

SCIENCE AND TECHNOLOGY PLAT FORM FOR AFRICAN DEVELOPMENT: TOWARDS A GREEN REVOLUTION IN AFRICA.

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EXECUTIVE SUMMARY

This report gives a review of agricultural sector development in Nigeria in particular and examines the strengths and weaknesses of agricultural development on the African continent in general. It discusses the pertinent issues of agricultural development in Africa. The report highlights the importance of science and technology in agricultural development, which had not been fully appreciated by the political elite in Africa in the past. It also examines the shortcomings of educational policies in Africa.

This paper proposes the way forward, towards a green revolution in Africa; defined as a system of sustainable modernization of agriculture and rural transformation.

The African green revolution is designed to have two major parts. The technological and the socio-political perspective. The technological perspective has four components.

1. The biological technologies that range from simple elite single selection from the local germplasm to advanced applications of biotechnology and gene transfer technology used to generate improved crop varieties.
2. The improved crop management technologies consisting of a combination of organic and inorganic fertilizers plus the crop management improved practices.
3. The biophysical technologies that range from single farm tools to soil and water management technologies.
4. Post harvest handling and marketing of technologies which vary from simple hand tools to agro-processing technologies for farmer value added products.

The socio-political perspective of the African Green Revolution has the community part and the Government part. The community part involves participatory planning, technology development and evaluation at the on-farm testing used to design the local farming systems and to prepare the communities themselves to receive the Green Revolution.

The Government part is responsible for providing guiding principles plus education policy linking up the promotion of science and technology to agricultural development. The Government must mobilize commitments from donors and governments to provide human, material, financial and logistical support.

The Government must also create institutional linkages and a favorable political environment for partnerships and networking between departments, organizations, districts, countries and among donors.

The paper suggests methods and strategic implementation plan, which can cause a Green Revolution to happen in Africa and show significant results at pilot sites in three selected countries in three years. This paper also shows further results at secondary / promotion sites in six selected countries in five years.

1.1 INTRODUCTION

The agricultural sector contributes 25% to 60% of the gross domestic products of most African countries, with a few exceptions like Algeria, Libya and South Africa where it contributes 5 to 8 % of GDP. Agriculture is an important source of food for the populations in addition to providing for household incomes, raw materials and being a major foreign exchange earner (Umalele 1992, FAO production 1999, African development report 2003). But since independence, in the 1960's and 1970's, agricultural production in Africa has grown at a slow rate and stagnated between -1 % to 3% p.a., thus being over taken by the populations growing at fast rates of 2.9% to 4.4% p.a. (World Bank development report 2002). Worse still there has been an occurrence of natural calamities such as drought, pest, diseases and famine. These imbalanced social-economic situations on the continent have been compounded by the inadequate capacities of research and development plus the absence of applications of Science and Technology for agricultural modernization. Consequently, the agricultural production in many African states is unable to satisfy the growing demands of urban population and the young industrial sector.

As NEPAD has noted, there is an urgent need to harness Africa's natural and human resources and make Science and Technology the foundation of sustainable Agricultural Development programs.

1.2 OBJECTIVES

The objectives of this paper are therefore to:

- a) Assess the strengths and weaknesses of agricultural development on the African Continent and the need to redesign the complex subsistence farming systems for the modernization of agriculture.
- b) Examine the role of education, research and development and the importance of the application of Science and Technology to Agricultural Development.
- c) Propose strategies that can be used to trigger off an African Green Revolution especially in semi-Arid zones of Africa.

2.0 REVIEW OF AGRICULTURAL SECTOR DEVELOPMENT AND THE PERTINENT ISSUES IN AFRICA

2.1 REVIEW OF AGRICULTURAL SECTOR DEVELOPMENT IN NIGERIA

In the 1960s, after independence, the Nigerian economy was dependent on agricultural production which contributed about 67% of GDP and 38% of the export earnings (World Bank Economic / social database 1989). The major cash crops were cocoa, rubber, palm oil / kernel and cotton. The development planning approach was used by the government, in the 1960s. Three hundred thousand small holders operating 1 to 2 acres of land were

doing the agricultural production. The farmers operated largely communal land tenure systems because in each state the producers were organized into communities. For the period 1960-1973 the government policies were not supportive of the development of agriculture. First the taxation policy was geared towards maximizing tax revenue irrespective of the benefits and conditions of the rural farmers. Secondly, the government failed to reinvest in the development of agricultural production, thirdly, apart from cocoa, there was suppression of the producer prices. By 1973, using 1960/61 as base period, changes in the producer prices of groundnuts had 11.2% reduction, cotton seed 18% increase, palm kernel 5% increase, and palm oil 8.7% reduction. Fourthly, the elite state class controlled access to the non-communal fertile land for commercial farming. Here the governors had the powers to revoke any occupancy on that land. In spite of the unfavorable policies from 1960 – 73, the agricultural production for both food and export crops and the industrial sector stayed afloat.

During 1974-89 the Federal government used a series of forward-looking policies to revitalize the agricultural sector. Firstly, the occurrence of natural disasters of drought, pest and disease had exposed the fragility of the traditional agricultural technologies especially in northern Nigeria. Secondly the oil boom had boosted the Nigerian economy. In 1974, the country became a member of OPEC and the state was no longer dependent on surplus generated from Agriculture. Instead it used oil boom revenue to finance large scale agricultural development programmes in order to invest in infrastructure and agricultural production systems. From 1975 – 76, the state implemented Operation Feed the National Production programme (OFNPP) and then the National Accelerated Food Production (NAFPP) programme.

From 1976-78 the Integrated Rural Agricultural Development Project approach starting with three ADPs (Funtua , Gombe and Gousau). The design of the first 3ADPs in North Nigeria was more unique and included provisions of improved seed and other inputs, like fertilizers and tools through agro-service centers. Then a network of feeder roads in addition to minimum producer price guarantees which were announced at planting time. Having been convinced by the significant impact and outcomes of the 3 pilot ADPs in Northern Nigeria, the government extended the ADP strategy to cover the whole country. In 1982, many more ADPs started in states within Nigeria. All the old ADPs were expanded, each to embrace state ward geographical coverage like in Kaduna, Kano, Bauchi, Sokoto, Oyo and Ondo states.

River basic development Authorities (RBDA) were created, they were each meant to also operate like an Integrated Rural Agricultural Development Project. All IRADP/ ADP in the 1970s and 1980s were formulated as community based projects focusing on large geographic rural areas.

The implementation objectives were to:

- a) Develop agricultural production of food crops (Maize, Groundnuts, Rice and Vegetables) and cash crops (Cotton).
- b) Provide infrastructure (roads) and social services (water, education and health)

- c) Improve the welfare of the small holder / grassroots communities in the target project area.

But the ADP projects were based on capital-intensive equipments and their implementation was heavily dependent on external funding from World Bank loans and a large number of foreign staff.

But the National Accelerated Food production Programme and River Basin Development Authority were largely financed by the Nigerian Federal Government using oil-revenue. If ADPs design had not overlooked on-farm adaptive trials, its large investment costs would have been an opportunity to cause the African Green Revolution.

2.2 THE DECLINE OF BOTH THE EXPORT CROPS AND THE INDUSTRIAL SECTOR IN NIGERIA

The oil-boom era of 1980's in Nigeria, led to a rapid urban population growth from 5% to 9%. The youths deserted rural villages and swarmed urban centers in search for paid employment and more attractive lifestyles.

The rural-urban exodus created a direct shortage of farm labour in the agricultural sector, which was left being manned by the physically weak old people, who were using the outdated production technologies (hand hoe, traditional crop varieties, hand weeding and non-use of fertilizer under unpredictable rain fed agriculture).

Meanwhile all the government efforts and massive agricultural investments went to promoting food crops like maize, beans, groundnuts, cassava, yams and cowpeas in an attempt to produce enough food for the growing population. Nevertheless, in the late 1980's, there was a dramatic decline in local industry and in the production of export crops. Moreover the agricultural sector was unable to produce enough to satisfy the large demand of urban populations for food and raw materials. So Nigeria in spite of the earlier food self-sufficiency programmes and policies and notwithstanding the federal government's declared intention of total ban on importation of rice and maize in 1985 plus ban on wheat in 1987, the country had to again increase her importation of rice from 30% to 50% (FAO trade 1990, Lawani and Babaleye, 1992).

2.3 NIGERIA'S AGGRESSIVE AGRICULTURAL DEVELOPMENT RECOVERY PROGRAMMES 1990'S AND 2000'S

Despite the frequent political changes, the federal government has been pursuing a policy to revitalize the agricultural sector.

- a) It has been using the budgetary instruments of institutionalizing the basic principles to link up spending to optimization of resources use
 - i) based on identified priority settings
 - ii) and using the basic implementation axioms of economy, efficiency and effectiveness.
- b) Making new investments in the promotion of education, plus Science and Technology including
 - i) information and communication technology and,
 - ii) the application of biotechnology.
- c) Diversifying the economy by providing appropriate fiscal incentives for private investments in tourism, agro industries and commercial agricultural production.

The current government is determined to reduce the level of poverty through efficient management and control of the country's abundant resources of oil, natural resources and human capital to achieve a projected economic growth rate of 6% p.a.

Currently the agricultural sector is contributing 41.8% of the GDP with a growth rate of 5% per annum, although the problem of food security is still present as the rate of urbanization has increased much faster and staple food prices have continued to escalate. Still 60% of the Nigerian population lives below the poverty line earning one dollar per day UNDP Human Development Report 2001).

3.0 DISCUSSION OF PERTINENT ISSUES.

3.1 THE PERTINENT ISSUES SURROUNDING THE PAST, PRESENT AND FUTURE DEVELOPMENTS IN AFRICA.

First pertinent issue has been the difficult question of maintaining economic development to keep abreast with the rapid population growth on the African continent. The populations of the African states are growing at the rates of 2.7% to 4.1% per annum, such that the total African population doubles its self every twenty years. For instance in 1970 total population in Africa was 360.75 million people then in 1990 it was 614.769 million people, in 2000 it was about 793.627 million people, and it is estimated that it will be 1,358.12 million by 2025 (FAO, Data files, World Bank Development Annual reports)

The situation with other demographic factors is such that the population pressure on the land has reduced per capita arable land from 0.86 – 5.99ha per person in 1965 to (0.42-2.09ha) per capita in 2000. The urbanization rate has increased from 2% in 1965 to 9% in 2000. (World Bank data base 1992). The demands for food and social services have continued to cause social/political agitations in many African Countries.

Meanwhile, the growth of agricultural production has been at -1 to 3.0 % pa, which is much slower than the population growth rates in most of the African countries (See Appendix 2).

The second important pertinent issue is the inability of the African nations to harness and utilize their natural resources of land, soils, water, forests and wildlife in a sustainable manner so that those resources can satisfy the needs and aspirations of the present and the future generations.

Land degradation is a serious problem in Africa. Out of the 2936.568 million hectares, 500 million hectares are moderately or severely degraded. Land degradation in Africa has been linked to consequences of food insecurity, poverty and population pressure. Other indirect causes of land degradation are poor land management practices, insecure land tenure systems and use of backward agricultural technologies. About 50% of the land degradation in Africa is caused by over grazing, 24% by crop production and 14% shifting cultivation and clearing forests/vegetation in subsistence agricultural production (harnessing technologies for development ECA 2002).

Crop production, overgrazing and overexploitation have caused soil degradation in Africa. The types of soil degradation are physical, chemical or water/wind erosion. They occur in areas where there is an intensive traditional subsistence farming system. When land is scarce and population pressure is high, the individual farmer has no alternative land to move to. Then he is forced to cultivate permanently in one location and use traditional (poor management) methods without replenishing the lost soil nutrients with organic and or inorganic fertilizers, thus causing overexploitation.

Soil erosion is common in the East African highlands of Uganda and Ethiopia. The enormous water resources on the African continent are poorly harnessed. There are eight major river basins (of Nile, Niger, Congo, Zambezi etc) with a surface drainage area of 14.36 million Km². But out of the 891 thousand Km² of irrigatable area, only 10% of it is irrigated (The Times World Atlas, Times book 1990).

Ground water resources in Africa also need to be conserved and properly harnessed because they are the main source of portable water for human consumption especially in semi-arid parts of Africa.

In addition, Africa has the richest biodiversity of 1,500 bird species and 50,000 plant species which are the main habitats of the indigenous tropical forests and are not allowed to be extinct.

The third pertinent issue is the inability to promote and apply science and technology to generate agricultural production technologies that can circumvent unpredictable rainfall, drought as well as reducing the impact of natural disasters of pests, diseases and famine especially in semi-Arid zones.

Semi-arid areas are those where precipitation (P) exceeds potential evapotranspiration (E) for a period of one to four months annually. When $P > E$, this indicates a period of water balance, where there is sufficient soil moisture available for crop production. By this definition, a large part of Africa stretching from west, central, eastern to southern Africa is semi-arid. In West Africa the agro-ecological zones change rapidly from tropical

grassland savannah to Sahelian conditions. From south to north the Sudan savannah (semi-arid) zone covers about one third of the land mass. The West African semi-arid zone includes a large portion of Benin, Burkina Faso, Mali, North Guinea, Ivory Coast, Ghana, Togo, Nigeria, North Cameroon, Chad and up to Cape Verde.

As pointed out above, most of the agricultural production on the African continent is rain fed and only 10% of the irrigatable land is under irrigation. But in the last 40 years, both the weather and rainfall patterns have radically changed. The rainy seasons in semi-Arid zones have become shorter from 120 days to 75 days of rainfall period when they have surplus soil moisture to maintain a crop. Thus the traditional annual crop varieties of maize, sorghum, millet and groundnuts that have long maturity duration of 90 to 120 days can no longer be squeezed to grow in a rainy season of 75 days. So traditional farmers in Sahelian zones cannot adequately depend on rain fed agriculture without supplementary irrigation. The onset of the rains, which used to be July to October in the Northern hemisphere has shifted and is unpredictable. Moreover, each onset of a rainy season has 4 out of 10 chance of being punctuated by prolonged dry spells of more than 10 days. This implies that every year in Africa, there is a 40% chance of crop failure due to drought especially with annual crops. Appendix 3 of this report shows a list of some selected African countries, which have experienced a serious drought at least three times in the last twenty years. Appendix 3 shows that countries like Ethiopia and Algeria have had 8 drought years in the last twenty years or have 40% chance of crop failure due to yearly drought. Another set of countries like Cape Verde, Chad, Kenya, Nigeria and Sudan have had 6 drought years or 30% crop failure due to drought in the last twenty years. This information also shows that in 1982, five African countries were seriously affected by drought. Then in 1992, the number of African countries affected by drought rose to 12, then 16 countries in 1995, 17 countries in 1997 and by 2000 18 countries were affected by drought. This suggests that persistent droughts in Africa are very common and they occur after every three years thus posing a serious threat to food security with rain fed agriculture. It is therefore no wonder that in the last one year alone, FAO recorded that almost 30 African countries experienced serious food shortages due to crop failure caused mainly by drought.

Besides the effects of unpredictable rainfall and drought, there are cases of crop and livestock pests and diseases.

These retrogressive situations require improved agricultural technologies, which need to be generated through the promotion and applications of science and technology. A good example is the case of green revolution in Asia and South America, which occurred in the years of 1966 to 1976. Thus green revolution refers to that historic period 1966-1976 during the development of modern agriculture of developing countries in Asia and South America. That period was characterised by massive adoptions of improved varieties of wheat and rice. Hand in hand was also the wide adoption of improved production technologies including use of fertilisers, irrigation, use of improved labour saving tools and above all an improved farming system. The Asian countries doubled their rice production per capita per year from 0.5tons to 1 ton/ha/pa.

3.2 THE SCIENTIFIC AND TECHNOLOGICAL INGREDIENTS OF ASIAN GREEN REVOLUTION

The fundamental scientific and technological ingredients of the Green Revolution are illustrated by the case of rice. The rice component of the Green Revolution originated from the innovative rice technologies developed by International Rice Research Institute (IRRI) Scientists, Philippines. The first release (IR8) by IRRI in 1966 caused a green revolution in rice production in Asia and South America.

The Green Revolution comprised of biological, chemical, mechanical and hydrological science and technology.

In the case of rice, the biological component was the creation of IR8, the miracle rice variety released by IRRI in 1966 and subsequent releases of IR9 to IR34. The attributes of improved rice varieties, were short and sturdy stems, erect and pointed leaves, non-photo period sensitivity, highly responsive to inorganic fertilizers, efficient water use and early maturing with high – yields of 3t/ha / season, which was double the traditional yields of 1965. But IR8 – IR34 rice varieties were still susceptible to pests and diseases. Later breeders introduced pest resistance in rice varieties of IR36, IR64 and IR72. this led to their wide adoption by 96% (1979) and 80% (1987) of the farmers in Philippines (Bingali *et al.*, 1998, Hamayi *et al.*, 2000). The chemical component comprised of the use of compound inorganic fertilizers.

The mechanical engineering component comprised the use of improved farm tools (hoes, rotary weeders, hand tractors) to ease the field labour demands for farm operations like weeding, threshing, and transportation.

The hydrological component - irrigation -, which gave farmers a complete water control, was also a very important technological component of the Green Revolution. Farmers were able to grow crops in the wet and dry seasons. Besides it is estimated that the irrigated crops produced three times more than the rain fed ones.

The advanced fundamental scientific basis for the Green Revolution was a combination of principles of biological sciences, genetic engineering, molecular biology and the applications of biotechnology with a broad genetic resource base of germplasm resources. Plant breeders used new tools of biotechnology such as *in vitro* production of haploids and somaclonal variation for plant breeding, and then used direct gene transfer technology to introduce in the rice plant the right attributes, e.g. producing a rice plant that is more resistant to diseases, insects, or more tolerant to salinity and drought. The semi dwarf genes were introduced in the high yield rice variety to prevent lodging. The scientists also produced a hybrid plant which has apomixes, i.e the ability to asexually reproduce off-springs that are identical to their parents.

The application of biotechnology has other advantages in addition to the use of gene technology to breed a plant that has many attributes. The breeders can combine genetic materials / germplasm from different environments. Biotechnology applications (such

somatic embryogenesis) enabled scientists to use plant tissue to produce new seeds. In this way they made use of rare genetic materials from South America, Africa's wetlands and Indonesia's rain forest and combined those genes to create the miracle rice variety. The tissue culture method is an application of biotechnology for rapid multiplication of plantlets. Biotechnology applications were used with selection techniques and regeneration systems making crops amenable to genetic engineering.

3.3 INSTANCES OF NEGLECTING THE IMPORTANCE OF SCIENCE AND TECHNOLOGY IN AFRICA

Unfortunately the promotion and application of science and technology in Africa has not been forthcoming for many reasons.

First the African political elite have not fully recognised the fundamental importance of science and technology in the modernisation of agriculture. This shortcoming is evident in the whole history of agricultural development of African countries. The government allocates insufficient funds of 0.1% to 0.36% (being less than 2%) of GDP to agricultural research for technology development to further the goal of food security and export earnings.

The shortage of agricultural researchers of less than 6 Scientists per 100,000 persons is still too small to make a critical mass that would have an impact. Except Egypt which has 100 researchers per 100,000 persons as compared to Germany which has 250 scientists and USA 350 scientists per 100,000 persons (Randforum 1993). African countries lack long-term commitment (no planned long term targets) in establishing human and institutional research capacities. In cases like Kenya, Malawi, Uganda and Senegal, the existing agricultural research resources are fragmented into many stations and programmes, where the research capacity of each program is too low to make any significant impact on their respective research areas. Even within one research programme, there is discontinuity of research focus. Discontinuities are sometimes caused by frequent transfers of staff, shifting the research focus/priorities every year or having research policies that are vague, unfocused or shifting or just rhetoric and not reflecting facts on the ground (Umalele 1992).

The scientific workers lack social recognition by government and society. They receive low remuneration and are rarely motivated or recognised for their contributions to society.

Secondly most African countries lack a technology policy. Such policies would lead to export-oriented industrialisation with the aim of increasing exports of labour intensive light industrial products from agro-based industries. Thus the farming communities would add value to their agricultural products for the world market.

In this case, the import substitution phase would be used by host African countries to get knowledge and skills of imported technologies, incorporate their local inputs, then make

their own adaptive components in order to increase their productive capacities. Examples of forward-looking technological policies are that of Egypt and South Korea.

South Korea in the 1960s linked up the implementation of their science and technology policy to their economic policy. In order to speed up the development process, they identified milestones on their industrial development roadmap.

- a) At milestone one, in the 1960s the main science and technology goal was to make a foundation for industrialisation through the development of import substitution industries and support the local producer goods industries. They strengthened scientific and technical education to build local technological infrastructure and to promote foreign technology imports.
- b) At milestone two, in the 1970s they had a science and technology strategy strengthening technical and engineering education in more advanced fields to promote research and development needs and facilitate the adoption of imported technology. Thus promoting and expanding the manufacturing sector.
- c) At milestone three in the 1980s and 1990s, they adopted a more advanced science and technology policy in the areas of comparative advantage, where the advanced level of technological acquisitions matched the local available resources. They then used engineering capabilities and market access opportunities. So to date, South Korea has been transformed from their third world economy of 1960s to a modern and industrialised economy of 1990s and 2000s.

But in the case of the African continent, the absence of science and technology policy renders many countries unable to lay out their agricultural development road map. For instance apart from Egypt, Algeria, South Africa and Zimbabwe, no imported production facilities such as machines, equipment for industrial, agro-industrial or any other modern agriculture activities have been fabricated in the host African country.

Consequently the African countries have become more and more dependent on foreign technology suppliers to provide them with equipments/technologies, spare parts/components and the service expertise. The technological gap has therefore become identical to the science and technology gap. It's no wonder that foreign firms and banks are determining the short term and long-term actions of the African economic productive sectors. So the local financial and management expertise have limited degrees of freedom for national decisions to maneuver.

Thirdly the educational policy in many African countries does not include the quality and the practical applications of science and technology. Experience has shown that the educational policies in many African countries target absolute numbers rather than quality and practical relevance of the education. In the educational policies, there is a problem of inadequate curriculum development at secondary and university levels.

Facilities like laboratories, equipment, chemicals etc for teaching science subjects are often insufficient or completely missing. Many university colleges of agriculture teach

the courses without field practicals. Worse still, after such courses, the authorities do not organize internships to enable fresh graduates to acquire field skills.

The present trend of university education in Africa is to turn out large numbers of graduates without the necessary technical knowledge and practical skills. There is a growing feeling among private entrepreneurs/employers suggesting that a science degree from an African university may be questionable. A country like Nigeria has 6,400 secondary schools with enrolment of 5 million students, 62 colleges of education with enrolment of 86,000 students, 62 colleges of education with enrolment of 120,000 students and 42 universities with enrolment 325,000 students, yet Nigeria has the problem of poor technical skills required for the job market. So private entrepreneurs in Nigeria are not motivated to expand their capital investments in this economy due to the poor technical skills of the workers (Dabalén and Oni 2000).

Finally there is the issue of adaptive on-farm research, which has been neglected in both the design and implementation of agricultural development projects and programmes by many African countries.

4.1 THE ROLES AND CAPACITIES OF SCIENCE AND TECHNOLOGY IN AFRICA

The role of science and technology in agricultural development is to generate robust agricultural technologies that can be used in the modernization and transformation of agriculture.

The application of science and technology enables a country to harness its natural resources of land, soils, water and forests through research and development. Thus science and technology applications can be used to generate simple agricultural technologies like simple selection of plant seeds and simple inputs like organic and inorganic fertilizers and simple farm tools.

Science and technology applications can also be used to generate more advanced technologies using advanced technologies like biotechnology involving genetic engineering and gene transfers. Other advanced applications of science and technology are chemical engineering, physical and mechanical engineering for a high level of technological development.

The capacities of the application of science and technology for instance in the fields of biotechnology in African countries is still very low. Out of 17 African countries surveyed and found with efforts in plant biotechnology, 13 countries are so far at the low application level of tissue culture and/or micro-propagation of planting materials for one to two selected crops. And four African countries have just started the process of genetic engineering.

Table 4.1. African countries with efforts in plant biotechnology

Country	Biotec. application	Country	Biotec. application
Burundi	Micro propagation	Malawi	Micro propagation
Cameroun	Tissue culture	Morocco	Micro propagation Molecular markers
Senegal	Micro propagation	Uganda	Tissue culture
Zambia	Tissue culture	Tunisia	Tissue culture
Congo D.R.	Tissue culture	Cote d'voire	Micro propagation
Egypt	Genetic engineering	Ethiopia	Tissue culture
Ghana	Micro propagation	Kenya	Micro propagation Marker assisted selection
Nigeria	Micro propagation DNA finger printing Genetic engineering	S. Africa	Genetic engineering
		Zimbabwe	Genetic engineering

Source: Harnessing technology for development ECA 200

Table 4.2. Number of agricultural research scientists in some countries of Africa

Country	Year	PhD	Bsc	Others Technical	Total
Burundi	1989	2	46	38	86
Djibouti	1993	-	5	3	8
Eritrea	1994	-	8	9	17
Ethiopia	1993	82	293	1538	1913
Kenya	1993	107	182	386	675
Madagascar	1991	20	38	111	169
Sudan	1993	315	833	448	1596
Tanzania	1990	34	136	157	327
Uganda	1993	61	76	194	331
Zaire	1992	70	226	48	344

Source: World bank technical report Numbers of 290-1995

No African country so far has had the advanced application of biotechnology such as gene transfer and genetic transformations.(See Table 4.1).

4.2 THE CAPACITIES OF RESEARCH AND DEVELOPMENT IN AFRICA

Besides the insufficient budgetary allocations of funds to research and development, the scientific research capacity in terms of human resources is also limited in many African countries.

The Institutions of research in a progressive economy are expected to generate research results and lead them into the productive and service sectors. Its capacities as pointed out above should be at least 100 scientists per 100,000 of the country's population.

In the research system, the scientists who can carryout a research activity in a mature manner are the ones at PhD level. Table 4.2 shows the number of agricultural research scientists in some countries of Africa. According to Table 4.2, some of the African countries have very few Ph.D. researchers. Instead, most of the personnel in agricultural research are B.sc holders and some others technical personnel who may not be able to conduct an independent research project. Table 4.2 also shows that the agricultural researchers with PhD are still in fact less than 20% of the research personnel.

4.3 THE ROLE OF EDUCATION IN PROMOTING SCIENCE AND TECHNOLOGY AND NARROWING THE TECHNOLOGY GAP BETWEEN RURAL AND URBAN AREAS.

Education is usually intended to impart knowledge and skills thus building human resource capacities for the application of science and technology to harness the natural resources for the agricultural development. Education also builds up the capacity of other users of science and technology such as providing entrepreneur skills to potential investors and developers. Education has the additional role of preparing the communities at large to stimulate them to make demands and be able to receive and consume the finished and processed products of science and technology.

Therefore Education at secondary and tertiary institutions like polytechnic and universities should be designed to incorporate science and technology so as to inculcate / cater for;

- (i) Entrepreneurial skills
- (ii) Research and Development aptitudes and skills to generate technologies for agriculture, industry and commerce for the development of the African economies. There should be skilled people in the universities and research institutions who should spearhead agriculture and industry operations providing all the necessary skills and knowledge, technologies, development models and the necessary expertise.

The Education system should aim at inculcating a science culture in the African societies and emphasise high level skilled man power training. Thus the scientists in Africa, in the industrial sector and the commercial services sector, should all play complementary roles. Where scientists respond positively to the research needs of the industry, the industry and commercial sectors can then both support research and development efforts morally and financially. Thus formulating technology triangles of scientists, collaborating with industrial entrepreneurs and financial institutions to develop market oriented new products resulting from the efforts of researchers.

Unlike the present Education system in Africa which is producing large numbers of college graduates without any practical skills, entrepreneur skills and entrepreneur spirit. Most of the present educated youth in African countries do not realize the potential entrepreneur activities in the rural areas. Instead they flock to urban centres in search of paid employment.

In order to build African societies that can successfully apply science and technology, all the training in secondary and tertiary institutions should get both the scientists and others learn to develop the entrepreneur spirit. This is required in addition to their knowledge and skills acquired from strong programmes of basic sciences, mathematics, engineering, agriculture, computer science, veterinary medicine, biotechnology and business management. This way, the youth can stay and work in the rural areas.

5. PROPOSED STRATEGY, DESIGN AND IMPLEMENTATION FOR TRIGGERING A GREEN REVOLUTION IN AFRICA

5.1 THE CONCEPT OF GREEN REVOLUTION STRATEGY IN AFRICA

The Proposed strategy, is such that when implemented it can bring about a system of sustainable modernization of agriculture and rural transformation thus causing a Green Revolution to happen in Africa. The concept of African Green Revolution was originally inspired by the events of the Asian Green Revolution. The concept was later supported by some successful applications of science and technology and research and development efforts suggesting possibilities of a Green Revolution happening in Africa. Between 1969 and 1991 results of improved crop varieties from on-farm trials in 11 West African countries showed increased yields of cotton 55%, ground nuts 54%, sorghum 67% and maize 130% over the traditional crop yields.(see Appendix 1.1+1.2) The use of irrigated crop fields along rivers of Senegal in Senegal, Niger in Guinea, Mali and north Nigeria showed even better prospects of a Green Revolution happening. In Africa there are also instances of redesigned / improved farming systems in Nigeria, Benin and Cameroon (Ngambeki *et al.*, 1987, 1989, 1989, 1991) which caused significant improvements of rural farmers sources of food and household income. There exists a high capacity for the application of biotechnology at International agricultural research centers and some four national centers in Africa.

5.2 THE DESIGN OF GREEN REVOLUTION FOR INCREASING CAPACITIES OF AGRICULTURAL SYSTEM TO COPE WITH PERSISTENT DROUGHT IN SAHEL AND DESERT PARTS OF AFRICA

The design of a green revolution in Africa, like that of Asia and south America has four major components, namely:

- i) The biological and improved crop management
- ii) The chemical consisting of organic plus half rate of inorganic/chemical fertilizers
- iii) The biophysical, mechanical engineering for improved farm tools, and hydrological irrigation, for complete water control.
- iv) On-farm adaptive research activities accompanied by redesigned improved farming systems

The specific technological ingredients of green revolution in Africa may vary from location to location according to the predominant and/or location specific agro-ecological zones. In case the of Sudan savannah and Saharan agro-ecological zones in the Sahara and desert parts of Africa, would have the following specific ingredients.

First the biological and crop management technologies. These are to include improved crop varieties of rice, maize, sorghum, millet, beans, cowpeas and cotton. The right traits in improved crop variety should be robust plant stem, early maturing, high yielding, responsive to enhanced plant nutrition, resistant to specific plant pests and diseases, adaptable to the two (semi-arid) agro-ecological zones and tolerant to salinity, alkalinity and low moisture but with ability to make efficient water use.

In order to get improved crop varieties with the desired traits, on one hand a breeder may start with simple selection techniques. On the other hand, scientists can also use advanced scientific basis of green revolution by combining the principles of biological sciences, genetic engineering, molecular biology and the application of biotechnology with a broad genetic resource base of germplasm resources.

The applications of biotechnology has many advantages:

The tissue culture method is an application of biotechnology for the rapid multiplication of plants for very scarce crop varieties. In addition biotechnology applications can be used with selection techniques and regeneration systems making crops amenable to genetic engineering. A breeder can combine genetic materials/germplasm from different environments. Biotechnology applications (such as somatic embryogenesis) enable scientists to use plant tissue to produce new seeds. In this way the IRRI research scientists in 1960s made use of rare genetic materials from wild plants to introduce resistance to drought, diseases, insects and salinity, in the semi-dwarf rice variety that caused the green revolution in Asia.

Most agricultural designers for Africa have neglected livestock. It should be noted that livestock is a major component of the farming systems in semi-Arid zones of Africa.

Moreover our modeling indicates a strong correlation between crop-livestock integration (CLI) and productivity/sustainability of several African farming systems (Ngambeki et al, 1991). Therefore the semi-Arid Green Revolution must take a harder look at animals in the African farming system. Our approach will involve selection of strong, healthy animals from the indigenous/local stock breeds, which are adaptable to Sahelian conditions and tolerant to pests and diseases, to be accompanied by improved animal husbandry.

Second component is organic materials plus half the rate of inorganic chemical fertilizers. Many experiments conducted in Nigeria, Kenya, Uganda, Zimbabwe, Ghana and Malawi showed that a combination of organic materials (like compost, farm yard, kraal and green manure) with half the dose of inorganic fertilizers produces high yields while maintaining the soil fertility of the land (Webster and Wilson 1991). This conforms to the crop/livestock interaction (Ngambeki *et al.*, 1991) tested in Northern Cameroon.

Third component, the biophysical technologies consist of soil and water management, small-scale irrigation systems and improved hand tools/techniques. Among the soil and water management technologies which have proven successful in dry areas of Africa are tied ridges, trenches and water pits, valley dams, green mulches, nitrogen fixing and improved fallow legumes (like *mucuna*, *cajanus cajan*). The small-scale irrigation schemes used to supplement low rainfall, besides being cheaper, have been more successful in Africa than the costly large-scale irrigation schemes. This has worked very well with rivers in bottom valleys, tube wells and construction of valley dams in Northern Nigeria for water harvesting. Among the biophysical technologies are the proven improved prototype hand tools such as rolling injection planter and walking tractor developed by IITA and IRRI, herbicides application for zero tillage and weed control, hoes and cutlasses.

The fourth component is participatory on-farm adaptive trials, which has three perspectives i) testing the characterized and redesigned modified farming systems, ii) farm level testing in the respective agro-ecological zones, of all the technologies being proposed for the African Green Revolution in the semi-Arid zone of Africa and iii) integration of livestock into the modeled farming systems. Other important perspectives are post-harvest technologies and marketing outlets to prevent on-farm losses and generate income for the reduction of rural poverty.

5.3 STATE GOVERNMENTS' COMMITMENT AND SUPPORT

One of the major conditions required for the African Green Revolution to happen in the field is state government commitment and support. Thus the strategy requires each participating African country to create a critical mass of scientists and invest sizable resources so as to mobilize for the promotion of science and technology, backed by long-term policy/priority commitment to sustainable modernization of agriculture and rural transformation. States need to have education policy linking up the promotion of science and technology to agricultural development.

For the African Green Revolution to happen, a participating African country should commit material and financial resources to develop her institutional and human capacities to harness science and technology for modernization of agriculture. Such a country needs sufficient number of scientists and institutions for teaching, research and extension. The investments in science and technology are needed to generate new knowledge, and entrepreneurial spirit, skills, thus bringing about human capital, which is one of the critical sources of development. At policy implementation level, the state government must endeavor to create linkages between policy makers, entrepreneurs and scientists to work together to develop national institutions. When many countries achieve optimum levels of investments in science and technology, high yielding technologies that are widely adopted by small-scale farmers who can at least double their production in the Saharan zone then the Green Revolution will have been achieved.

Under the proposed Green Revolution in Africa, countries that share the same semi-Arid zones will be advised and encouraged to formulate and coordinate their science and technology policies and/or programs. Besides, some countries may not have sufficient resources to invest in science and technology at optimal levels. In such cases, a group of neighbouring countries could form partnerships to share the use of germplasm and/or science and technology facilities for creation of improved varieties through cross-breeding and biotechnology (including gene technology).

The concept of partnerships and networking will be applied to stakeholders internally (for example, between public sector including entrepreneur investors) and stakeholders externally (for example, neighbouring countries, International Research Centers and International Donor Agencies).

5.4 METHODS AND IMPLEMENTATION OF GREEN REVOLUTION IN AFRICA

5.4.1 STAGES OF IMPLEMENTATION AND NETWORKING PARTNERSHIPS: GREEN REVOLUTION IN AFRICA

- A. Divide the African continent into regions/or consider existing socio-economic groupings based on similarities and differences with respect to agro-ecological zones, farming systems, available potentials/opportunities.
- B. Appoint technical design and coordination teams consisting of three to seven persons of major professional disciplines and charge the teams with responsibilities to:
 - i) Conduct in country and inter-country consultation meetings on national policies/strategies/priorities for promotion of science and technology for agricultural development and intra country partnerships.
 - ii) Facilitate participatory selection of promising available technologies, redesign the farming systems and designing of on-farm trials/research programme, generate agro-climatic information and natural resource management.

C. Organize and facilitate stakeholder strategic planning meetings by region of national governments, political/technocrat representatives, NGOs etc to discuss priorities of science and technology, set education technology policies/priorities/targets.

5.4.2 SET TARGETS OF IMPLEMENTATION PLAN

The selection of key on-farm testing sites within the target semi-arid zones based on geographical spread and climatic / farming systems characteristics. The technologies need to be tested and adapted to location, specific characteristics including the redesigned farming systems. The plan is to use practical designs and implementation approaches that can produce visible results at pilot sites in three countries in three years and show similar results replicated at secondary sites after five years.

6.0 RECOMMENDATIONS ON ROLES OF STAKEHOLDERS

6.1 SUMMARY OF STRATEGIC PLAN FOR CAUSING GREEN REVOLUTION IN AFRICA

The purpose of this paper is to show how to improve agriculture in Africa for food security and better incomes in spite of pests and diseases and persistent drought. The way forward is to immediately develop and implement a strategic plan that can cause Green Revolution to happen in Africa. The new plan needs all the aspects of the technical and social/economic/political ingredients including the internal and external partnership.

The essential ingredients of the African green revolution are below:

First the biological component starting from the simple selection of elite improved crop varieties, diversity of local germplasm to the more advanced applications of biotechnology and gene technology.

The second technological ingredient is that the biological technologies need to be accompanied by their complementary technologies such as improved farming methods (good seed bed, planting in lines, optimal mixed cropping or monoculture, timely weeding) and improved inputs (organic and/or inorganic fertilizers, tools and so on). Crop/livestock interactions are a highly desirable integral part of the biological technologies as well as the redesigned improved farming systems.

Thirdly the biological technologies can be even more efficient when complemented by an irrigation system. Simple, small-scale irrigation systems (like sprinkle, tube well and river irrigation canals similar to horticulture irrigation system in Kenya) or harvested water can still cause and sustain a Green Revolution in Africa.

The fourth essential ingredient is the selection of key on-farm testing sites within target semi-Arid zones. The technologies must be tested and adapted to the practical factors on the ground. Adaptation to the local conditions can be done by selection, crosses and / or genetic engineering technologies, which can be further tested in on-farm research.

In addition to the on-farm testing, there is the essential basic element of characterization and redesigning of the existing farming systems. Smallholder subsistence farming systems in Africa are too complex to be dragged along the road to agricultural modernization without their modification and improvements. In the past, many researchers and development workers in Africa have tended to oversimplify, changing the local subsistence farming systems to planting of monocrops, or else overlooked the question of an improved / designed farming system.

6.2 THE ROLE OF AFRICAN STATES TOWARDS DESIGN AND IMPLEMENTATION OF A GREEN REVOLUTION IN AFRICA.

a). Regional mobilization of state governments for long-term commitment and support. This means putting the right policies in place, then making sizable investments (in terms of human, material and financial resources) towards the cause of agricultural modernization through the promotion of science and technology; b). The African governments should go beyond political/trade groupings and enter into development partnership and create regional partnerships (between state and donors) and c). Regional networking to share both responsibilities and benefits of a Green Revolution; d) They should divide roles, exchange information about their priorities and policies for promotion of science and technologies, thus promoting joint strategic plans or policies. African Governments under similar agro-ecological conditions should harmonize their research, testing centers, germplasm collections and biotechnology applications so as to make the most efficient use of their available resources / or capacities.

6.3 RECOMMENDATIONS TO AFRICAN FARMING COMMUNITIES AND REGIONS

In order for a proposed Green Revolution to happen, it is recommended that the farming communities and regions reform their land ownership and land tenure from traditional and/or customary laws, in order to enable the ordinary or poor farmers to access and use the land with ease. The farmers need secure and stable tenancy on the land for them to make the necessary investments in modernization of agriculture. Where there are farmers who are tenants on the land, there should be reform to make the tenancy long term, so that the farmers have operational legitimacy such as land lease or operational leasehold. National governments to respond to the urgent need of reducing illiteracy rates (from 60% to 20%) through formal and informal education, increasing public awareness to prepare the society for receiving and interacting with advanced technologies of our time and of the future.

6.4 RECOMMENDATIONS FOR AGRICULTURAL AND RURAL DEVELOPMENT AND OTHER SCIENCE AND TECHNOLOGY EXPERTS IN THE FIELD.

It is recommended that all agricultural and rural development personnel plus S&T experts who are working in the same sub-county, community, district or even country should get coordinated and focused on the common goal (promotion of science and technology for modernization of agriculture and rural transformation). It is further recommended that all development workers in the same district should have their objectives, priorities and work plans incorporated into one umbrella or master plan document. That way, their efforts can easily be complementary to each other and produce visible results in 3 to 5 years. When the plans of different teams are in one document and their implementations are being coordinated, they are automatically sharing responsibilities and networking. These are already two practical pre-conditions for a Green Revolution to happen in Africa.

6.5 RECOMMENDATIONS FOR AFRICAN GOVERNMENTS (LOCAL/NATIONAL)

National governments should put in place and streamline education, science and technology, research and development and national technology policies. They need to create institutional linkages of university training and scientific research and development. Thus creating linkages between scientists and entrepreneurs, (in agriculture industry and commerce) and policy makers. Linking education to promotion of science and technology, to research and development and to the planned targets of agricultural development programmes. The national government should provide more financial material and political support to increase their national technology capabilities. Provide guidelines and regulatory process to facilitate the importation and adaptation of foreign imported technologies. National governments must promote inter-country exchange of research results and germplasm collection, on-farm research at in-country and interregional on-farm testing sites.

6.6 RECOMMENDATION TO NEPAD

The African Union and NEPAD need to mobilize and provide political support to target African Governments to identify and initiate the necessary measures/policies contributing to the African Green Revolution, embracing the concepts of partnership and networking.

It is recommended that NEPAD start to target African Governments and donors in order for them to support the concept of African Green Revolution. It should sell the idea, and help to launch its pilot phase in the next two years. The other UN Agencies like UNESCO should also promote and support the African Green Revolution and in particular the promotion of science and technology in Africa in general.

BIBLIOGRAPHY

1. Debalen, Andrew and Bankale oni (2000). Labour market prospects of university graduates in Nigerian Institute of Social and Economic Research, NISER, Ibadan 2000.
2. World Bank Economic/Social data base 1989
3. Ngambeki, D. S. and B. Ndunguru 1987. An approach to increasing food productivity under drought conditions. A case of north Benin. In food Grain Production in semi-arid Africa by Menyonga J.M et al.
4. ECA Policy Research Report 2003 Harnessing technologies for development in Africa
5. Odhiambo T. R. and T.T. Son. Science for development in Africa
6. World Bank technical report 1991. Strengthening National Agricultural Research System in Eastern and Western Africa.
7. FAO production year book 1999
8. World Bank development report 2002
9. FAO trade year book 1990
10. UNDP 2001, Human Development Report Nigeria Lagos
11. FAO data files
12. Rand forum 1993 science-led development in Africa, proceedings Nairobi 1993
13. STRC / SAFGRAD / FSR / IFAD 1990, 1985 – 1989; technical report.
14. Ngambeki et al. 1989, SAFGRAD / FSR. Cameroon country report.
15. Menyonga S et al. 1986. Food production in semiarid Africa
16. Sohannes Roseboom and Philip Pardey 1995. Survey of agricultural research investments in sub-Saharan Africa.
17. Marco Quinones and Tekere Gebre 1995 an overview of the Sasakawa Global 2000 project in Ethiopia.
18. Uma Lele, World Bank 1992. Aid to African agriculture.
19. Hayami, Y and M. Kikuchi. 2000. A rice village saga: three decades of Green Revolution in the Philippines. IRRI
20. Lawani S, and T Babaleye IITA, 1992. Recent developments in cereal production in Nigeria.
21. FAO 1987. Irrigation and water resources potential for Africa.
22. Tribe Derek 1994. Feeding and greening the world: the role of international agriculture research, CAB international.
23. Times Brooks 1990, the times world atlas of the world. London
24. Webster, C.C and Pren Wilson. 1989. Agriculture in the tropics, Wageningen
25. Ngambeki .D.S, R.Deuson and L. Lowenberg DeBoer 1989. The impact of farming systems research on agricultural productivity. The case of north Cameroon. *J of Farming Systems* vol.1(c) 1990, pp 125 – 152.
26. Ngambeki D.S, R .Deuson and P. Preckel, 1991. Integrating livestock into farming systems in north Cameroon. *J Agric Systems* vol 38, pp 319-338.
27. Khush, G and G. Toenniessen, 1991. Rice biotechnology. IRRI.
28. UNDP Agriculture, “Green revolution” with new African rice types?

29. Bosco, Pierre-Marie and Ellen H. Freund-1994. Agricultural Innovation in cotton zones of Francophone West and Central Africa. IITA / FAO Workshop on Sustainable cropping systems for Moist Savannah zones, Sept. 1994, IITA, Ibadan.

Appendix 1. Successful diffusion of improved crop technologies in some countries in West Africa.

1.1 Yields of cotton from on-farm trials in West Africa 1991.

Country	1969-1971	Cotton yield kg / ha 1991
Benin	844	1,168
Burkina Faso	368	894
Cote d'voire	908	1083
Mali	753	1279
Senegal	1064	1118
Togo	730	1157
Cameroon	552	1249
Chad	385	651
Ghana	540	1103
Nigeria	458	644
Average Cotton kg / ha	634	984(55.2%)

Source: 1.1 ministere de la cooperation cited in Bosc and Freud 1994

1.2 Yields of maize and sorghum in some countries of Africa.

Country	Crop	Yield Kg / ha 1988	
		Local	Improved seeds
Benin	Sorghum	331	1210
Burkina Faso	Sorghum	967	1620
Cameroon	Maize	1852	4351
Cameroon	Sorghum	1719	3688
Average for Sorghum Kg / ha		1005.6	2172.6 (1160%)

Source: 1.2 Ngambeki,D et al 1989,SAFGRUAD / FSR Cameroon country report 1989

.Appendix 2 Agricultural development indicators of some West African countries.

Country
 2001,population
 (million people)
 2001 Cereal production 1000 MT
 2001 maize yield ta / ha
 Millet yield 200 ta / ha
 2000, fertilizer use 1000MT

Benin
 13.57
 878

57

3.1%
 (-1.4%)

(-15.0%)

BurkinaFaso
11.55%
2796

34

(2.4%)
(2.5%)

(8%)

Coted'voire
52.32
1970
8.2

71

(3.3%)
(1.7%)
(0.0%)

(-6.6%)

Mali
11.09
2658
8.7
5.5
50

(2.5%)
(1.4%)
(0.6%)
(0.8%)
(-16.1%)

Senegal
9.77
1026
12.0
5.9
41

(2.7%)
(-0.2%)
(-1.1%)
(0.0%)

(-3.7%)

Togo

4.65

740

11.4

5.2

20

(2.7%)

(3.9%)

(0.7%)

(0.4%)

(5.4%)

Cameroon

15.2

1196

48

(2.5%)

(-1.6%)

(-7.8%)

Chad

7.92

1230

18

(3.0%)

(-5.2%)

(-7.3%)

Ghana

19.71

1686

13.0

7.0

15

(2.4%)

(-0.6%)

(0.4%)
(1.9%)
(-0.9%)

Nigeria
129.87
22.891
12.7
10.5
187

(2.8%)
(2.3%)
(0.9%)
(0.3%)
(-10.1%)

SierreLeone
5.13
222

0.0

(2.3%)
(1.0%)

0.0

Gambia
1.34
176
16.9
10.8
1

(4.1%)
(0.1%)
(-2.3%)
(0.7%)
(1.8%)

Source:World Bank African development indicators 2002.(Figures in parentheses represent annual percentage growth rate)

Appendix 3. The African countries which have experienced at least three persistent droughts in the last twenty years

Country	1982	1992	1995	2000	No. of drought years in 20years
1. Botswana	D	D	D	D	3
2. Burkina Faso				D	2
3. Cape verde		D		D	6
4. Chad			D	D	6
5. Eritrea				D	4
6. Ethiopia	D	D	D	D	8
7. Kenya		D		D	6
8. Malawi	D	D			5
9. Niger	D		D	D	6
10. Rwanda			D	D	5
11. Sudan	D		D	D	6
12. South Africa		D	D		3
13. Tanzania		D		D	5
14. Uganda				D	3
15. Zambia		D	D		5
16. Zimbabwe		D	D		4
17. Algeria			D	D	8
18. Morocco			D	D	4
19. Tunisia			D		3
Total no. of countries affected by drought in a given year	5	12	16	18	

APPENDIX4

DESIGNING THE AFRICAN GREEN REVOLUTION: FIELD CASE STUDIES AND FIELD EXPERIENCES OF ANAFRICAN RESEARCHER, 1977-2003

The following field case studies each had an instance of redesigning a farming system for modernization, productivity and sustainability, of agriculture at specific sites in a few African countries.

Field Case Study 4.1: Introduction of Upland Rice using on-Farm trials in Ogun state of Nigeria.

Where, Ngambeki was sponsored to lead university and state research team.

4.1.1 Problem statement

By 1976, Nigeria's importation of food was 60% of total costs of all national imports, yet Federal and state governments had formulated a policy on food self-sufficiency and were concerned to have the policy implemented for alleviating food shortage.

Among the root causes of food shortages; Oyo and Ogun states had high urban populations and a deficit in food production. The climate and vegetation represent a typical tropical humid forest. Two rainy seasons, farming systems consisted of cassava, yams, maize, cowpeas, beans, soyabeans and okra, a few goats and hardly any cows. The varieties of staple food crops cassava and yams were late maturing cassava (3years) and yams (1year). Acreage under crop was very low with poor yields. People eating habits- rice preferred dish mostly for high income group who could afford the imported rice. Gari (Cassava roasted flour) was staple food for the low class, yams and plantain (eba and dodo) for middle class. But scarce for being produced mainly in mid-belt and eastern Nigeria

4.1.2 Technical intervention:

Designed on-farm trials to: Introduce a new crop in the farming systems, that is early maturing and the improved management technologies and a modification of the farming system to accompany the new crop. Upland rice was suitable for the climate and land resources plus its favourite place in people's diet.

Moor Plantation Research Station and IITA, provided three promising upland rice varieties, Oyo and Ogun state governments provided vehicles and their extension staff. Two hundred farmers volunteered to participate in the trials.

In the first round of trial, most of the farmers planted the trials according to their traditional farming systems, with low yields due to problem of poor land clearing methods (left with high stumps) and birds' damage.

A participatory redesigned cropping sequence, planting dates, cropping calendar, how farmers could plant in clusters, and modified farming systems, led to subsequent plantings with a sequence of cereal/legumes/cereal/fallow and destumping their newly cleared land and applying half-rate of fertilizers which enabled the farmers to use their land sustainably.

4.1.3 Outcome: For many farmers, cluster planting of upland rice on same dates in adjacent fields dramatically reduced birds damage. Upland rice of 2000 kg / ha. By 1978, the state governments adopted Upland rice trial design.

By 1978, the design was adopted by the Federal Government to promote, improve technologies of maize and cassava trials under the National Accelerated Food Production Programme (NAFPP)

Field Case Study4. 2 –OAU / STRC / SAFGRAP Farming Systems Design, North Benin 1985, Burkina Faso 1985 Cameroon 1986—1988

4.2.1 Problem statement:

The prolonged drought of 1980 / 82 in Africa caused

- i) desertification threat from the Sahara desert across north west, central and eastern African Countries.
- ii) Depletion and further threat against livestock by the drought

Incase of Republic of Cameroon

- iii) Forage shortage forced pastoralists to drive their herds from North to southwards into Sudan Savannah zone in search of pasture and water. That created fierce ethnical/social conflicts between crop-farmers and livestock keepers.
- iv) Problem of food shortage and farmers poor response to cotton promotion project. The province of North Cameroon had been the major producer of cotton and a earner of foreign exchange. The French company SODECOTON had made a lot of investments in the Cotton project, providing extension services and input credit in form of Ox-plough, fertilizers, pumps, herbicides, insecticides, cotton seeds, tractor hire services for ploughing to farmers. Each farmer was encouraged to plant at least one acre of cotton. But farmers gave a luke-warm response to cotton project because the French extension staff did not pay attention to the biting problem of food shortage.
- v) The shortened duration of the rainy season from 180 days to 90 days could no longer sustain the late maturing traditional varieties of white and red sorghum and millet that required 150 to 170 days to mature.

4.2.2 Technical intervention:

- i) Redesigned the farming systems i) introduced new crops which can be squeezed / fitted into the 85 days of soil moisture surplus period (early maturing maize 75 days, early maturing cowpeas 60 days) + cotton and Sorghum 90 days.
- ii) Redesigned cropping calendar in a participatory manner
- iii) Promoted technologies that accompany new improved crop varieties a) improved management practices b) soil fertility, Kraal manure + ½ fertilizers c) Ox-plough d) Soil moisture conservation tie ridges
- iv Interaction with breeders and other researchers of IRA, IITA and ICRISAT to produce the required improved crop varieties and other technological components that fit into short rainy season.
- v Designed and Implemented farmer participatory On-farm trials to test the redesigned farming systems and the technological components.

4.2.3 Out comes:

On-farm trials started with 300 farmers participating in 1986, and in 1987 they increased to 500

Implementation of the trials utilized the opportunity of having SODECOTON extension staff. A French team took over the trials when

The SAFGRAP project ended.

Field Case Study 4. 3: SAFGRAD / Farming Systems Design, North Benin 1985-86

4.3.1 Problem statement in case of North Benin

In addition to desertification threat due to drought 1980 / 82 in Africa, Northern Benin had:

- i) Late rains and shortened rainy seasons; annual rainfall declined by 40% - there were only 100 days of moisture surplus available per year.
 - ii) Frequent dry spells of more than 14 days in May/July causing severe moisture stress to the crops at their critical period of growth, plus water logging by heavy showers when it rained.
 - iii) Shortage of pasture in the dry season
 - iv) poor soils
 - v) Frequent crop failure and food shortage.
 - vi) Tight schedule of farming activities – shortage of labour for soil preparation (ridging + mulching), planting, weeding.
 - vii) Some farmers were only crop farmers and others only livestock keepers.
- Local traditional subsistence systems, shifting cultivations
Soils: Sandy soils with low moisture retention capacity.

4.3.2 Technical intervention (North Benin)

- a. redesigned an integrated improved farming system consisting of
 - i) Improved varieties of Cassava, Sorghum and Millet, Crop-trees and livestock interactions (trees – leguminous shrubs – Sun hemp (*Crotalaria* sp.) + other trees as source of green manure for crop and foliage for animals.
 - ii) Soil – water conservation technologies: Tied – ridges, trenches and bund terraces.
 - iii) Labour – Saving technologies : Ox – plough , Ox – cart and roulette – a grain seeder
Interaction with other Researchers, Agronomists, Breeders and Engineers for the appropriate technological components.
 - iv) Designed on-farm trials for the July 1985 – 6 (Implementation / testing of the technological components and the Design of the improved farming systems.

4.3.3 Out comes

The integrated farming systems showed economic viability. Farmers food security improved after two years.

4.4 Field case study :Use of integrated participatory planning for sustainable development approach in Mbozi district ,Tanzania 1999-2000.

Ngambeki recruited by UNDP to lead Mbozi district planning team as a pilot project in Tanzania

4.4.1 Problem statement :

After 30 years of research and development, no significant impact on the ground. Still Chronic food shortage, very low production, low income and widespread poverty. The development process at Central and district levels had:

- no linkages between village and district development plans
- no linkages between district and national development plans
- all plans lacked participatory planning input and poorly coordinated

- low levels of revenue collection
- weak, unmotivated team of technical staff at all levels especially the decentralised local district Governments.

4.4.2 Technical interventions:

(a)organized a series of in-service training workshops in participatory planning at division , district and central government development planning levels, and/or SWOT analyses of the existing development planning systems at district and division levels to create the missing development planning linkages and incorporating sustainable management of natural resources.

- introduced new development activities in the integrated development planning

(b)Redesigned local (Mbozi) farming systems, and introduced new crops- upland rice and rehabilitation and liberalization of coffee marketing.

(c)Recommended increases of local government investments in infrastructure (rural feeder roads, health centers, education and rural markets) linking up rural communities to urban markets

(d)Recommended broadening tax base at the village and district levels like trade licences,market dues.

4.4.3 Outcomes after 2 years

- 1000 farmers enrolled for upland rice production scheme
- 500 farmers licensed to carry out marketing activities and/or getting petty trade in farm produce marketing.
- Mbozi district revenue collection increased by 30 percent from the second year of implementing the recommendations.
- sales of seeds and fertilizers increased

Field Case Study 4.5: Redesigning Banana based Farming Systems in Central Uganda, 1991-1994, 1998, 2000-2003

4.5.1 Problem statement

Results from a participatory diagnostic survey of banana production systems in Uganda in 1992 showed that banana production in the country had shifted from the traditional banana producing districts of Central Eastern to Western Uganda. Thus banana production had severely declined in the Central region due to a host of biotic and abiotic constraints like built up of pests and diseases, exhausted soils, drought, poor crop management. Susceptible low genetic potentials of traditional banana varieties.

- Existing farming systems, in Luwero farmers had shifted from banana cultivation to annual crop cultivation, i.e maize, millet, cassava, sweet potatoes, beans, ground nuts and kayinja (beer banana)
- Bamunanika subcounty, in Luwero district, had sand soils which were prone to drought
- A bimodal rain season punctuated by prolonged dry spells.

- Women provided 60% of farm labour yet women's contributions to rural development including food security was not properly recognized.
- Also women not actively participating in decision making for farming activities.

4.5.2 Technical interventions

a, Redesigning the existing farming systems to include:

i) Reviving banana production in the central region to address food security and sources of income.

ii) Introduced 4 elite / improved East African Highland banana cultivars and 4 exotic / introduced bananas cultivars which are tolerant / resistant to drought, pests and diseases.

iii) Mobilize, sensitize and train farmers including 6 farmer trainers about improved banana management practices.

iv) Promote soil and water improved management practices

v) Empower women, through community participatory training to participate in farm decision making and rural development as a whole.

b, Designed and conducted 200 community participatory on-farm banana trails to test and promote the proposed technologies in Bamunanika Sub County.

4.5.3 Outcomes

a) Over 20% of farm households in Bamunanika Sub County have adopted improved banana technologies. Over 16 hectares, 18,000 improved banana suckers have been disseminated to new farmers.

b) About 15% of the women population is actively participating in the cultivation of bananas for food and to earn their income as activity or banana plot leaders and participating in farming decision making as household partners.

c) Women involvement in the management of the trails has promoted early farmer acceptability of exotic banana cultivars (Which are slowly capturing its share of the local banana market) and rapid adoption of banana improved technologies.

d) Food security in Bamunanika is now assured and the average farm income has improved 90,000 ushs to 240,000 shillings/= per house hold per annum. About 20% of the contact farmers have improved their socio-economic status by using incomes obtained from bananas to pay children's school fees, make home improvements, and purchase a cow, a goat, a bicycle, T.V, and / or mobile phone.

e) Many communities in neighboring sub counties are seeking improved banana planting materials and training to adopt banana improved technologies.

2. Over three NGOs have now joined the promotion of banana technologies in Luwero and neighbouring districts.

Source: Ngambeki et al 1989,SAFGRAD / FSR Cameroon country report.

-Ngambeki' et al 1989.The impact of farming systems research on agricultural productivity-case of North Cameroon J. of farming systems vil.1 1990.

-Ngambeki et al 1991 –Integrating livestock into farming systems in North Cameroon.3.Agric.systems Vol.38