMENT IN NIGERIA

Mineral Exploration in Nigeria: Dowsing, Lottery, Serendipity or Science Dowsing

59. Dowsing is defined as a type of divination employed in attempts to locate ground water, buried metals or ores, gemstones, oil, gravesites and many other objects without the use of scientific apparatus. Dowsing is as strictly defined the claimed ability to discover underground

sources of water or metals by means of a "dowsing rod." Another term used is "divining." However, this terminology and its scope have been expanded and are now used with a far greater range of meanings.

Figure 4 Dowsing rods

60. Dowsers use a Y- or L-shaped twig or rod claim a response of the rod to buried objects.

61. Dowsing has been used for a long time in Europe and America (since the Renaissance of magic in Germany) and in fact remains popular among believers there is no accepted scientific rationale behind the concept and no scientific evidence that it is effective.

62. Surprisingly dowsing continued to be used to date and in societies that should know better. A search on the internet provides the following list of work and reports in the last fifty or so odd years. Some of them in last year!

- In the late 1960s during the Vietnam War, some United States Marines used dowsing to attempt to locate weapons and tunnels
- An extensive book on the history of dowsing was published by Christopher Bird in 1979 under the title of The Divining Hand.
- A 1986 article in Nature included dowsing in a list of "effects which until recently were claimed to be paranormal but which can now be explained from within orthodox science.

63. A number of devices resembling "high tech" dowsing rods have been marketed for modern police and military use: none have been shown to be effective.

- The more notable of this class of device are ADE 651, Sniffex, and the GT200.
- Global Technical GT200 (manufactured by Global Technical Ltd) is a dowsing type ex-

plosive detector which contains no scientific mechanism.

- Sandia National Laboratories tested the MOLE Programmable System manufactured by Global Technical Ltd. of Kent, UK and found it ineffective.[28]
- A US government study advised against buying "bogus explosive detection equipment".
- The ADE 651 is a device produced by ATSC (UK) and widely used by Iraqi police to detect explosives. Many have denied its effectiveness and contended that the ADE 651 failed to prevent many bombings in Iraq.
- On 22 January 2010, the director of ATSC, Jim McCormick was arrested on suspicion of fraud by misrepresentation. Earlier, the British Government had announced a ban on the export of the ADE-651
- SNIFFEX was the subject of a report by the United States Navy Explosive Ordnance Disposal that concluded "The handheld SNIFFEX explosives detector does not work."

Lottery

64. Lottery by definition is a chance event and the process that produces the outcome is in the realm of low probability. It is a mere 'throwing of the dice'.

Although the outcome is determined by chances it important that some consideration is given to taking part in the process. The person playing the lottery believes that this might lead to simple ways of removing the odds. In many cases they do not. It is the same for mineral exploration.

65. Current expansion in mineral exploration is no more than a lottery as it is speculative. Mining companies from Nigeria and abroad staked claims in tenement adjacent or near existing occurrences or mines in the hope that the occurrence in point A, would probably extend to another point B.

66. The informed mining companies are engaged in enlightened speculation. In this case investors engage geologist who with limited data or knowledge extrapolate the occurrences based on proximity or similarity existing resource.

67. A case in point is the search for Gold in Osun and Zamfara States where most of the areas around historical mines have been covered by speculative licenses, many of which have found little or nothing.

68. Many of the speculative nature and the odds in mineral exploration can certainly be reduced by application of rigorous scientific principles in the search for the minerals. The data, information and knowledge for this to happen are now available and this will be demonstrated later in this lecture.

The Barefoot Doctors in Mineral Development

69. The purveyors of dowsers and lotteries are what I have called elsewhere the barefoot experts (Malomo 2004). The terminology refers to amateur, novices, charlatans and a motley crew of uniformed people who make pronouncement on mineral resources and even proffer advice and provide services on mineral exploration and development.

70. They invariably are involved in mining activities, most of which are illegal and sometimes dangerous. The positive origin of the word barefoot (e.g. the barefoot doctors of China) usually would not apply to the one in mineral exploration or mining.

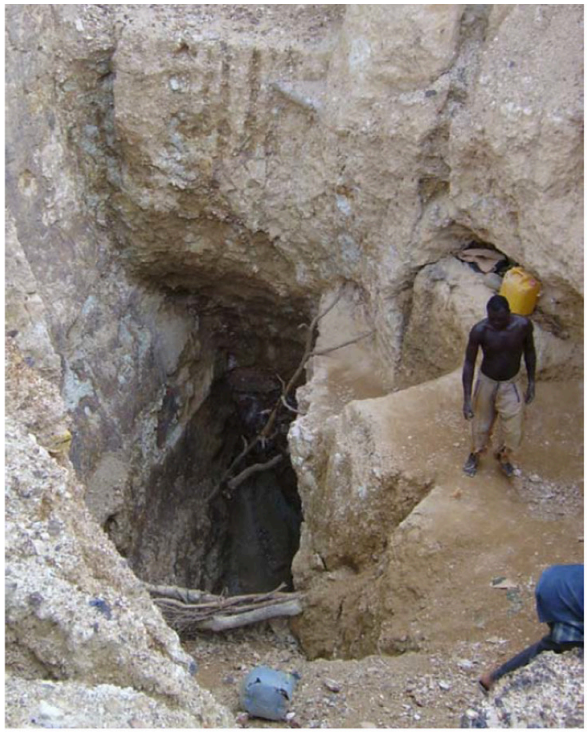

Figure 5. Illegal Mining of Barytes

Figure 6. Environmental degradation due to the mining of barytes

Serendipity

71. Serendipity is the accidental or consequential event or is unplanned or unexpected result of a planned action. It is a fortuitous discovery, especially while looking for something entirely different.

72. Its root of the word comes from comes from Serendip an old Persian name for Sri Lanka; however its usage in English is from an English writer Horace Walpole, who wrote a fairy tale called The Three Princes of Serendip.

73. It is the surprise that shows up when a scientist is conducting a process and an unexpected substance or reaction occurs. According to the Oxford English Dictionary, the precise definition is "The faculty of making happy and unexpected discoveries by accident."

74. The simplest way to describe "serendipity" is to call it a happy accident. In other words, a serendipitous event is an extremely pleasant and unexpected surprise.

75. An example of a serendipitous discovery is that of development of penicillin when Alexander Fleming discovered that the staphylococci bacteria culture he had neglected to clean up before going on vacation would not grow around mould on a plate.

76. Other events like the discovery of electricity and making of raisins or peanut butter are serendipitous, simply because the personnel involved sought to discover something other than what they actually discovered.

77. However Serendipity can only be achieved and indeed produce a useful outcome through preparation. There is no substitute for a good education and good grounding in science. It is captured in the words of Louis Pasteur (the French scientists) who said, that in the field of observation, chance favours only the prepared mind.

78. The ability to spot the significance of inconsequential clues is a skill that separates the erudite from the novice; and it is the outcome of such observations that brings value for the advancement of science and thus presents a platform for us to understand what we didn't understand before.

79. Serendipity is a lot more than finding a pot of gold in a muddy puddle at the end of a rainbow. It is therefore well beyond the realm of dowsing and lottery. Serendipity would apply in the search for Lead (mineral galena) which usually occurs with Zinc (mineral sphalerite) but throws up substantial amounts of Silver (native or Argentite) which usually has more economic value than the original objects of interest.

Science

80. Science is from the Latin scientia, meaning "knowledge". Aristotle used the words to mean a corpus or body of reliable knowledge that can be logically or rationally explained. The origin of science is linked to philosophy and only fairly recently has the there been a distinction.

81. It is now accepted as a collection of ideas; data, information and knowledge that has an underlying link that are testable and predictable. The value of science and scientific methodology lies in predictability and repeatability.

82. There are several approaches to the fundamental understanding of scientific enquiry but I would like to quote Richard Feyman who said, the principle of science, by definition, is that "the test of all knowledge is experiment. And that there is "an expanding frontier of ignorance"

83. This lecture is not about a discourse on science, scientific enquiry or the scientific method. I have brought the matter of science to show distinction between what had gone on in the mineral industry in Nigeria until recent times an what is now been done about it in the last few years particularly in the

Nigerian Geological Survey Agency which I head.

84. A famous quote that I use (I am not sure of the origin though) while talking to students is to recognise the "difference between knowing something and knowing the name of something". The barefoot experts and practitioners of pseudo-science in mineral exploration just know the name of something!

Science and Mapping at the Nigerian Geological Survey Agency

85. The NGSA is the primary Agency for Geoscience of the Federal Government of Nigeria. It is in the review of the progress achieved by the Agency, in the lasts six years, that one can see the spectacular, but unheralded progress, that has been achieved by the country in acquiring new scientific data and tools for the opening up the information on the geology and mineral resources of the country.

Mapping History

86. Mapping for mineral investigation in Nigeria commenced in 1903 and the Geological Survey of Nigeria was formerly established in 1919. At the establishment the mapping was responsible for the mineral finds such as the Jos Plateau (tin), Enugu (coal) Ewekoro (limestone). However the mapping was directed only at areas where potential benefits have been identified leaving large gaps in areas that could be possibly mineralised but not known at the time.

87. To fill the large gap areas, systematic geological mapping for nationwide coverage of the country was carried out 1952- 1975. Most of the results were not published following decline

of interest in solid minerals developments after the discovery of oil. The outputs of the efforts (preliminary reports and maps) were abandoned in shelves and cupboards of the former Geological Survey Department (GSD).

88. The inactiveness of the GSD under various ministries (Mines and Power, Mines Power and Steel, Petroleum and Minerals, Solid Minerals) led to the establishment of an autonomous Agency, the Nigerian Geological Survey, for the accelerated mapping, generation and dissemination of geoscience data and information.

Current Mapping and Outputs

89. The Nigerian Geological Agency mindful of the tremendous challenge and gaps that it has to fill as a consequence of the long years of decline has correctly reemphasised the use of broad mapping tools for mineral investigation in the country.

90. This is of course as it should be, as geological surveys all over the world normally carry out broad investigations, to ascertain the resources , document, archive and disseminate these information to users. The users namely investors, academic and those with engaging curiosity who can them take on the data and information for a deeper analysis and enquiry.

91. It is not that Geological Surveys should not have the capacity (human, equipments and facilities) to carry out further and deeper mineral investigations. It should, but the argument is that it should only do so when called upon to do so for a specified and important reason. Notable examples include national decision making or at chargeable cost to the private sector as in a consultancy.

92. Three types of surveys are currently employed. These are:
i. Regional Geological Mapping
ii. Airborne Geophysical Surveys
iii. Regional Geochemical Mapping

Regional Geological Mapping

93. It is now widely accepted that regional geological mapping and the outputs of mapping viz. maps, mineral databases, petrographic studies, geochemical analyses are the bedrock of the information that mining companies require to take decisions whether to invest in a country or not.

94. Regional Geological mapping provides information on the rocks on every part of the country i.e. beneath our feet (whether mineralised or not). Such information is useful for the identification and development of mineral resources, land use planning, agricultural and infrastructural development.

95. Geological mapping is carried out at different (and fit for purpose) scales. The scale of a map to be used depends on the purpose for which it is required. For instance the geological mapping required for foundation studies for a new highway route location between States would require maps at a scale of

1:250,000 while foundations studies for urban road would require maps at

1:100,000 or greater. Similarly the mapping required for a broad knowledge of mineral occurrence in the country would require maps at scale of 1: 250,000

96. A more appropriate scale of mapping required for mineral investment and infrastructure development is at scale of 1:100,000. In producing maps of the country during the early years of geological mapping, emphasis was placed on known mineralised areas, such as the tin fields of Jos plateau and coalfields of Enugu, the mapping of the rest of the country which could equally be mineralized was not give attention.

97. The field work for systematic geological mapping at 1:100,000 scale commenced in the 1950's and was 95% completed by 1990. However less than 6.5% (22 out of possible 337 maps) of the initial work was carried to fruition, in the production of geological maps and reports. The results of the field exercise were limited to notes and field maps, kept in shelves and cupboards, most of which are now either lost or obsolete.

98. The NGSA in 2004 began to update the work where possible and have taken the field mapping to fruition in producing and publishing maps on the appropriate scale. It has now produced additional 17 maps.

99. Having regard to the need to upscale the geological mapping of the country for mineral investment, the Agency has also begun fresh systematic mapping of all unmapped areas in all the geopolitical zones of the country.

100. Currently out of a possible 337 maps at the scale of 1:100,000 only 48 have been produced to date (since 1919 – 22 maps before the establishment of the NGSA and 26 maps since the establishment).

100. NGSA started the journey by publishing small scale maps,

Published maps to date are:

- National Maps – 3, Maps of all Geopolitical zones – 6, Maps of all the States of the Federation and the FCT – 37
- Localised (Sheet) Maps on 1:100,000 – 26
- Commodity maps of the Strategic Minerals – 7, Combination

Commodity Maps – More than 2million is possible depending on the request

- Current Projects
- Map publication – 22 maps in progress

- Detailed Geological Mapping on a scale of 1: 50,000 to be published on 1:100,000 – (36 projects to produce 9 maps)

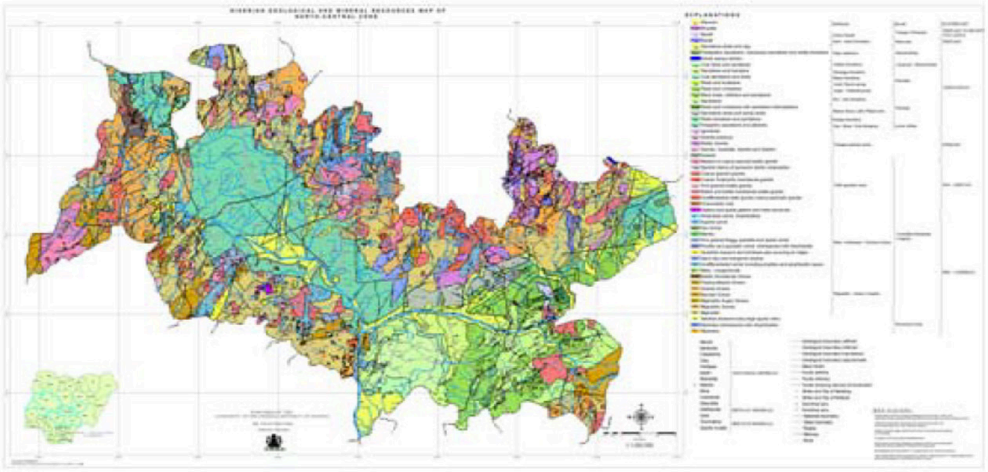

Figure 7 Regional Map (1:500,000) of North-Central Nigeria

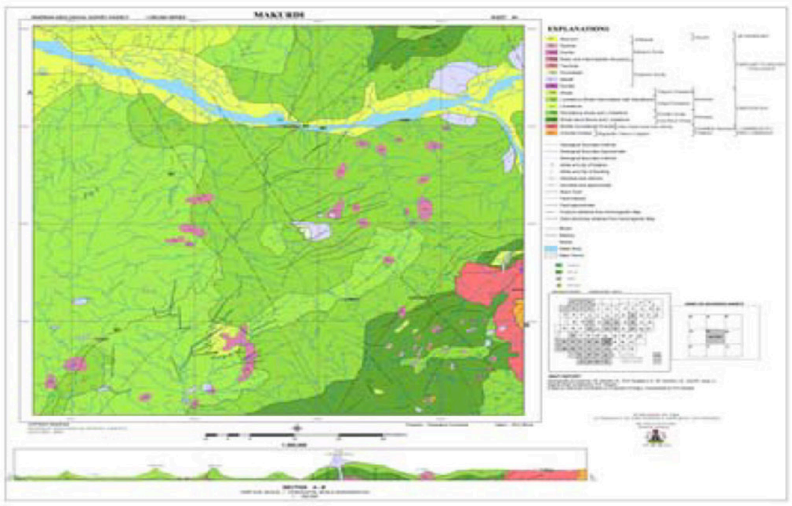

Figure 8. 1: 250,000 Geological Map of Makurdi sheet

Airborne Geophysical Surveys

101. Airborne Geophysical Surveys is a rapid and effective way of unravelling areas of possible mineralisation and is currently being carried out by more than forty countries in the world. The aims of the surveys are:

a) To produce a fast coverage of vast areas;
b) To produce a cheaper and faster rate of coverage
c) To overcome problems of rugged and inaccessible terrains.

102. We have been using a variety of geophysical techniques at the NGSA. The most common are magnetic, radiometric and gravity.

103. Gravity and magnetic exploration are potential fields exploration. They are employed to provide non-intrusive methods of identifying the nature of earth beneath the Earth's surface through the sensing of different physical properties of rocks (density and magnetization, respectively). Gravity and magnetic exploration can help locate faults, mineral or petroleum resources, and ground-water reservoirs.

104. Aeromagnetic anomaly maps show variations in the Earth's magnetic field that are caused mainly by magnetic minerals in crustal rocks. These anomalies vary with amount and type of magnetic material and the geometry and depth of the magnetic body. Igneous and metamorphic rocks frequently are magnetic enough to cause anomalies, whereas sedimentary rocks commonly are nonmagnetic.

105. The differential between these types of rocks can also be employed in identifying the nature of the rocks. This enhances the usefulness of aeromagnetic surveys as mapping tools. Aeromagnetic anomaly maps are important tools for mapping superficial and buried rocks, for determining geologic structure, and for discovering some types of mineral deposits.

106. Regional geological features may become evident after individual aeromagnetic surveys are compiled and plotted at the same scale in a consistent way.

Radiometric Surveys

107. Radiometrics is a measure of the natural radiation in the earth's surface, which can tell us about the distribution of certain soils and rocks. Geologists and geophysicists routinely use it as a geological mapping tool to ascertain rock types and changes in rock formations.

108. Radiometric surveys involve the measurement of gamma radiation resulting from natural radioactive sources. Instruments are available to measure either total count or provide spectral information on individual elements such as uranium, thorium and potassium in order

to identify specific sources of radiation.

109. Radiometric measurements are primarily used in mineral exploration but can also be applied to the detection of faults, location of caves and for mapping contamination.

110. From airborne surveys, using the distinctive gamma ray spectra from the three radioactive elements, the concentrations of potassium, uranium and thorium have been mapped over 100% of the required areas for information in Nigeria.

Nigeria's Airborne Geophysical Surveys Programme

112. The Federal Government of Nigeria has now completed the acquisition of airborne magnetic data for the entire country. This was recently completed with the last tranche of the project on the Niger Delta. In addition radiometric data acquisition for all the required areas (the county minus the Niger Delta on account of the wetness was acquired. Gravity data was acquired for the Niger Delta only.

113. This represents 2.5 million line kilometres for the magnetic, 1.94 million line kilometres for the radiometrics and 4.5 million line kilometres for the gravity data. All the data sets were acquired at 500 metre spacing at a flight height of 80metres. The ambitious data set represent the only country in Africa with such total coverage to date.

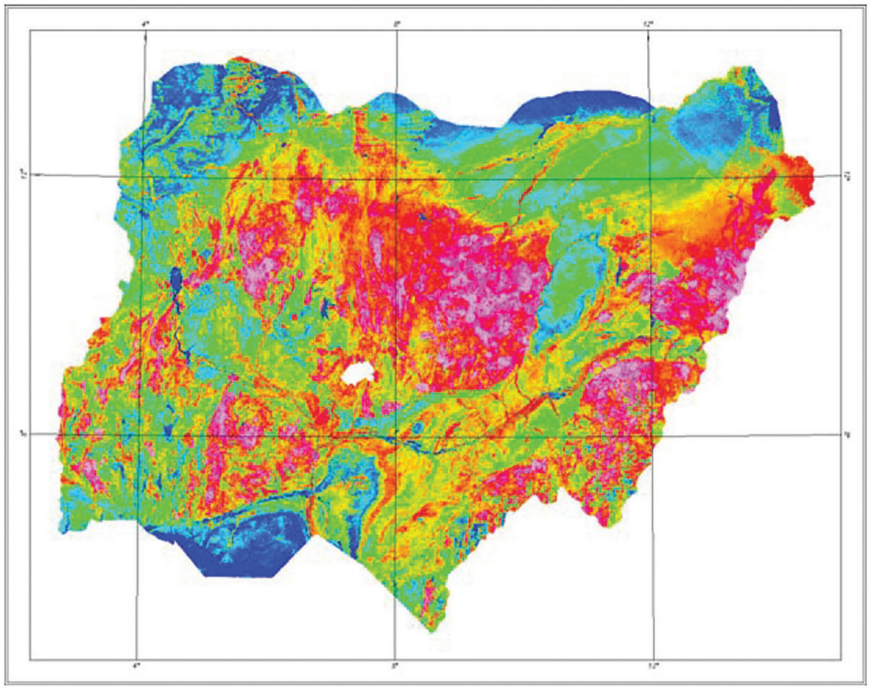

Figure 9 Total Magnetic Intensity map of Nigeria (minus the Niger Delta)

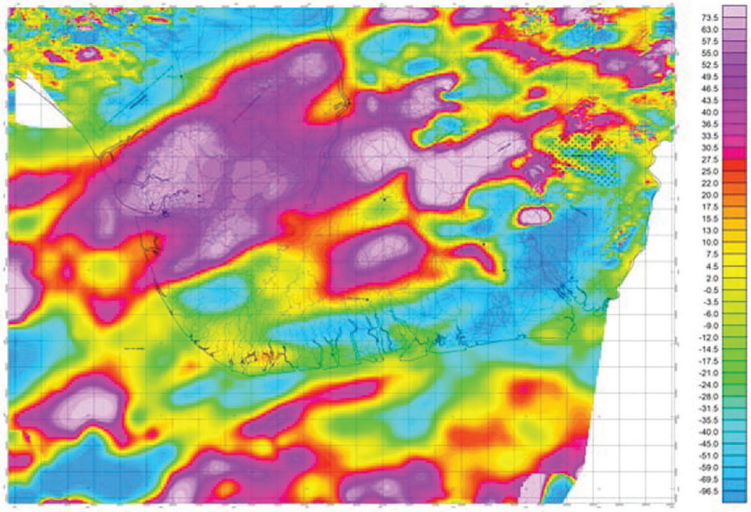

Figure 10 Total Magnetic Intensity map of the Niger Delta

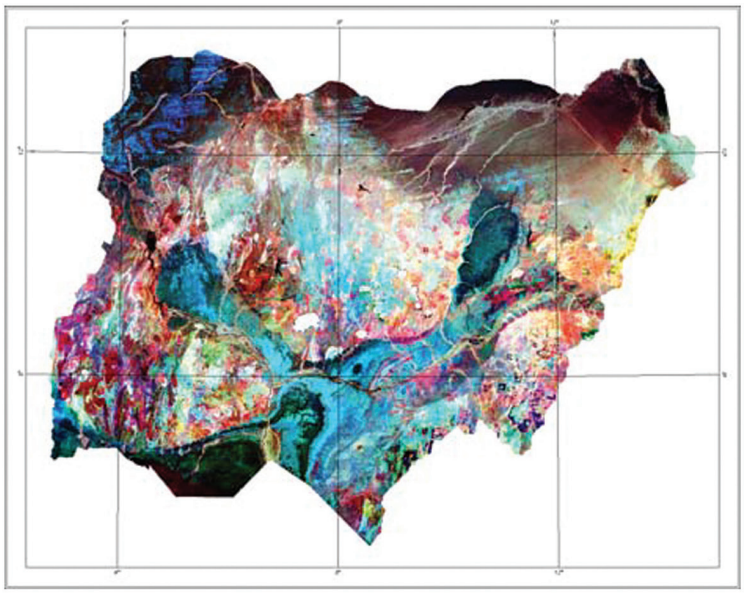

Figure 11 Ternary Radiometric Map of Nigeria (minus the Niger Delta)

Regional Geochemical Mapping

114. This is the analysis of soil, sediments and water (sometimes plants) on a regional basis to produce a body of geochemical data for the country. The sampling and the analyses are carried out using a consistent set of methods.

These dataset produced will generate complete, national-scale geochemical coverage of the country. It enables the production of geochemical maps and provides broad estimates of baseline (or background) geochemical values.

115. The purpose of regional geochemical mapping is to provide information on prospective areas for mineral exploration and where possible information on the relationship between health and trace element deficiencies and toxicities in the environment.

116. Regional and national-scale geochemical surveys have been used for many decades to locate areas of the Earth's crust where mineralisation processes have occurred. Data generated for geochemical exploration purposes can also be used to establish geochemical baselines for use in environmental

Figure 11 Ternary Radiometric Map of Nigeria (minus the Niger Delta) studies, to resolve controversies arising from questionable correlation of geologic units, and for many other purposes.

117. The outputs fro geochemical mapping surveys are usually multi-element atlases showing the distribution of elements on a regional scale. Several maps are usually produced. More than 50 different maps can be produced, with each depicting a particular distribution of element.

118. The Nigerian Geochemical Mapping Project consists of four components. An initial component funded by the Federal Government carried out by the NGSA Staff, a second component which is collaboration between the British Geological Survey (BGS) and the Nigerian Geological Survey Agency (NGSA) facilitated by the Sustainable Management of Mineral Resources Unit of the Ministry of Mines and Steel Development. A third component carried out by NGSA staff with some supervision by the BGS and a final component to be done by NGSA staff without any supervision.

119. The purpose of the project is to provide baseline geoscientific information for mineral exploration and environmental management through a study of the distribution of important metallic elements on the Nigerian land surface. The Global Reference Network is made up of 5000 cells out of which 44 are contained wholly or partly in Nigeria. The project has completed the first two components and begun (November 2010) the third component.

120. The collaboratory effort of the second component obtained stream sediment samples from two of these cells, analysed the samples and produced geochemical maps. 80 Nigerians and about 20 foreign earth scientists were involved in the collection, analysis and interpretation of the samples.

121. A total of 1656 stream sediment samples were analysed comprising 284 and 1307 stream sediment samples from two cells in the South-western and Minna areas respectively, and 65 standard control samples. The samples were analysed in the BGS Keyworth laboratories as well as at the Acme Laboratories in Canada. The concentrations of a total of 57 elements were obtained using ICP-MS. Key and Johnson (2010).

Figure 12. Global Reference Network (GRN) Index Map for Nigeria. The darker cells are the areas mapped to date

Total number of cells for Nigeria: 44. Completed: 6 Cells, On-going: 2

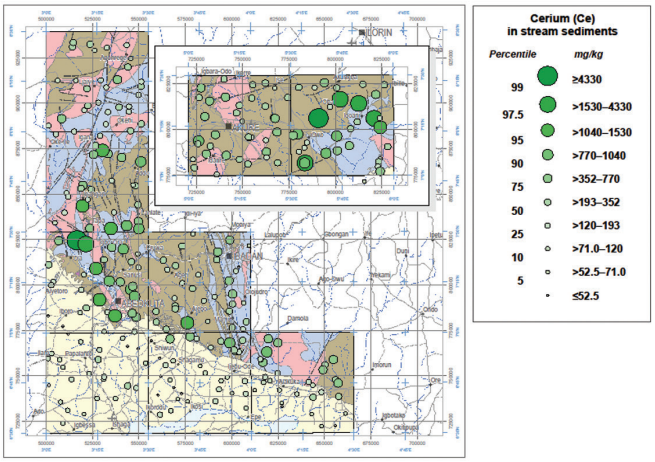

Figure 13. Cerium (Ce) distribution in the South-western Master Cell

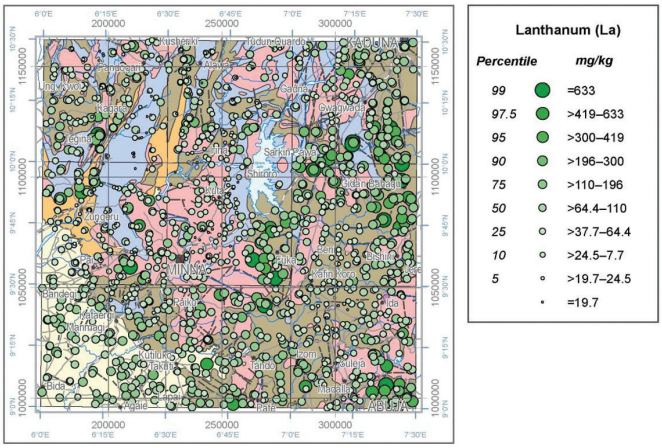

Figure 14. Lanthanum (La) distribution in the Minna Master Cell.

The Outcome of the Minerals Development Reforms

122. There are already, green shoots of recovery in the effort by the government. One barometer of change is the number of enquiries (including investors) received in the last four years. Figure shows the number of enquiries received at the offices nationwide during 2007-2009

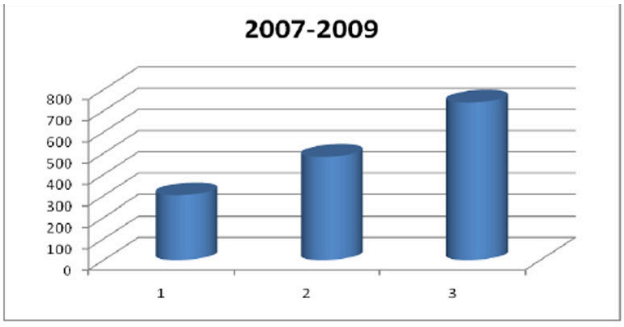

Figure 15. Nationwive NGSA Investor Enquiries 2007-2009

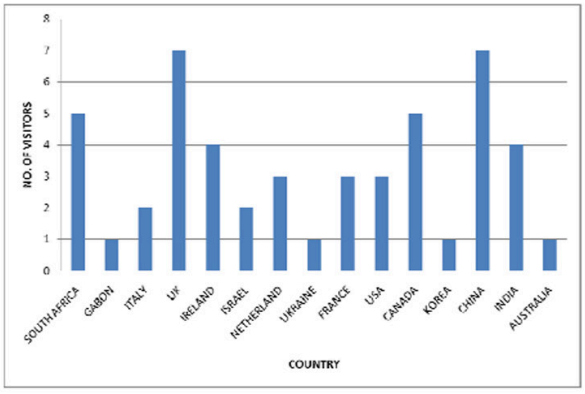

Figure 16. Summary of Foreign Investors by country to NGSA Headquarters' Customer Service Centre (2009)

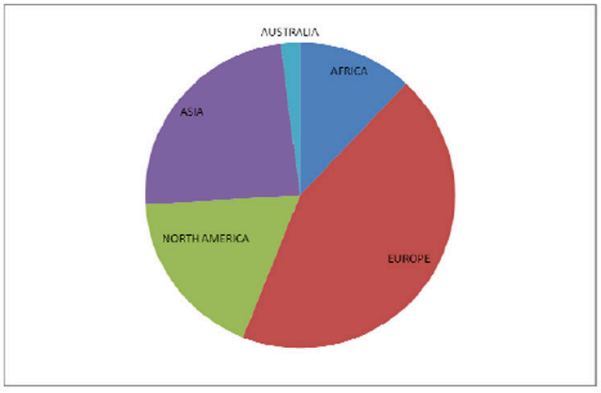

Figure 17. Distribution of Foreign investors to NGSA Headquarters' Customer

CONCLUSION

123. I have gone at great length to illustrate that geology is no longer confined to the study of rocks and minerals but for a variety of purpose beyond wining of metallic and non-metallic products for sale.

124. Outcomes of the mapping surveys have shown us that there is no replacement for logic and science in development. Record of overseas visitors at the NGSA headquarters in Abuja since May 2006; have shown a significant increase in numbers and quality of enquiries. We are now having enquiries from credible local and international investors.

125. The understanding of the nature, distribution and value of Nigeria's Mineral resources have an impact on the generation of wealth, industrial development provision of infrastructure and the sustenance of life on earth.

Mr Chairman
Special Guest of Honour
Thank you for the attention. God bless you.

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AFRICA AND CANCER: PREPARING FOR THE NEXT EPIDEMIC

Isaac Folorunso Adewole FAS
A NAS public lecture delivered January 2012

INTRODUCTION

1.1 A Big Honour

It is my singular honour to deliver this guest lecture to a distinguished audience under the auspices of the Nigerian Academy of Science (NAS). Essentially tagged first quarter lecture in 2012, it can be likened to a state of the Union Address to the nation through NAS. I am proud to be a fellow of the Nigerian Academy of Science (NAS), the foremost scientific organization in Nigeria with the aim of promoting the growth, acquisition, and dissemination of scientific knowledge and to facilitate its use in solving of major problems of national interest. I am also aware that our President is likely, Dr. Goodluck Jonathan, GCFR, to assume office as the next Chair of the African Union and have taken the liberty as President of the African Organisation for Research and Training in Cancer (AORTIC) to deliver a sermon on Cancer to Africa on this occasion. I thank the President, Prof Oye Ibidapo-Obe FAS,and the entire fellows of the Academy for the honour bestowed on me. I also thank my Chairman, Chief Wole Olanipekun SAN, who graciously accepted to chair this occasion at such notice despite his busy schedule.

1.2 Africa in brief

Africa is the world's second largest and second most populous continent, after Asia. Africa with a landmass of about 30.2 million km2 (11.7 million sq mi) including adjacent islands, covers 6% of the Earth's total surface area and 20.4% of the total land area.

With 1.0 billion people in 65 territories (including 54 recognized states), it accounts for about 14.72% of the world's human population. The continent is surrounded by the Mediterranean to the north, both the Suez Canal and the Red Sea along the Sinai Peninsula to the northeast, the Indian Ocean to the southeast, and the Atlantic Ocean to the west.

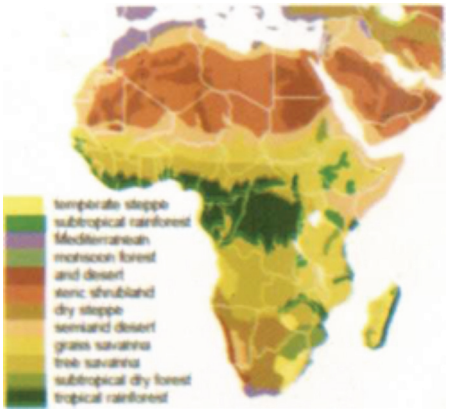
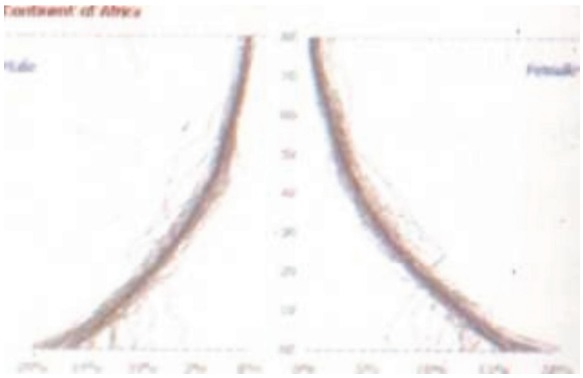


Figure 1

Africa straddles the equator and encompasses numerous climate areas; it is the only continent to stretch from the northern temperate to southern temperate zone.



Africa's population is relatively young but has rapidly increased over the last 40 years. In some African states, half or more of the population is under 25 years of age. The total number of people in Africa grew from 221 million in 1950 to 1 billion in 2009.

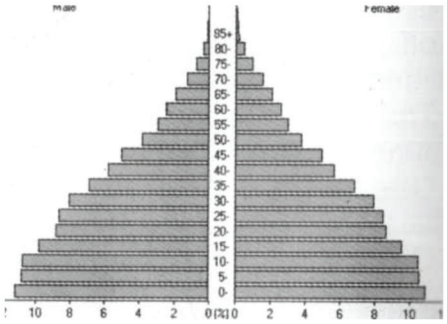


Figure 2: Population pyramid by country continent of Africa

According to the UN report, the population of Africa has grown exponentially over the past century, and consequently shows a large youth bulge, further reinforced by a low life expectancy of below 50 years in most African countries. The population doubled in the period 1982-2009 and quadrupled from1955-2009. Africa's population, growing by 2.5% a year, will exceed 1.2 billion people by 2025 (UN 2001). It is projected that there will be considerable differences by region. Growth will be slightly faster in Central Africa (3.0%), West Africa (2.9%), and East Africa (2.6%) but slower in North Africa (2.1%) and Southern Africa (1.0%). The explosive growth in population is putting pressure on the continent's natural resources (UN Report, 2004).

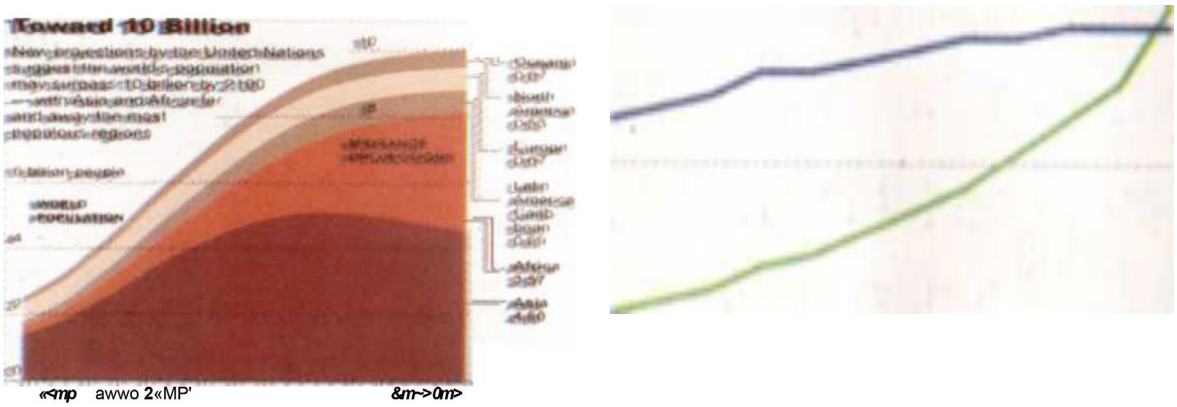


Figure 3: Map showing population projections for Africa

Africa, particularly central Eastern Africa, is widely regarded within the scientific community to be the origin of humans and the Hominidae clade (great apes), as evidenced by the discovery of the earliest hominids and their ancestors, as well as later ones that have been dated to around seven million years ago - including Sahelanthropus tchadensis, Australopithecus africanus, A. afarensis,Homo erectus, H. habilis and H. ergaster - with the earliest Homo sapiens (modern human) found in Ethiopia being dated to circa 200,000 years ago.

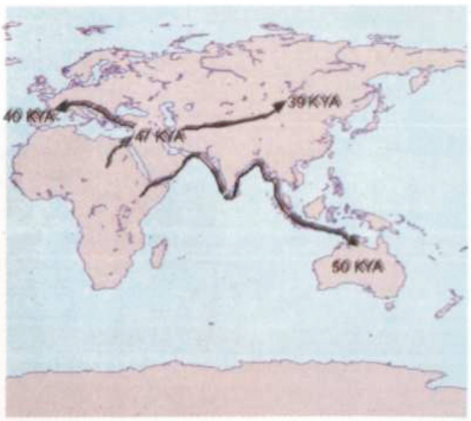


Figure 4: Population pyramid by country continent of AfricaMap showing the Archeaological evidence for route of migration of Homosapien

Figure 5:
Picture of one of the oldest skull (Ethiopia)

Figure 6:
Toumai Chad (Brunet et al 2002, Nature, 418: 145-151 Reported about 7 million ago.

Today, Africa contains 54 sovereign countries, most of which still have the borders drawn during the era of European colonialism. UNESCO has estimated that around two thousand languages are spoken in Africa. Most are of African origin, though some are of European or Asian origin. Africa is the most multilingual continent in the world, and it is not rare for individuals to fluently speak not only multiple African languages, but one or more European ones as well. There are six major language families represented in Africa, of which four is indigenous.(Wikipedia...Languages of Africa)

These are:

- Afro-Asiatic spread throughout the Middle East, North Africa, the Horn of Africa, and parts of the Sahel
- Nilo-Saharan is centered on Sudan and Chad (disputed validity)
- Niger-Congo covers West, Central, and Southeast Africa Khoe is concentrated in the deserts of Namibia and Botswana
- Austronesian on Madagascar.
- Indo-European on the southern tip of the continent

Figure 7: Map Showing Africa major families languages

Since colonialism, African states have frequently been hampered by instability, corruption, violence, and authoritarianism. The vast majority of African states are republics that operate under some form of the presidential system of rule. However, few of them have been able to sustain democratic governments on a permanent basis, and many have instead cycled through a series of coups, producing military dictatorships.

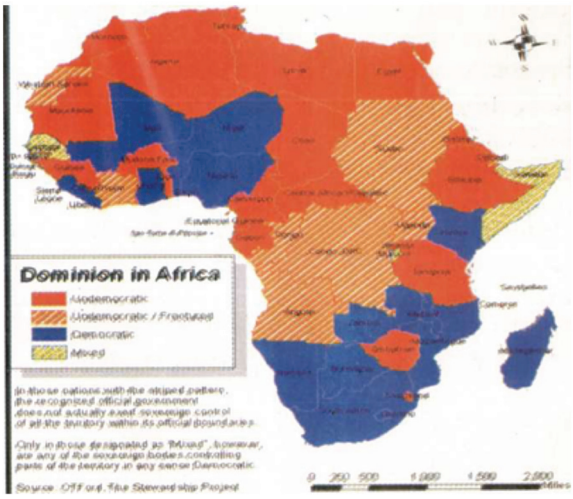


Figure 8: Map showing distribution pattern of type of Governance in Africa

Great instability was mainly the result of marginalization of ethnic groups, and graft under these leaders. For political gain, many leaders fanned ethnic conflicts that had been exacerbated, or even created, by colonial rule. In many countries, the military was perceived as being the only group that could effectively maintain order, and it ruled many nations in Africa during the 1970s and early 1980s. During the period from the early 1960s to the late 1980s, Africa had more than 70 coups and 13 presidential assassinations.

Africa leaps out as the place where the most people fear for their next meal, while the rich world has more to fear from obesity.

In 2005, Sahel had one of the worst experiences of famine in history with very large causalities in Niger and over six million people were living without food for months in the country. This resultant effect led to the death of over 300 000 children which were attributable to malnutrition by the end of that year. In 2006,11 million people were said to be facing starvation. These numbers comprise of 2.5 million people in Kenya, 1.4 million in Somalia, 1.5 million in Ethiopia, and 60 000 in Djibouti. About 2 million children were said to be surviving on one poor meal a day. The affected countries already had high rates of malnutrition and morbidity before the crisis as a result of endemic drought since the 1980s. Families lost crucial sources of nutrients as livestock, from which they got meat and milk, perished due to incessant droughts. While the much-publicized crises came, went, and returned, the problem of poor food quality has remained constant over several decades.

Figure 7: Effects of Famine in Africa on both family and livestock

In several countries in Africa, there is a symbiotic relationship between food insecurity and conflict. These twin challenges have contributed to the pattern of public health issues in Africa.

Contrary to popular belief, Africa's civil wars are not due to its ethnic and religious diver-

sity. Using recently developed models of the overall prevalence of civil wars in 161 countries between 1960-1999, the outcome shows that the relatively higher prevalence of war in Africa is not due to the ethno-linguistic fragmentation of its countries, but rather to high levels of poverty, failed political institutions, and economic dependence on natural resources. Evidence revealed that political development is much more effective than economic factors in reducing the risk of violent conflict. Moreover, the spillovers from the globalization process may imply that the pace of political reforms toward an improved political right could be accelerated. In addition, improvements in the political front are prerequisites for stable economic growth and other developmental policies.

1.2 Economic situation in Africa:

Although, it has abundant natural resources, Africa remains the world's poorest and most underdeveloped continent, the result of a variety of causes that may include the spread of deadly diseases and viruses (notably HIV/AIDS) and corrupt government that have often committed serious human right violations, failed central planning, high levels of illiteracy, lack of access to foreign capital, and frequent tribal and military conflict (ranging from guerrilla warfare and genocide). Africa's expected economic growth rate was at about 5.0% for 2010 and 5.5% in 2011. According to the UN Human Development report in 2003, the bottom 25 ranked nations (151 st to 175th) were all African.

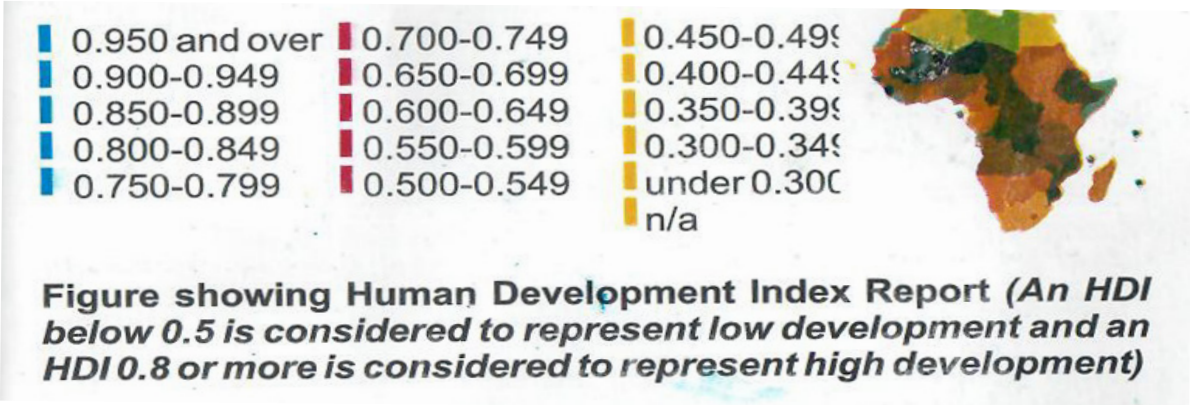


Figure 10

Poverty, Illiteracy, malnutrition, and inadequate water supply and sanitation, as well as poor health, affect a large proportion of the people who reside in the African continent. In August 2008, the World Bank announced revised global poverty estimates based on a new international poverty line of $1.25 per day (versus the previous measure of $1.00). About 81 % of the Sub-Saharan Africa population was living on less than $2.50 (PPP) a day in 2005, compared with 85.7% for India. Recent figures confirm that sub-Saharan Africa has been the least successful region of the world in reducing poverty ($1.25 per day); some 50% of the population living in poverty in 1981 (200 million people), a figure that rose to 58% in 1996 before dropping to 50% in 2005 (380 million people). In 2011, Democ atic PP^'IHHC of Congo, Niger and Burundi were at the bottom of the ladder(2011 UN HDR).

2. EPIDEMICS IN AFRICA

Africa shoulders the world's largest burden of disease. Disease outbreaks are the most common news in Africa after conflict and political instability. It is the epicenter of the global resurgence of infectious epidemics and pandemics. Africans remain troubled by diseases like malaria, diarrhoea, measles, cholera, HIV/AIDS and tuberculosis that have long been overcome elsewhere with the help of modern medicine and efficient public health systems. Notwithstanding the fact that the correlation between political economy and health was established in the 1970s, the twin challenge persists unabated in most of Africa.

Africa's share of the global burden of ill health is as disproporte^ely huge as its share of global poverty. In spite of many conference resolutions, innovative global plans and other laudable undertakings, the state of health in Africa remains appalling. Health reports indicate that all health conditions are worse in Africa than in any part of the world. Until recently, we thought infectious diseases had been overcome and the focus was to shift to lifestyle diseases like cancer, diabetes, hypertension, heart diseases, depression, and so forth.

While communicable diseases are an occasional occurrence in the developed world, they are Africa's daily bane.

While globally the number of deaths due to communicable diseases and nutritional conditions was 30% of total deaths in 2004, in Africa, these conditions accounted for 69% of natural deaths. These amounted to almost eight million deaths in Africa out of an estimated 17 million deaths caused by communicable diseases, maternal, perinatal and nutritional conditions globally.

Table 1: Showing Death by cause estimate

CAUSE	WORLD		AFRICA	
Population (000)	6 436 826		737 536	
	(000)	% total	(000)	% total
Total deaths	58 772	100.0	11 248	100.0
I. Communicable diseases	17 971	30.6	7 682	68.2
Infectious and parasitic diseases	9 519	16.2	4 849	43.1

Source: WHO, *Burden of Disease Statistics*, Geneva: WHO, 2

2.1 Infectious epidemics in Africa.

It is axiomatic that infectious diseases do not respect national borders. But this simple truth does not convey the degree to which pathogens migrate great distances to pose health hazards everywhere. The effect is worse in Africa compared to other countries. Human beings congregate and travel, live in close proximity to animals, pollute the environment, and rely on over-

taxed health systems. This constant cycle of congregation, consumption, and movement allows infectious diseases to mutate and spread across populations and boundaries. The complacency of several countries in Africa makes them vulnerable and that is why they carried the highest burden of many infectious diseases. In addition, the lack of health priority, poor living standard and epileptic health financing are contributory to these recurrent infectious epidemics.

Significant impacts of the high burden of infectious disease especially in low and middle-income countries include social, economic deprivation, potential for rapid spread and human security concerns.

2.1.1. Malaria

Malaria is a grave health threat globally, with nearly half of the world's population living in areas where malaria is endemic. Some 109 countries are classified by the WHO as 'malarious.' Fifty of 109 malarious countries are in Africa. Forty-six countries are in control mode, meaning they are battling the disease using normal control measures such as the supply of insecticide-treated bed nets, indoor spraying of homes and conducting targeted diagnostic tests and administration of curatives. Malaria is responsible for the death of 397 000 people in Africa, which is 45% of total malaria related deaths. Some 203 000 cases of malaria were detected in Africa alone in 2005, out of a total of 241 000. This means that Africa accounts for 84% of total global incidence of malaria. Malaria accounts for around 100 000 infant deaths and is responsible for 18% of deaths among children under the age of five.

Some African countries have recorded success in malaria eradication programme and they have been placed on elimination phase.

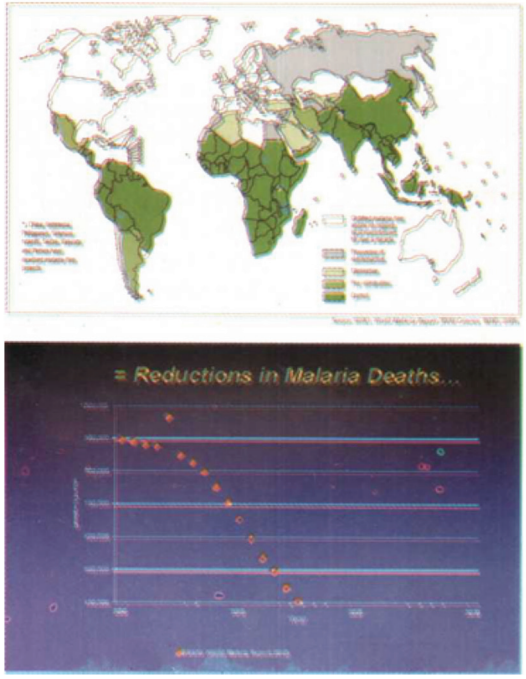


Figure 11

This also means a resurgence of malaria incidence is deemed unlikely. What we have been able to document is that the entire world has demonstrated increased spending on anti-malaria programs.

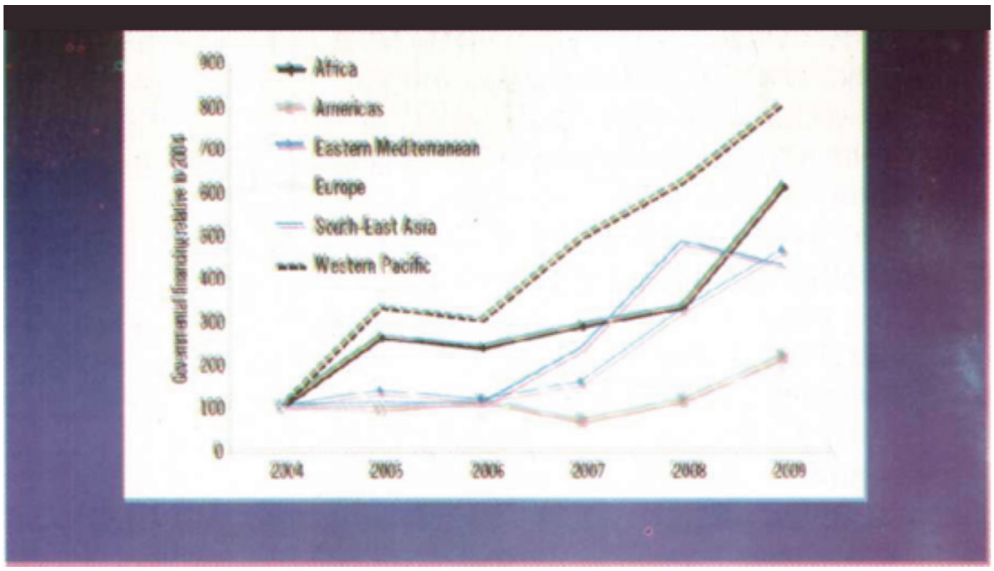


Figure 12: Increase in Anti-Malaria Spending

The successes registered in these countries are generally ascribed to effective use of control measures. This indicates that the rollback malaria campaign is having an impact in some countries and lessons are being learned for application in the rest of the malaria-prone countries.

2.1.2. Cholera

The most common cause of death, which falls into the category of secretory diarrhea, is cholera. Cholera is caused by enterotoxin-producing strains of the bacterium called vibrio cholera. It is transmitted between humans through eating food or drinking water contaminated with the bacterium passed from other sufferers. While cholera is no longer a major public health issue in most of the world due to improved sanitary conditions, the disease has re-emerged as a grave threat in Africa since 2005. A total of 125 082 cases were recorded in Africa in that year, 31% higher than ugures for 2004 and accounting for 95% of global outbreaks. Some countries such as Sierra Leone, Liberia and Zimbabwe still have huge burden from Cholera especially in their suburbs.

2.1.3.Tuberculosis

TB is one of the oldest health challenges in Africa. The incidence of TB has been rising in Africa at alarming levels since the mid-1990s as the prevalence of HIV and AIDS also increased. The dramatic explosion of the HIV and AIDS epidemic in Africa, making the continent its epicenter, diminished immune resistance of many to this infectious disease. In some cases, HIV

infection accounts for as much as a 60% rise in the incidence of TB. About 30% of AIDS-related deaths are caused by TB in Africa.

2.1.4.Poliomyelitis

The global rate of polio infection declined in recent decades to the point where the disease was almost eradicated. This year, the disease has experienced resurgence, as basic health care collapsed in large parts of Africa and in other poor countries around the world. The Global Polio Eradication Initiative, a mass immunisation programme started in 1988, cut the number of cases from 350,000 cases per year in 125 countries when the programme started to 783 cases in 6 countries in 2003. The "Kick polio out of Africa" campaign run by the World Health Organisation (WHO) cut the rate of polio infection in Africa from 205 cases a day in 1996 to just 1 case a day in 2003. Some countries are still recording cases of Polio, but generally, the epidemic is over.

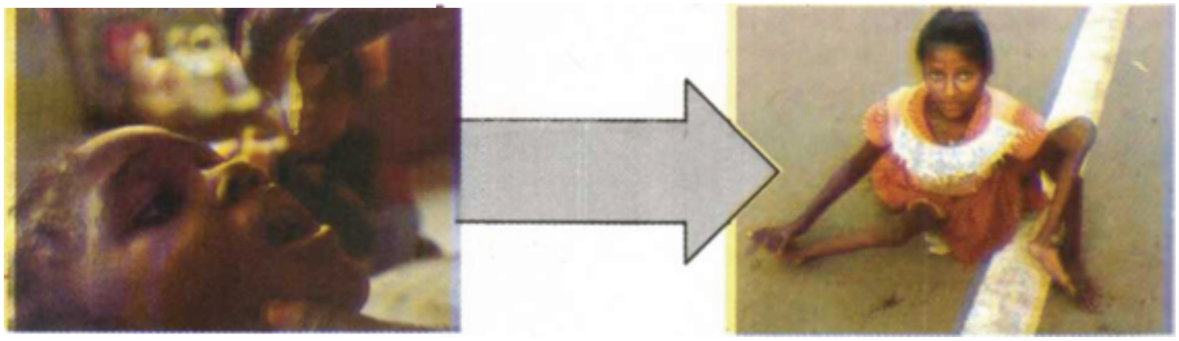


Figure 13

2.1.5. HIV/AIDS

HIV/AIDS is one of the most devastating conditions of the 21st century. Globally, an estimated 34 million [31.6 million-35.2 million] people worldwide were living with HIV at the end of 2010. There were 2.7 million [2.4 million-2.9 million] new HIV infections in 2010, down 21% from the peak of the global epidemic in 1997. HIV incidence has fallen in 33 countries, 22 of them in sub-Saharan Africa, the region most affected by the AIDS epidemic in 2005. An estimated 6.6 million people in low- and middle-income countries were receiving HIV treatment at he end of 2010 - an increase of more than 1.35 million over 2009 and nearly half of those eligible. As a consequence of expanded treatment, AIDS-related deaths are decreasing, and growing numbers of people with HIV are living longer and productive lives. The number of people dying from AIDS-related causes fell to 1.8 million [1.6 million-1.9 million] in 2010, down from a peak of 2.2 million [2.1 million-2.5 millions] in the mid 2000s. A total of 2.5 million AIDS-related deaths have been averted since 1995 due to antiretroviral therapy being introduced. (UNAIDS Data tables, 2011). The world has moved from a mother to child transmission of HIV of 20-40% to almost zero. We have changed our battle code from prevention of mother to child transmission (PMTCT) of HIV to eradication of mother to child transmission (e MTCT) of HIV.

Generally, the burden of HIV though is still very high compared to other parts of the world but there has been a remarkable progress in the area of prevention and treatment due to increased political commitment, donor support and mobilization of the populace.

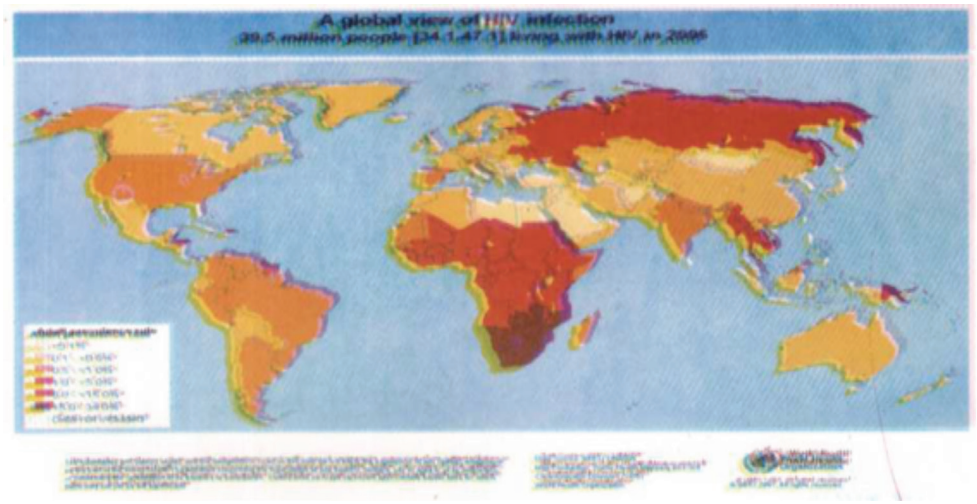


Figure 14: A global view of HIV infection

3. CANCER IN AFRICA: DOCUMENTING THE COMMON CANCERS AND TREND

Africa's health crisis starkly illustrates current complex global public health challenges such as rapidly widening health inequalities, and unprecedented emergencies such as the pandemic of HIV/AIDS, Tuberculosis, Malaria and other communicable diseases. Several low-income countries including Africa are experiencing emerging epidemics of chronic diseases and injuries both earlier thought to be mainly confined to middle-class and urban population due to rapid westernization of habits and lifestyles.

Burden of Cancer in Africa

2002	2030
There were 650 000 new cases of cancer, and 506 000 people died from the disease. •CFR-78%	The figures will rise to 1.60 million new cases with 1.23 million deaths. •CFR-77%

Cancer is now the third leading cause of death worldwide, with 12 million new cases and 7.6 million cancer deaths estimated to have occurred in 2007. By 2030, it is projected that there will be 26 million new cancer cases and 17 million cancer deaths per year. Africa, our dear and own continent, is projected to record a disproportionately higher rate of increase than Europe and United States of America.

Increase in Deaths Due to Cancer
(Globocan 2008)

	European Union	United States	Africa
2010	1.274.607	587.675	460,030
2030	1,687.733	927.539	819.422
%increase	32%	58%	78%

Figure 14

Globally, it is estimated that cancer killed more persons than HIV,TB and malaria combined.

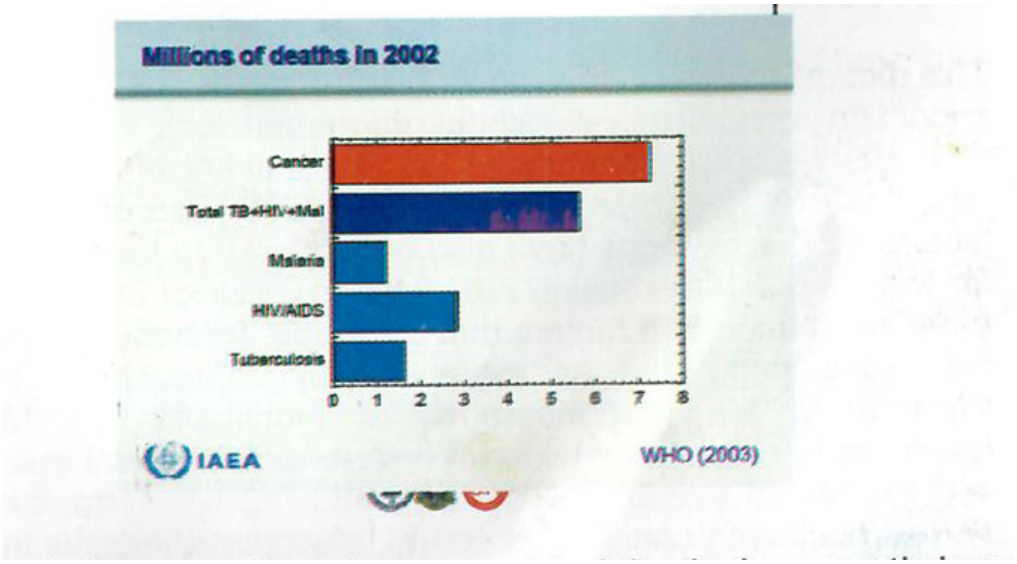


Figure 15: Comparison of Mortality due to Cancer s. Infectious Dideases

Although, the proportion of cancer related deaths is currently low in Africa, several factors point to worsening scenarios if urgent and concrete steps are not taken to stem the tide.

Table 2: Estimated worldwide and African mortality by cause in 2002

	World (n=57 million deaths)	Africa (n=10 million deaths)
Infectious and parasitic diseases, %	19·1	52·7
Tuberculosis, %	2·8	3·3
HIV and AIDS, %	4·9	19·6
Malaria, %	2·2	10·7
Respiratory infections, %	6·9	10·5
Maternal and perinatal conditions, %	5·2	7·4
Cancer, %	12·5	3·8
Cardiovascular disease, %	29·3	9·7
Injuries or violence, %	9·1	7·0
Other causes, %	17·9	8·9

Table 1: Estimated worldwide and African mortality by cause in 2002[1]

Moreover, the global distribution of cancer and types of cancer that predominate continues to change, especially in economically developing countries. Low- and middle-income countries accounted for about half (51%) of all cancers worldwide in 1975; this proportion increased to 55% in 2007 and is projected to reach 61% by 2050.

This global increase in the cancer burden and its disproportionate impact on economically developing countries is being propelled by both demographic changes in the populations at risk and by temporal and geographic shifts in the distribution of major risk factors. These changes have also been shown to be responsible for the on-going increasing prevalence of cancer in Africa. The three most important factors that contribute to these trends are: the aging population as evidenced by improvement in life expectancy, the preponderance of modifiable risk factors (particularly cigarette smoking, Western diet, physical inactivity, and increased sexual liberty) in developing countries and the slower decline in cancers related to infectious etiologies in low-resource countries than in high-resource countries.

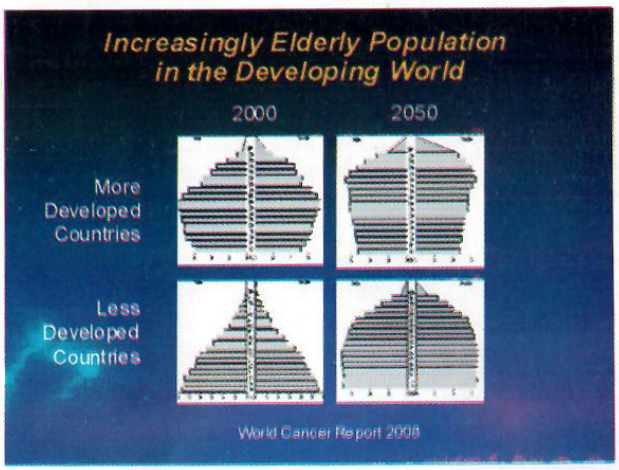


Figure 16: The map showing the prevalence pattern of cancers in Africa in male and females

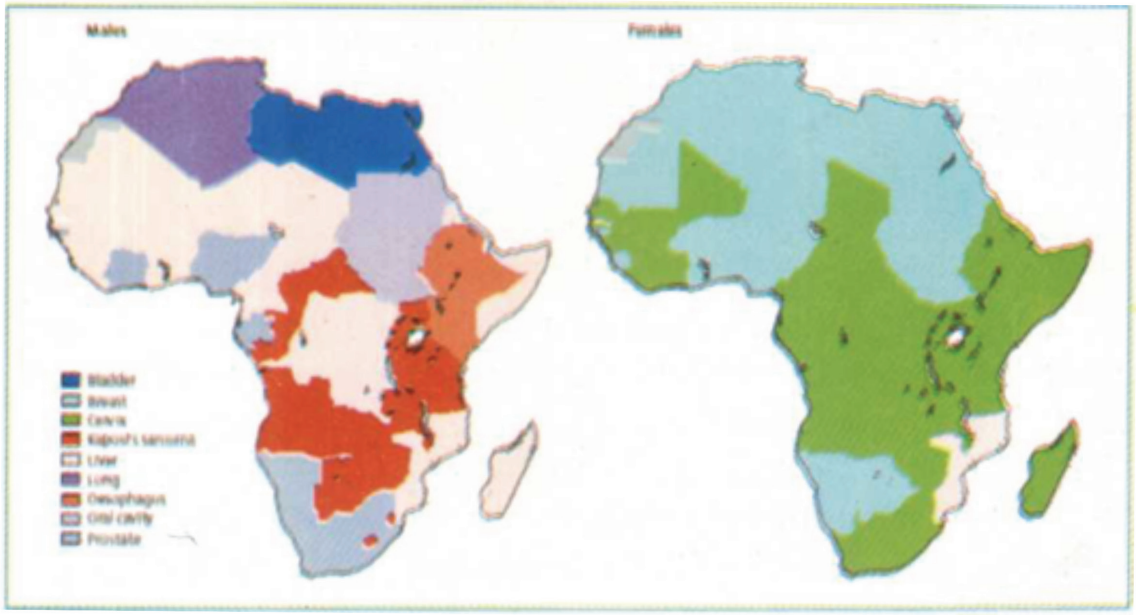


Figure 17

Furthermore, demographic transition refers to a change from a period of high fertility and mortality to one of low fertility and mortality which occurs as a result of an increase in income, education and employment, while the epidemiological transition refers to a change from a period of high prevalence of infectious disease associated with poor sanitation, famine and malnutrition, to a period of high prevalence of chronic and degenerative diseases.

Community studies from South Africa have found that underweight and stunting coexist with overweight and obesity. In a study by Garrett and Ruel, using demographic and health survey (DHS) data from several developing countries, the relationship between stunted children and overweight and obese mothers was confirmed. In SSA, the percentage of stunted children with overweight mothers ranged from 0.6% in Mozambique to 8.2% in Namibia. Countries in SSA are currently experiencing changes associated with the advancing nutrition transition, while at the same time struggling to eradicate the high prevalence of infant and child mortality prevalent in developing countries.

In a multi-country analysis of relationship between diet and pattern of mortality, the report revealed that the prevalence of overweight and obesity is as high as 54 percent in South Africa. In Nigeria, the prevalence is about 22 %.

Table 3: showing the prevalence of overweight/obesity in different countries in Africa (Abrahams et al BMC Public Health 2011,11:801)

Country	infant Mortality Rate	Stunting *m*	Underweight -forage f%)	Low birth weight (%)	Ewriusiveiy Breastfed f%)	*H€D* Morality Rate	Under weight *m*	Normal Weight *m*	Ovemetgm/ Obese *m*
Angola*	130	50J	273	12	111		n/a		n/a
						ion			
Senin	76	44.7	202	15	431	835	*92*	71,8	w
Burkina Faso	92	443	37.4	16	68	924	20.8	69.9	93
Burned**	102	611	38.9	11	447	919	n/a	n/a	rva
Cameroon	82	364	166	11	212	840	6?	646	49,3
Cape Verde*	24	21.4	US	6	596	591	rVa	n/a	rVa
Centra! African fiepubic* (CAR)	115	44,6	218	13	231	868	n/a	n/a	n/a
Chad	124	44.8	319	*22*	2.1	910	201	72	9.6
Comoros	75	46.9	210	25	213	713	98	673	184
Congo BrazavSe*	80	312	*it**	13	19.1	716	n/a	n/a	rVa
Cote dvose*	8?	40.1	16?	17	4.3	946	sVa	n/a	a/a
Democratic Republic of Congo {DflCJ	126	458	282	12	361	921	5 84	?1.3	111
Eritm*	41	45.7	343	14	52	686	373	53.8	89
Ethiopia		507	346	20	49	817	25.6	69,1	44
Gabon			88	14	*$2*	716	66	64	293
Gam be*		276	158	20	408	830	n/a	n/a	n/a
Ghana	51	286	!43	9	628	*m*	8.6	61.4	30
GuktM	90	4O0	208	12	48.1		112	725	143
Gomes Ssau*	117	281	172	24	279	925	ft/a	a/a	n/a
Kenya	81	338	163	10	n/a	729	123	62,6	231
Lesotho	63	452	166	13	36.4	581	i?	52	413
Lfceria	100	394	204	14	291	931	10	694	203
Madagascar Malawi	68	S28	368	17	n/a	.799	267	67	63
	65	512	15.5	13	567	796	*92*	.77,1	*m*
Mali	MB	3as	279	19	3?8	K?	115		17.6
Mozambique*	90	47	212	15	30	*777*	*nfi*	rva	n/a
Niamtoa*	31	296	173	16	21.9	513	119	56	281
Niger	*79*	548	399	27	n/a	1030	19,2	679	227
tagera	96	41.0	267	14	131	909	122	65.7	221
fevanda	72	51.7	180	6	884	878	M	787	its
Sao Tome ano Principe'	6*	332	101	8	n/a	788	7.7	587	317
Senegal*	57	201	143	19	341	852	rrt	n/a	rV*
Sierra Leone	123	374	213	24	112	*mi*	IU	591	297
South Africa fRSA)	48	243*	170[1]*	15	72	867	62	,38.9	54f
Swaaland	59	293	61	9	323	70?	32	*462*	506

*** indicates countries with missing data <Va mdcates a mis,w*g data**

The competing demands for resources on key sector of economy, low level of awareness, poor health seeking behaviour and weak health care system have negatively affected cancer management and prevention in Africa.

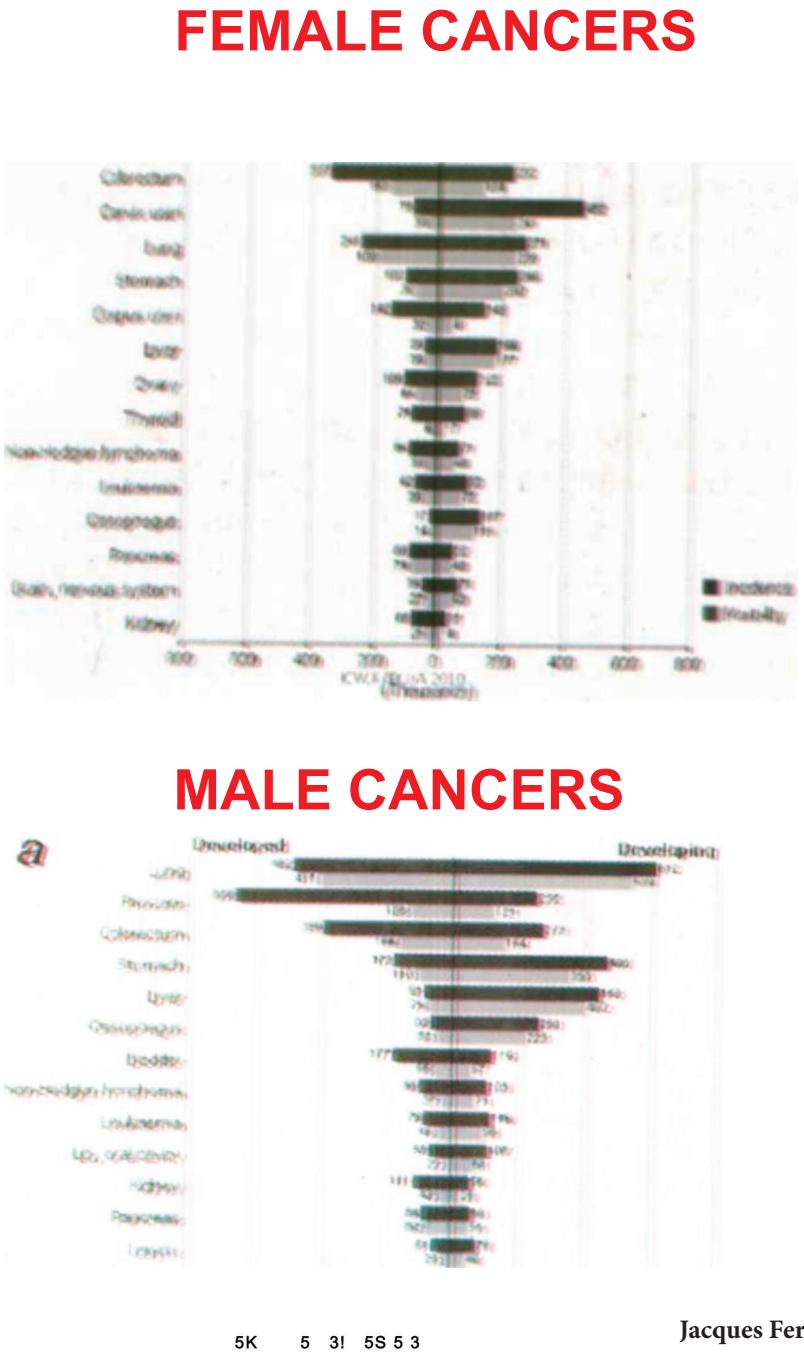


Figure 18

4. PRIORITY CANCERS IN AFRICA

These are

- Lung
- Breast
- Hepatocellular
- Cervix
- Prostate
- AIDS Associated
- Childhood

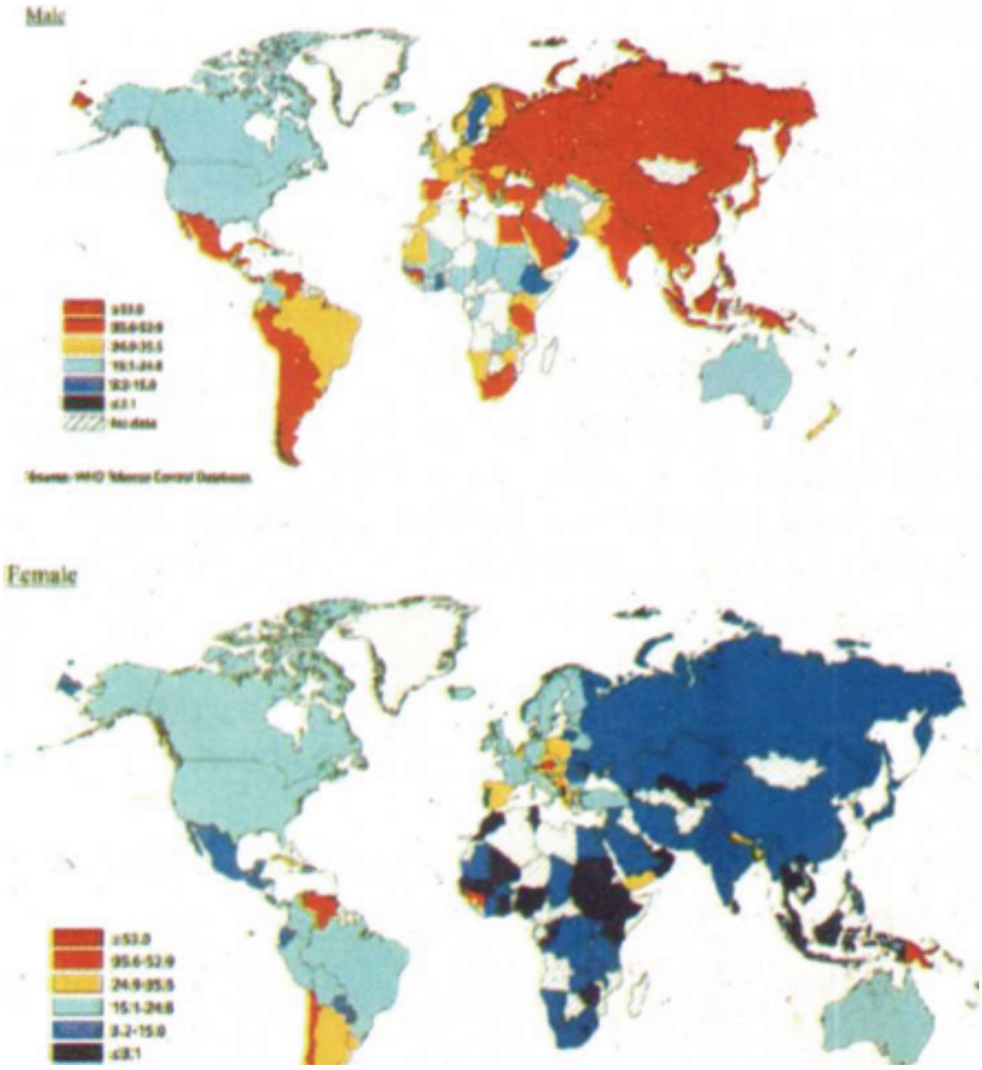
I will illustrate the challenges of preventing and managing cancer in Africa by using my experience in cervical cancer and breast cancer morbidity and mortality.

4.1 Lung Cancer in Africa

Lung cancer is most commonly attributed to smoking; 80-90% of lung cancer cases are attributed to smoking and a smaller proportion (10-20%) is attributed to occupational exposure to agents such as uranium, ionizing radiation, asbestos, silica, arsenic, beryllium, chloromethyl, nickel chromates, indoor emissions from burning fuels, and polycyclic aromatic hydrocarbons (PAHs) from industries. The acquired immunodeficiency syndrome (HIV/AIDS) has also recently been associated with the development of lung cancer.

Figure 19: Sources of smoking (individual or industrial smoke)

Recent evidence suggests an increase in smoking in the region, especially among young people. Further, decreasing markets for the tobacco industry in the developed world will cause the industry to seek new markets, such as in sub-Saharan Africa, where it sees enormous potential for growth. Use of chewed tobacco is high in some African countries, especially in villages in rural areas. Efforts must be made to control this more traditional use of tobacco in order to avert cancers of the mouth and throat.



Source: WHO Tobacco Country Database

Figure 20: Map showing the Africa's contribution towards Lung Cancer (Male and Female Population)

4.2 Breast Cancer in Africa

Breast cancer is the commonest female cancer in Nigeria and the second commonest in Africa and the incidence is rising. However, most present very late to warrant curative treatment. Studies reveal dramatic difference between breast cancers in US and Africa. Preliminary finding from a study comparing, for the first time, breast cancers from Nigeria, Senegal and North America has found that women of African ancestry are more likely to be diagnosed with a more virulent form of the disease than women of European ancestry. Other researchers studied the pattern of gene expression - a measure of which genes were turned on and active -in breast cancer tissue from 378 women in Nigeria and Senegal. They found three significant differences:

First, breast cancers in African women were more likely to arise from basal-like cells, rather than the inner milk-secreting luminal cells, which are the most common source of breast cancers for U.S. and European women. This type of basal-like breast cancer is also observed among women with inherited BRCA1 mutations. Tumors that arise from basal cells have a worse prognosis, regardless of race. Second, African breast cancers often lacked estrogen receptors. Although 80 percent of breast cancers in Caucasian women have estrogen receptors, only 23 percent of African tumors did. These tumors do not depend on estrogen and thus will not respond to drugs, such as tamoxifen, that prevent estrogen from reaching the cancer cells. Third, cancers from African women were slightly less likely to express the cell-surface marker HER2. HER2 is the target for the drug Herceptin, which was recently approved for metastatic breast cancer. It is over-expressed in about 23 percent of Caucasians and 19 percent of Africans. Public-health campaigns should encourage breastfeeding unless there are good reasons not to (eg, HIV infected mothers, where milk powder and sterile water are freely available). In addition, self breast examination is still a useful preventive strategy that can been done by all at no cost. Although population screening (at age 45 years and above) by mammography is the only preventive intervention proven to be capable of decreasing breast-cancer mortality, the cost of implementation is too high for countries with restricted health-care resources.

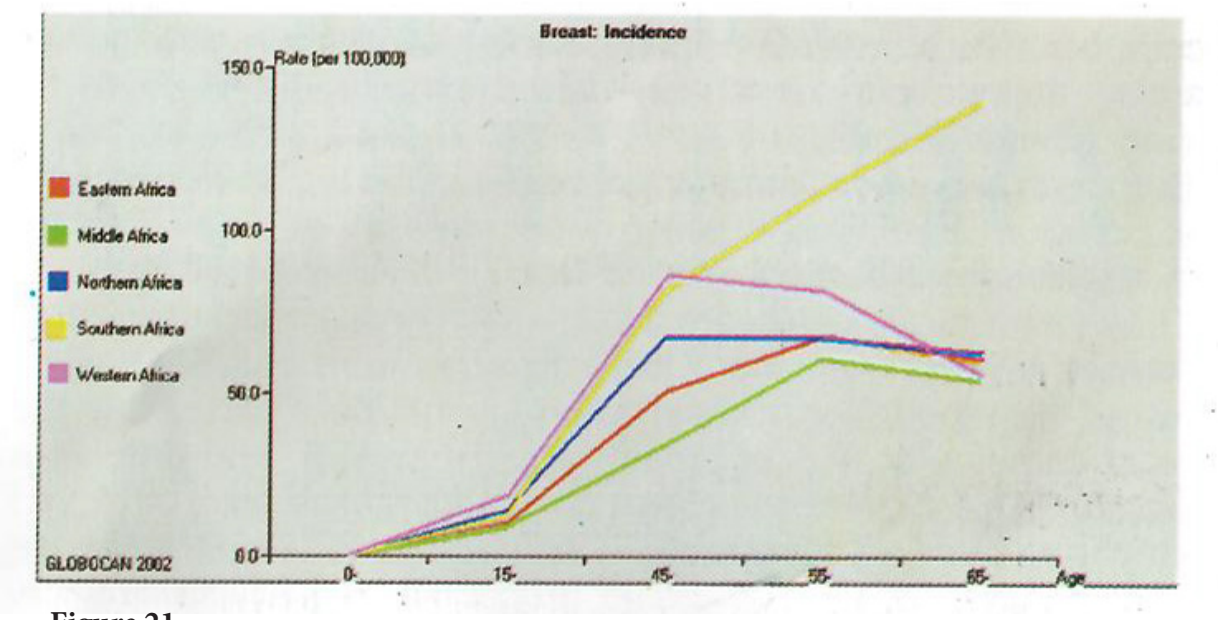


Figure 21

4.3 Cervical cancer in Africa

Cancer of the cervix is the most common cancer among women in sub-Saharan Africa (SSA). Of the approximately half a million women that develop cervical cancer each year, developing countries account for the highest number. Nearly 80% of cervical cancer deaths occur in developing countries, and by 2020 this proportion is expected to increase to 90% if no serious intervention is implemented.

Africa accounts for the majority of cervical cancer morbidities and mortalities. In 2008 alone,

about 78% of those diagnosed with cancers died from the disease. In his evaluation of 341,658 all of cancer survival all over the world, Sankaranarayanan et al found that the 5-year survival was lowest among Africans. Moreover, access to cutting edge cancer management (anti-cancer therapies) are very limited in almost all African countries with only 22% of African countries with access to anti-cancer drugs, compared to 91% in Europe. Furthermore, there is shortage of cancer management experts in most African countries. HIV/AIDS epidemics in Africa have also added to the burden of the disease. Inspite of this heavy burden, most African countries are yet to declare cervical cancer as a health priority. Although, preventive strategies have recently involved use of Human Papilloma Virus Vaccine which has revolutionized the intervention especially in developed world, but this can not be said for many African countries. The beauty of the immunization is that it is safe, effective and has a prolonged period of effectiveness.

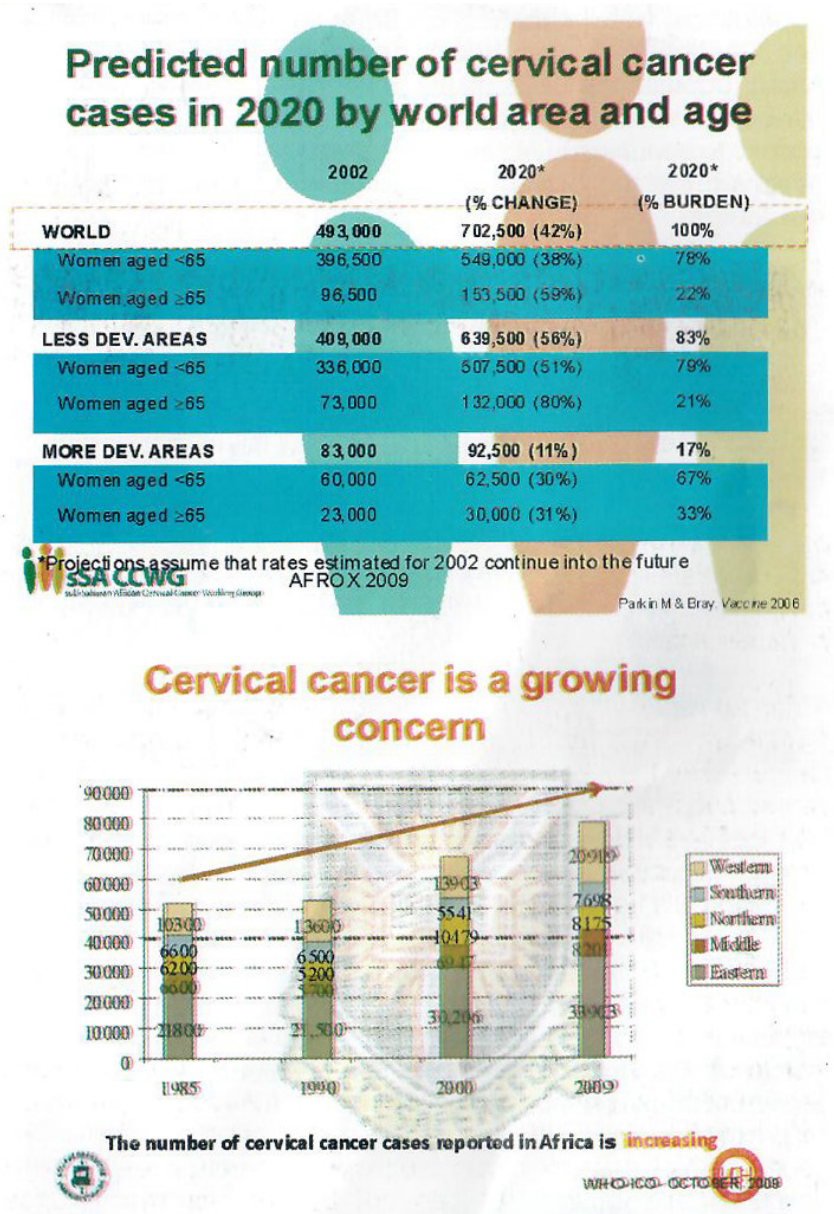


Figure 22

4.4 Prostate Cancer in Africa

Prostate cancer incidence and mortality rates vary widely among populations, with the highest documented rates among American and Caribbean men of African descent and the lowest rates in Asian populations. It is likely that these differences can be attributed to variation in genetics, environmental exposures, access to health care, screening patterns, and treatment patterns; however, the reasons for these differences have not been fully elucidated.

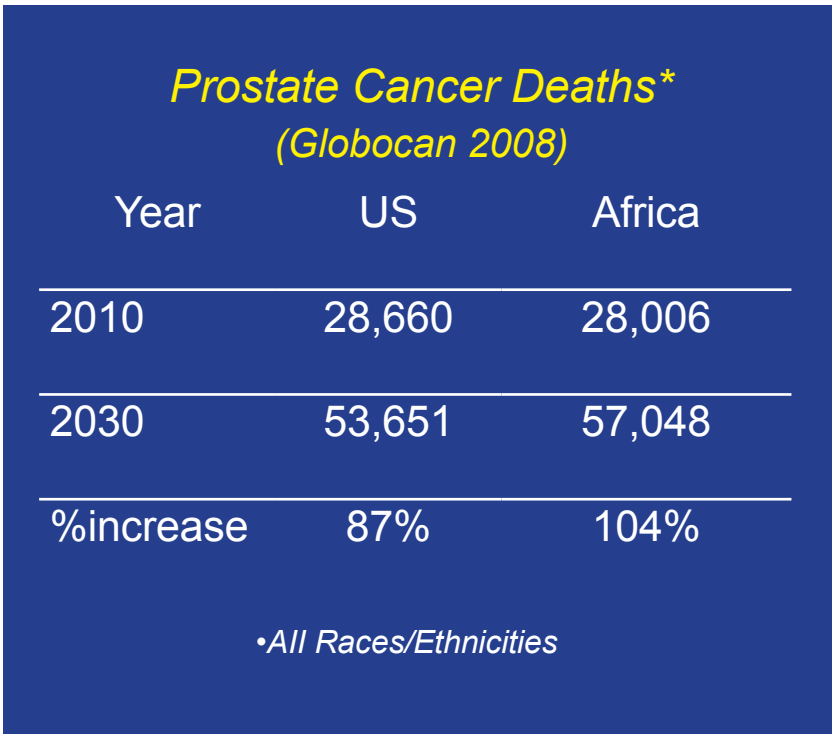


Figure 23

5. CANCER CONTROL IN AFRICA

Out of the 53 countries in Africa, only two have cancer control plans. These two programmes, are not well funded or supported adequately. (Cape Town Declaration on Cancer Control in Africa-2006). Only 25 have functional radiotherapy facilities. The number of teletherapy machines per million populations is less than 0.2 machines/million populations. (The number for Europe is 5.0). As of November, 2011, little or no progress have been made .Nigeria, Tanzania, Senegal, Cameroun, Uganda, South Africa now have plans, but there are challenges.

5.1 The Challenges of Cancer Control in Africa: These include

- Poverty
- Plagued by absence of prevention effort
- Poor health infrastructure
- Human resource deficits
- Promoted by lack of awareness
- Poor health seeking behaviour

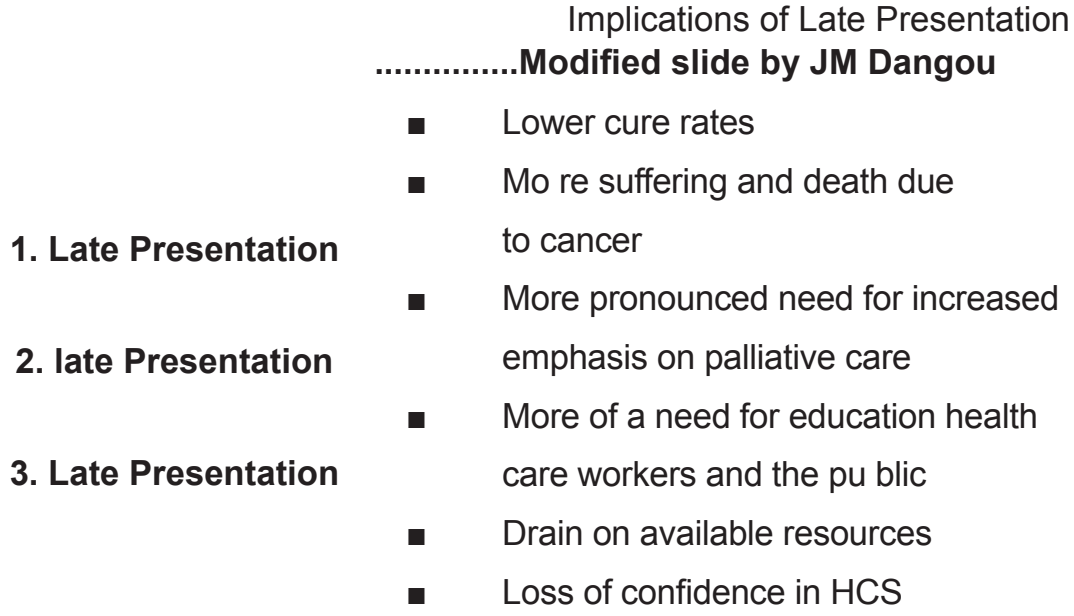


Figure 24: The 3 Most Significant Features of Cancer in Africa

5.2 Cape Town Declaration on Cancer Control in Africa-2lD06

The declaration calls for recognition of cancer as a critical public health problem alongside HIV AIDS, malaria, and TB in the Africa region and one which should be placed as a priority on the public health agenda of relevant agencies, including New Partnership for Africa's Development (NEPAD) and the African Union (AU) Commission.

It also expressed the commitment of African Nations to the development, implementation and adequate funding of comprehensive national cancer control plans and programmes led by Ministries and National Departments of Health through an active national steering committee; In addition, it called for the Performance of comprehensive needs assessment at national levels utilising mechanisms such as PACT partnership; and agree to meet periodically to review progress made.

5.3. WHAT IS NEEDED:

Africa requires the following if we are to prepare ourselves against the impending cancer epidemic:

- National Cancer Control Plan
- A Cancer Control Department
- Cancer Control Committee
- Prioritization
- Registration & Surveillance
- Prevention

- Treatment
- Palliative care

5.4 ELEMENTS OF CANCER CONTROL

The following are critical components of cancer control:

- Awareness creation (Behavioural Change Communication)
- Cancer Intelligence Unit
- Tobacco Control
- Life style modification - Diet and sexual habits
- Early diagnosis and Prevention
- Cure the curable
- Training and Education
- Palliative Care

6. PREVENTING THE NEXT EPIDEMIC

The world stands to gain a lot from the anti-malaria campaign that has recorded remarkable success globally.

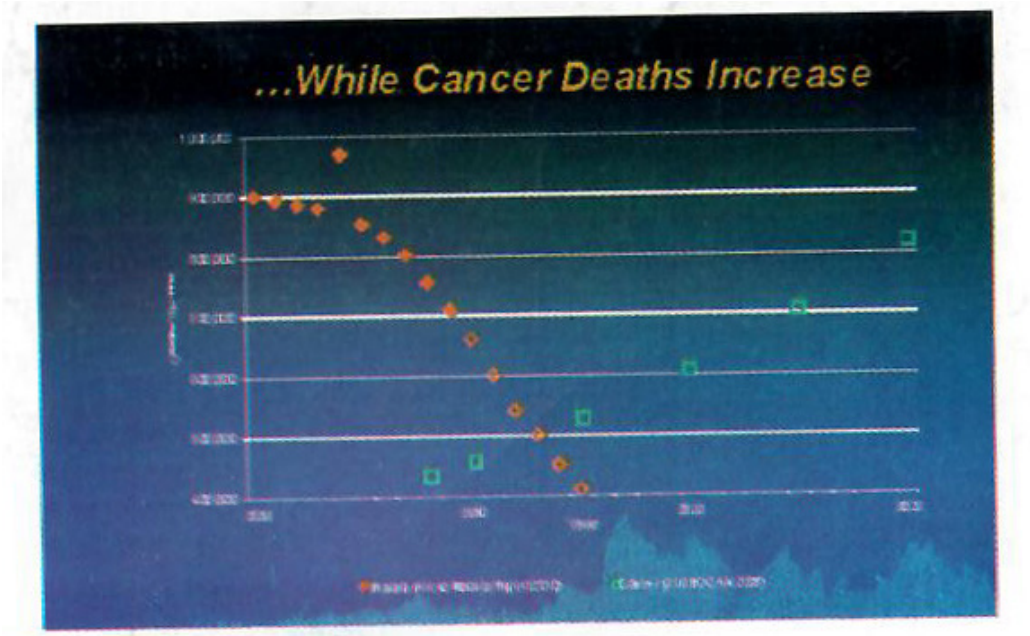


Figure 25

6.1 Create Awareness

Awareness creation is key to success of cancer control in Africa and this has to be performed in a multi-prong version for it to be effective. The process will include:

- To create awareness within the community and to health care workers on risk factors, preventive measures and treatment of cancer.
- To create awareness on the signs and symptoms of cancer in the community
- To educate health workers and the communities on preventive measures and treatment

options available for cancer.

- Train health care workers on the current methods for cancer screening.
- To lobby government and other stakeholder to prioritise cancer as a health emergency

6.2 Promote Life Style Changes

Increase in socio-economic well being across Africa is expected to contribute to the elevation of cancer burden

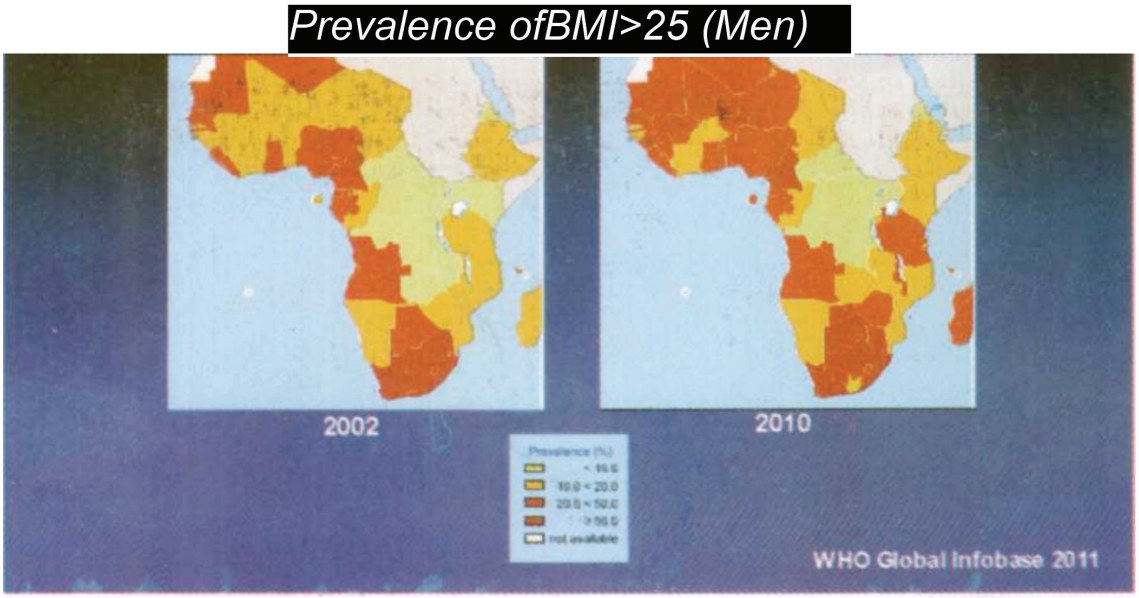


Figure 26 *Changes in Lifestyle and Exposures*
(Concomitant Increase in Specific Cancers)

Figure 27: British America Tobacco Factory, Ibadan (Nigerian Youths are exposed)

6.3 Imperatives

We need to strategise and implement fully the African regions strategy for cancer control. The objective of this is to contribute to the reduction of morbidity and mortality due to cancer in the

African Region. The areas of priority interventions are:

1. Cancer prevention and control policies, legislation and regulations
2. Comprehensive national cancer control programmes
3. Advocacy, resource mobilization and appropriate allocation
4. Mobilization and coordination of partners' interventions
5. Capacity development
6. Cancer Primary, Secondary and Tertiary Preventions
7. Strategic information, surveillance and research

6.4 Establish Cancer Registries

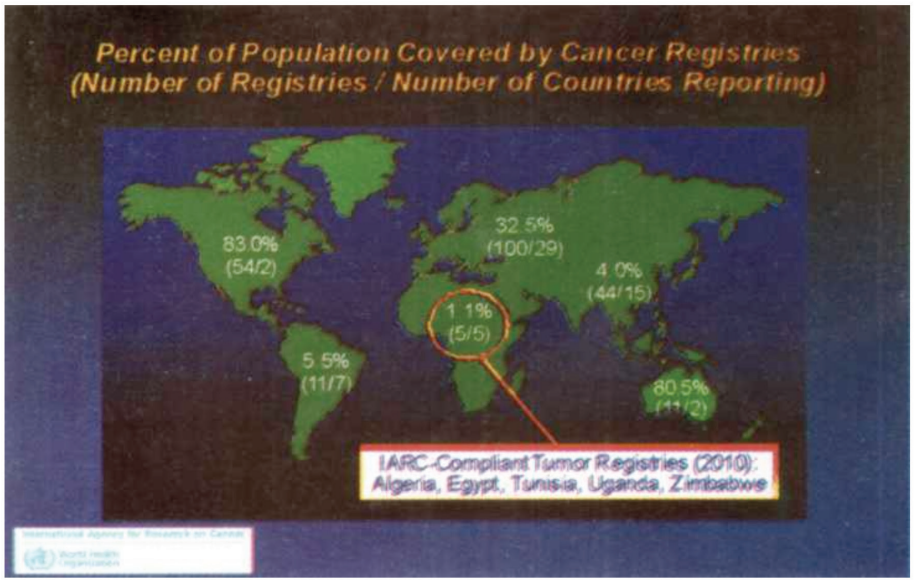


Figure 28

6.5 Establishment of centres of Excellence

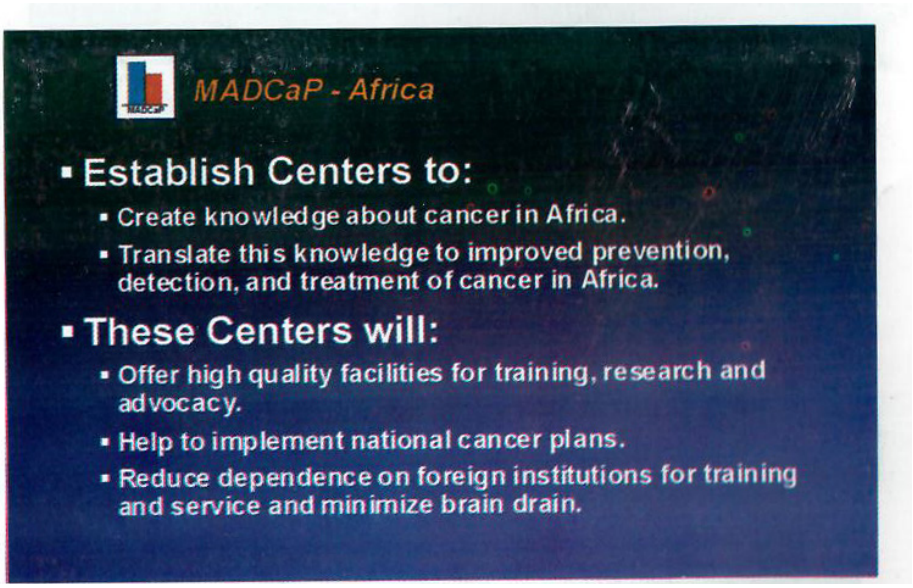
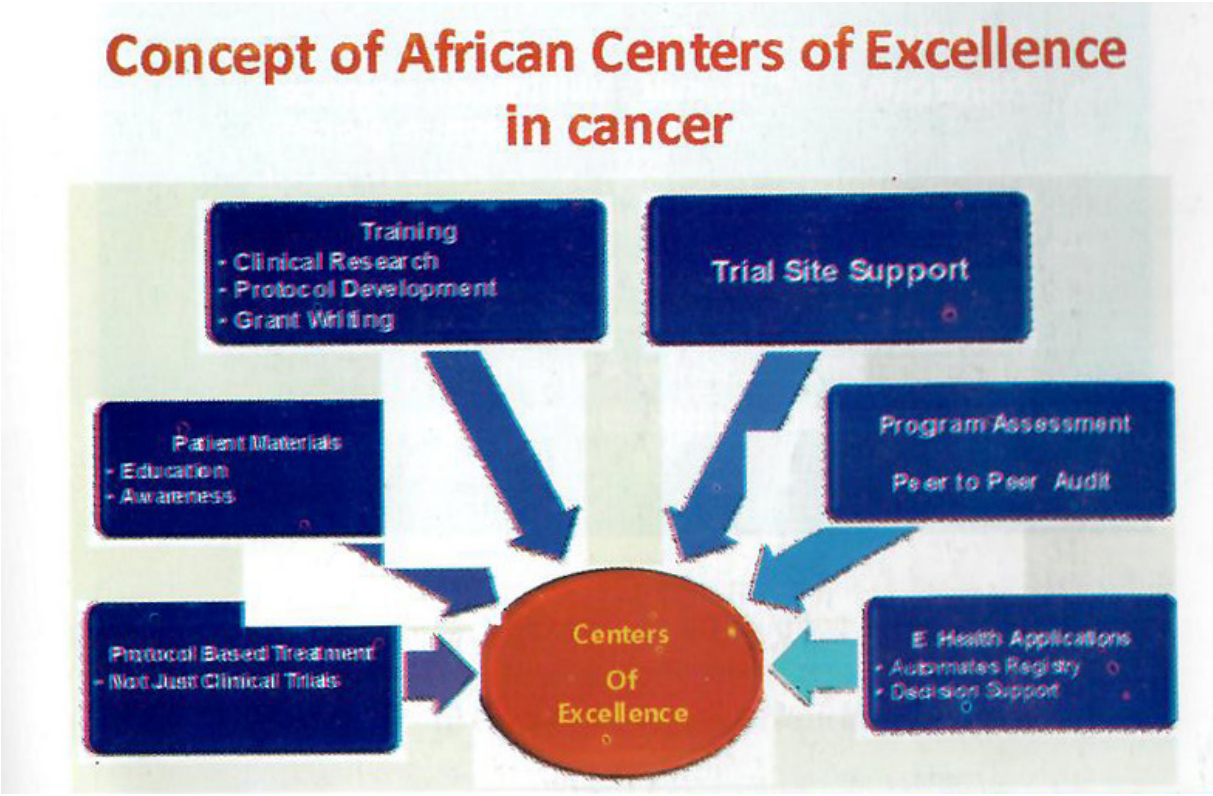


Figure 29



6.6 Invest in Radiotherapy Centres

lumber of People Served by Each Radiotherapy Center

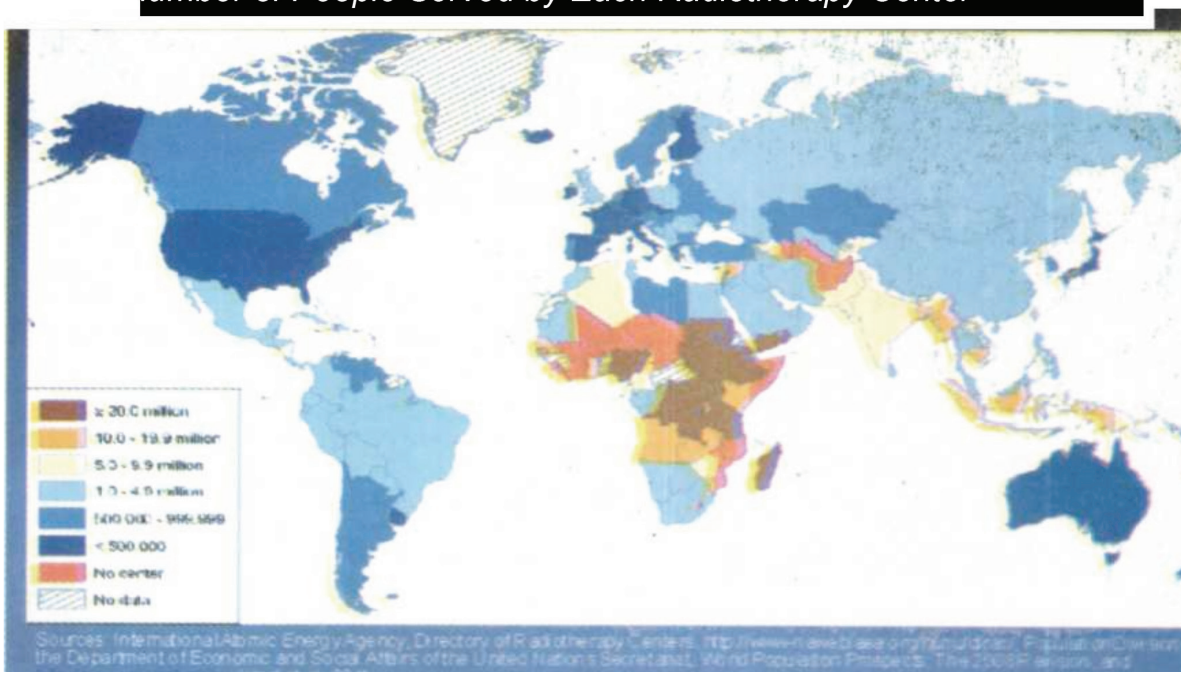


Figure 30

6.7 THE LANCET Challenge

Lancet Editorial in a rare display of courage titled the revolution has begun (....www.thelancet.com Vol 376 October 2, 2010) alerted the global community of the need to do be proactive. In a piece titled Expansion of cancer care and control in countries of low and middle income: a call to action...An the same issue, Paul Farmer and colleagues challenged the public health community's assumption that cancers will remain untreated in poor countries, and noted the analogy to similarly unfounded arguments from more than a decade ago against provision of HIV treatment. (Paul Farmeretal Lancet 2010; 376:1186-93)

7. ROLE OF PROFESSIONAL ORGANISATIONS-AORTIC

It is our dream that AORTIC will provide leadership in cancer care, control, training and research in Africa. We have developed a strategic plan designed to place cancer on the continental agenda for health. It is our plan to network with all stakeholders interested and or working to cage cancer in our continent.

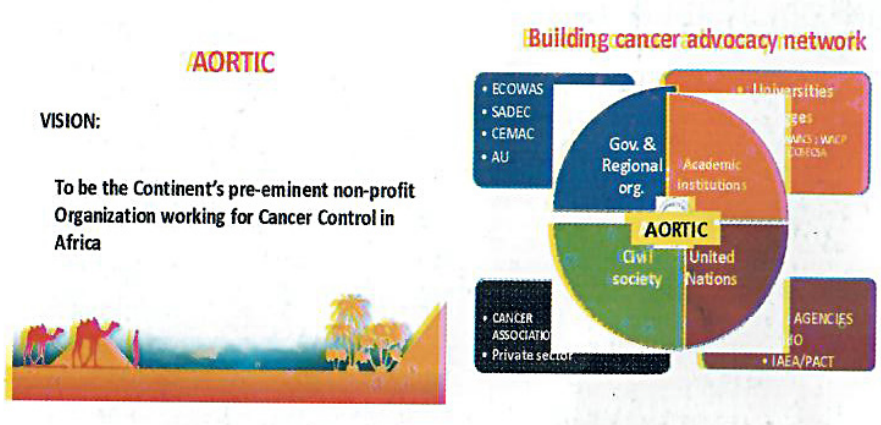


Figure 31

Developing Partnerships

Work with:

- ❖Leaders-Politics, Business, Religious
- ❖Policy people
- ❖Wives of key Government Leaders
- ❖Professional Associations
- ❖Women Associations
- ❖Community Groups
- ❖Media

New Initiatives

- Mother and Daughter Initiatives
- African Women Initiatives
- Eradicate CC in Africa
- Create a Sense of Urgency
- African Cancer Eradication programme
- Africa Against Cancer

Wanted...Cancer Research Policy

- Goal...
- To provide an enabling framework for the development of an effective national Cancer Research System that will facilitate the generation and use of nationally-relevant, high-quality, culturally appropriate and ethically-sound evidence to drive the national agenda.

Research Priorities

- Basic sciences
- Clinical sciences,
- Public health;
- Social and behavioural sciences;
- Economics, operations research, and health systems
- Natural substances
- Human rights and access to care

Research priorities

- Surveillance
- Pathogenesis
- Clinical Trials
- Quality of care/Quality of Life/Survivals
- HIV and cancer
- Cost effectiveness
- Health seeking behaviour
- Service utilisation
- Palliation

Building Human Resources for Ca

- Map Resources
- Document gap in HR needs
- Promote Task shifting
- Improve cancer care skills
- Develop sub-specialisation in cancer care
- Develop twinning programmes
- Develop specialised treatment centres
- Promote Increased resource allocation

What can be done to surmount obstacles

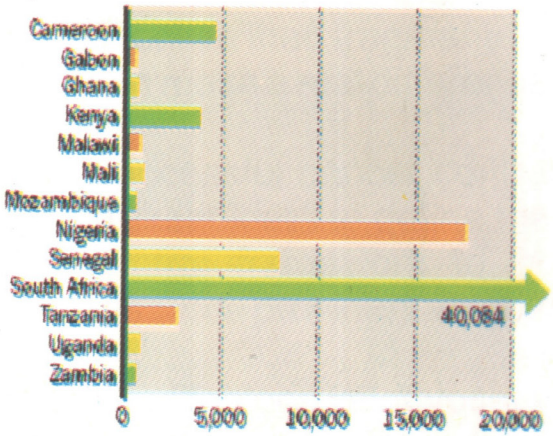
- Build research training capacity regionally
- Create Regional Centers of Excellence
- Provide central services where economy of scales exist for clinical research
- Develop joint projects
- Build community engagement, advocacy
- Build awareness by media and governments

STRATEGIES

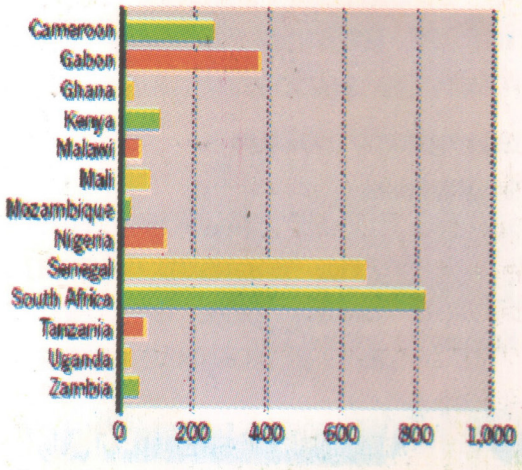
- Development of cancer registries
- Prevention
- Early Detection & Screening
- Effective Treatment at the doorstep
- Easy Access to Palliative Care

The view from the frontline.
Vivienne Irikefe et al...Nature 2011;474:556-9

NUMBER OF RESEARCHERS



RESEARCHERS PER MILLION INHABITANTS



FOSTER AND SUPPORT COLLABORATION AND PARTNERSHIP

- National governments / Regional organizations
- Academic institutions
- International agencies
- Non-Government Organizations (NGOs)
- Institutions, foundations
- Public and Private stakeholders
  - research, training, cancer care management, and educational activities directed toward the cancer control in Africa

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FUTURE GOAL: AFRICAN CENTERS OF EXCELLENCE IN CANCER

- An ultimate goal is to promote the establishment of national Centers of Excellence in Cancer throughout the continent
- These Centers will :
  - offer high quality facilities for training, research and service
  - reduce dependence on foreign institutions for training and service and promote brain sharing

Concept of African Centers of Excellence in cancer

Working Together

Learning from the scripture

Security Forces

Collectively we achieve MORE

Together each achieve more-TEAM

Keep cancer under LOCK

CANCER BUSINESS

- AORTIC can mobilise and move Africa

"The chance for a cure, the chance to live, should not be an accident of geography."

.....HRH Princess Dina Mired of Jordan

...In..Closing the Cancer Divide

8. CONCLUSION

A powerful advocacy is key to cancer prioritization, prevention and management in Africa. Advocacy for cancer control is needed in any resource setting in order to influence policy and to urge decision-makers to create an environment conducive to improving the way cancer control knowledge is put into practice.

The key messages for people involved in advocating for comprehensive cancer control planning and implementation are as follows:

- Advocacy for cancer control is most likely to be successful if it is synchronized with advocacy for non-communicable diseases and other cancer-related problems. By com bining their voices to deliver the powerful message that comprehensive and integrated cancer control is more effective than fragmented or isolated approaches, advocates can make a real difference.

- Successful cancer control greatly depends on the ability of stakeholders to define the value of a comprehensive cancer control framework to policy-makers and other potential resource providers whose sustained support is crucial.

- The lifeblood of advocacy is good strategic communication, which educates people about a need and mobilizes them to meet that need in a collaborative way. Participants in the advocacy process need to interact and freely share information regarding cancer control, and other chronic diseases and related issues.

- Good communication skills in those advocating for cancer control are vital. These in clude being able to speak clearly and concisely, and an ability to convey complex information in an organized and easy-to understand manner.

  Advocacy will yield good dividends and provide roadmap for effective and functional cancer care strategy. This is our minimum demand.

"Change does not roll in on the wheels of inevitability, but comes through continuous struggle".
Dr. Martin Luther King Jr. (1929-1968)

Distinguished Colleagues, Ladies and Gentlemen, I thank you for listening to my sermon.

Thank you and God bless!

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