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Green Technologies for African Agriculture and Energy and Possible Strategies for Incubation and Development

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Abstract

African agriculture and energy needs are among current issues in developing literature. Using secondary data and extensive literature, the performance of African agriculture with other regions in terms of capacity of export was examined. It found that African agriculture is less competitive. It further explored classical and new technologies for African agriculture and energy development amidst climate change to remedy the situation. The technologies explores includes integrated aquaculture/crop/energy production system. Drip irrigation not only for food crops but also for plantation crops, green house technologies such as 'aeroponics' for growing potatoes and seawater greenhouse for producing vegetables. The paper examined also the strategies for implementation of the innovation. The discussion explored the use of contact farmers, value chain financing, agricultural cooperatives, school to land agriculture, restructured farm settlement scheme and small medium scale enterprises funding strategy to incubate and developed the innovations. It concludes by opining that the ongoing call for African agricultural transformation can adopt the approached presented in order to create wealth, alleviate poverty and contribute to climate change mitigation and low carbon energy production.

Keywords: Agricultural Exports; Integrated Fish and Crop System; Bio-fuel; Irrigation; Green House Technology.

INTRODUCTION

African agriculture though affected by globalization and climate change is still fundamental to economic and social development in Africa. Agriculture is undoubtedly the most important sector in the economies of most non-oil exporting African countries. It constitutes approximately 30% of Africa's GDP and contributes about 50% of the total export value, with 70% of the continent's population depending on the sector for their livelihood (CEEPA, 2002). Production is subsistence in nature with a high dependence on the rain. The debate on climate change and its impacts on agriculture are therefore very crucial to the very survival of the continent and her people. The continent is particularly susceptible to climate change not only because of its position in the tropics but due to the fact that some of the world's poorest nations who have very low capacity to mitigate climate change and adopt best technologies are in African practicing small-scale agriculture.

During the second half of the 19th century a growing number of African smallholders became involved in the international trade with agricultural products. While the cause for the increased trade included improved incomes in Europe and increased demand for tropical products, many local systems of production in sub-Saharan Africa (SSA) benefited from the trend (Mkpado, 2012). The most well known example of this is probably West Africa where the production of export crops such as cocoa, groundnuts and palm oil as well as cassava was performed almost solely by smallholders. The development of commercial smallholder agriculture was much more modest in Central and Eastern Africa during the same period (Mkpado, 2012; Mkpado and Arene 2012). It was during this period that climate change has become a global issue. In view of the forgoing, a few research questions are: What is the ongoing trend or characterization of African agricultural exports? What technologies and development strategies are needed to catch up with other regions of the world?

The objectives were to employ the performance of African agriculture as well as climate change indictors and present technologies and innovations for African agriculture and energy amidst climate change and employ possible strategies for incubation and development within African context.

Methodology

The paper relied heavily on literature search. Secondary data were sourced from United Nations Centre for trade (UNCTAD) data base and other reputable literature sources were used. Descriptive statistics was used to present the results while qualitative analysis was employed in discussion.

RESULTS AND DISCUSSIONS

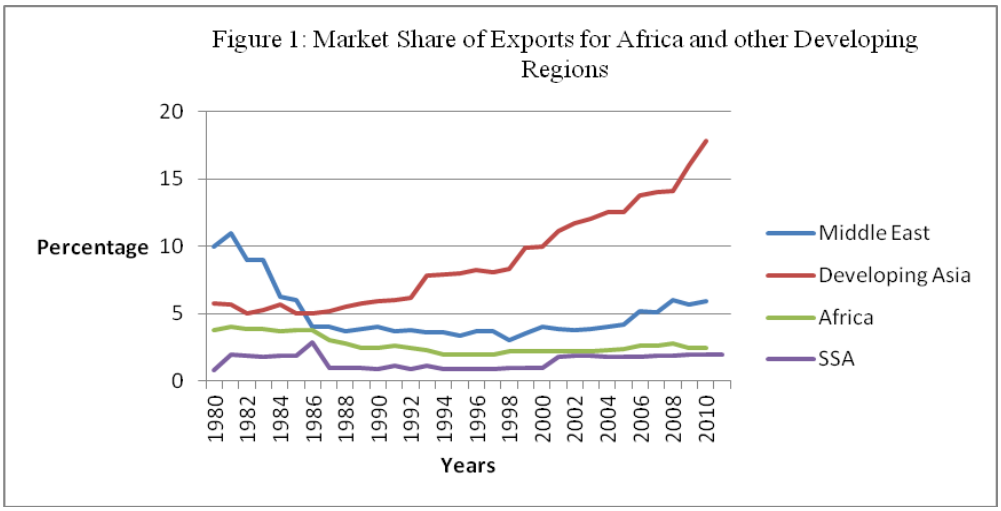
Exports primary agricultural commodities such as cotton, coffee, cocoa, tea, groundnut, palm oil and kernel, potatoes, cassava products, hinds and skins as well as some fish dominate African international trade (Mkpado, 2012). On average, exports of agriculture commodities are as high as 80 percent of total exports in several African countries (Ogunleye, 2012). Mkpado (2012) trend analysis of performance of African agricultural trade showed that African share of agriculture in merchandise export decreased from 12.9 in 2000 to 10.2 in 2009, while the share in merchandise imports also decreased from 15.1 to 14.3 for the same period. On the other hand, agricultural export share in primary products decreased from 17.7 to 13.7 while imports decreased from 51.9 to 51.5 for the same period (see table 1). On the contrary for instance Asia export of primary ranged from 48.0 to 36.9 while imports ranged from 24.8 to 34.7 with a decreasing trend.

Table 1: Share of agricultural products in trade in total merchandise and in primary products by region in percentages

		2000		2001-2004		2005-2008		2009	
		Export	Import	Export	Import	Export	Import	Export	Import
Share in total merchandise	World	9.0	9.0	9.1	9.1	8.3	8.3	9.6	9.6
	North America	10.0	5.9	10.533	6.15	9.55	6.0	11.2	7.0
	South and Central America	18.4	9.0	21.525	9.55	25.375	8.78	30.5	10.0
	Europe	9.4	10.0	9.325	10.05	9.05	9.20	10.5	10.7
	Commonwealth of Independent States	8.9	10.7	8.85	11.125	7.3	11.65	8.7	14.0
	Africa	12.9	15.1	14.13	15.4	8.65	13.88	10.2	14.3
	Middle East	2.4	13.1	3.15	12.575	2.325	10.35	2.6	11.2
	Asia	9.0	9.0	6.4	9.125	5.675	7.45	6.3	8.6
Share in primary products	World	40.7	40.7	40.625	40.625	29.85	29.85	34.1	34.1
	North America	58.2	33.8	56.15	32.7	40.675	24.15	45.1	28.6
	South and Central America	47.3	44.1	47.05	42.825	38.375	30.075	43.9	35.3
	Europe	57.2	47.3	56.5	47.2	46.125	35.2	52.3	40.7
	Commonwealth of Independent States	20.7	41.8	20.05	46.7	10.2	49.15	12.1	53.8
	Africa	17.7	51.9	20	57.45	11.225	47.375	13.7	51.5
	Middle East	3.2	59.9	4.125	65.875	3.075	52.175	3.7	55.5
	Asia	48.0	34.7	46.2	33.6	35.1	36.9	36.9	24.8

Source: UNCTAD database in 20012

Market share measures trade intensity of countries vis-à-vis their competitors. It is a good measure of trade performance because it compares the market share of each region or country to others. Thus one can identify the global trend of trade. It is a composite indicator of performance in terms of technology for production, processing and marketing. Figure 1 is an illustration of market share of Africa with those of Middle East and Asia. From a global annual average trade share of three (3) percent in the 1980s, African's global trade share declined slightly to annual average of two (2) percent in the 2000s. SSA performed better on this measure when compared to Africa with a slight improvement from one (1) percent annual average market share in 1980s to two (2) percent in 2000s. However, this performance is dwarfed by Asia that increased her market share from annual average of five (5) percent in the 1980s to 12 percent in 2000. The similarity between the results for Africa and the Middle East is not surprising given the similar structure in exports of these countries that are dominantly primary commodities. It can be noted that the share of fast developing Asia countries such as China, Japan, South Korea, and Singapore are taking over the world market while the African share is decreasing (Mkpado, 2012).



Source: IMF's Direction of Trade Statistics CD-ROM, September 2011.

Climate change and Agriculture

Figure 2 is a graphic representation of the projected increase in carbon dioxide (CO_2) emissions from fossil fuels in five of the emissions scenarios used by the International Panel on Climate Change (IPCC), compared to the International Energy Agency's (IEA's) actual observational CO_2 emissions data from fossil fuel consumption. Data from IPCC emissions scenarios; Data spreadsheet compared with International Energy Agency's CO_2 emissions from fuel combustion of 2011 highlights and supplemental 2010 IEA data. Figure 3 is an illustration of climate change with respect to increasing surface temperature. The various GCM scenarios support anticipated increase in surface temperature. The impact modeling approach for each overall economic-demographic scenario, use five climate scenarios: two General Circulation Models (GCMs) with respect to the atmosphere and ocean – MIROC (Japanese) and CSIRO (Australian), two Special Report on Emissions Scenarios (SRES scenarios) – A1B and B1, and perfect mitigation (reference scenario). It was estimated that by 2020, between 75 and 250 million people are projected to be affected by water shortages due to climate change. Also in some countries, yields from rain-fed agriculture could be reduced by up to 50 per cent. Agricultural production, including access to food, in many African countries is projected to be severely compromised. This would have a further adverse effect on the supply of food and would exacerbate malnutrition *(IPCC, 2007*). Towards the end of the 21st century, projected sea level rise will affect low-lying coastal areas with large populations. The cost of adaptation could amount to at least 5 to 10 per cent of gross domestic product (GDP). But by 2080, an increase of 5 to 8 per cent of arid and semi-arid land in Africa is projected under a range of climate scenarios (Ludivine et al 2009; IPCC, 2007)

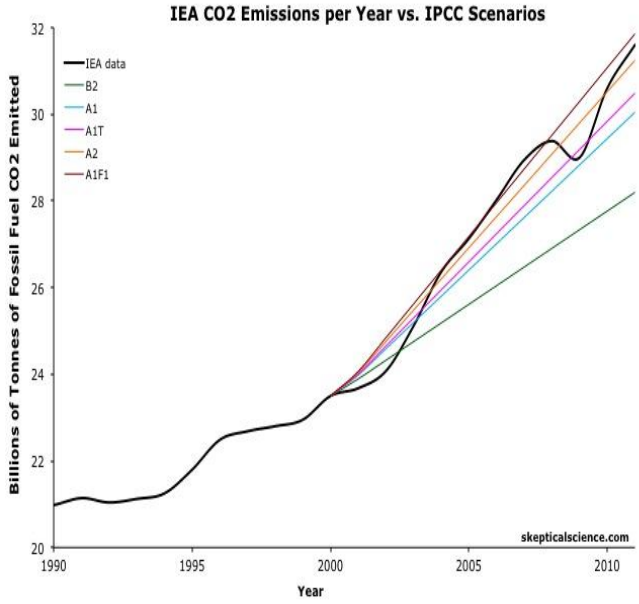


Figure 2: IEA CO2 Emission per year
Source: Wikipedia, the free encyclopaedia

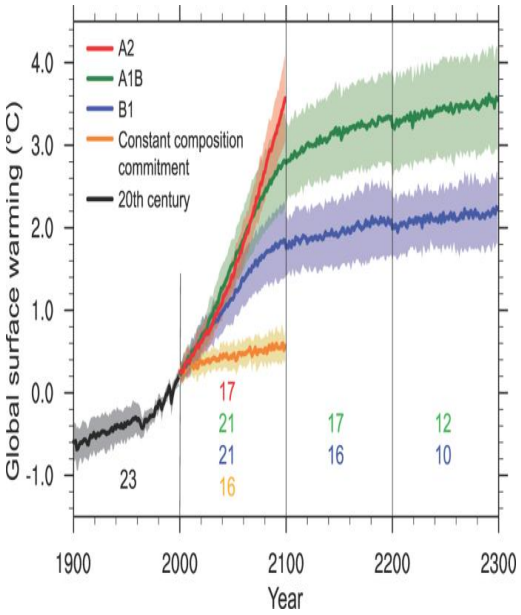


Figure 3: Global surface temperature
Source: Meehl, et al. (2007); *IPCC. 2007*

As climatic patterns change, so also do the spatial distribution of agro-ecological zones, habitats, distribution patterns of plant diseases and pests, fish populations and ocean circulation patterns which can have significant impacts on agriculture and food production (FAO, 2007; Igbokwe and Mkpado, 2011)). Increased intensity and frequency of storms, drought and flooding, altered hydrological cycles and precipitation variance have implications for future food availability. The potential impacts on rain-fed agriculture *vis-à-vis* irrigated systems are still not well understood (FAO, 2007). The developing world already contends with chronic food problems. Climate change presents yet another significant challenge to be met. While overall food production may not be threatened, those least able to cope will likely bear additional adverse impacts (WRI, 2005). The estimate for Africa is that 25–42 percent of species habitats could be lost, affecting both food and non-food crops. Habitat change is already underway in some areas, leading to species range shifts, changes in plant diversity which includes indigenous foods and plant-based medicines (McClean *et al.*, 2005). In developing countries, 11

percent of arable land could be affected by climate change, including a reduction of cereal production in up to 65 countries, about 16 percent of agricultural GDP (FAO Committee on Food Security, Report of 31st Session, 2005). Changes in ocean circulation patterns, such as the Atlantic conveyor belt, may affect fish populations and the aquatic food web as species seek conditions suitable for their lifecycle. Higher ocean acidity (resulting from carbon dioxide absorption from the atmosphere) could affect the marine environment through deficiency in calcium carbonate, affecting shelled organisms and coral reefs.

The resilience of many ecosystems is likely to be exceeded this century by an unprecedented combination of climate change, associated disturbances (such as flooding, drought, wildfire, insects, ocean acidification) and other global change drivers (such as land use change, pollution, fragmentation of natural systems and overexploitation of resources). Approximately 20 to 30% of plant and animal species assessed so far are likely to be at increased risk of extinction if increases in global average temperature exceed 1.5 to 2.5°C. For increases in global average temperature exceeding 1.5 to 2.5°C and in concomitant atmospheric CO_2 concentrations, there are projected to be major changes in ecosystem structure and function, species' ecological interactions and shifts in species' geographical ranges, with predominantly negative consequences for biodiversity and ecosystem goods and services, e.g. water and food supply (Bates,et al 2008, IPCC, 2007). Crop productivity is projected to increase slightly at mid- to high latitudes for local mean temperature increases of up to 1 to 3°C depending on the crop, and then decrease beyond that in some regions. At lower latitudes, especially in seasonally dry and tropical regions, crop productivity is projected to decrease for even small local temperature increases (1 to 2°C), which would increase the risk of hunger. Globally, the potential for food production is projected to increase with increases in local average temperature over a range of 1 to 3°C, but above this it is projected to decrease (Bates,et al 2008, IPCC, 2007). Climate change impacts depend on a range of the climate parameters and on a country's social, cultural,

geographical and economic background (Nzeh and Eboh 2011). Building resilience capacity to climate change is related to adaptation and mitigation processes, as well as technologies adaptations rates.

Some Green Technologies for African Agriculture and Energy amidst climate change

The technologies explores includes integrated aquaculture/crop/energy production system; such as fish production integrated with renewable energy derived from waste-to-energy plant, fish production integrated with irrigation of biofuel plantations or food crop production. Drip irrigation is not only for food crops but also for plantation crops. A few green house technologies such as 'aeroponics' for growing potatoes and Sweat water green house for vegetables were included.

The basic principles of integrated Fish/poultry/crop/biofuel production systems: Using integrated fish farming and irrigation technology, dual use of water is possible, first for fish production, then for biofuel crops such as sugarcane (or a desirable starch crop). Fish sludge and fish processing scarp are used to produce biodiesel or Fish Fluidized Fertilizer in order to increase crop plantation efficiency. Bioethanol is an alcohol made by fermenting the sugar components of plant materials and it is made mostly from sugar and starch crops. The model is presented bellow as figure 4 (Aquaculture, 2012).

Advantages of integrated irrigation system include efficient use of water resources, production of animal protein such as eggs and meats; fish and fish products as well as biofuel. This is green technology that has the potential of creating employment, wealth and climate change mitigation.

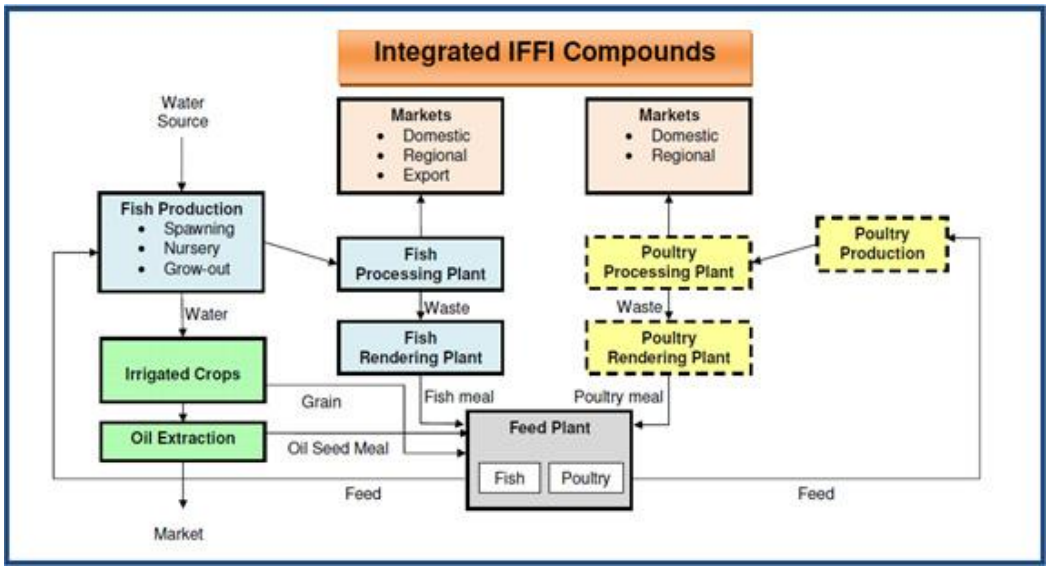


Figure 4: IFFI = integrated fish farming and Irrigation

Source: Aquaculture (2012)

According to Aquaculture, (2012), fish production integrated with renewable energy derived from waste-to-energy plant including integration with intensive irrigation (in greenhouses, in cold climates), and based on:

the energy center providing electricity and waste heat to enable year-round production of fish under any climatic conditions (in closed systems).

the fish production system discharges sludge, and the fish processing plant provides scrap, both converted to liquid fertilizer by the bio-digester, to be used by the greenhouse to improve vegetable production, or to produce biodiesel.

CO_2 emitted in the process of fish respiration can optionally be diverted, as CO_2-rich warm air, into the vegetable greenhouse atmosphere to facilitate photosynthesis at optimal temperatures.

Drip irrigation as mentioned earlier is not only for food crops but also for plantation crops. The application of drip irrigation in plantation crops such as cocoa and oil palm can boast production and increase income derivable from the enterprise. For instant net income derivable from a 20 –hectares irrigation of plantain and banana in Southern Coast of Puerto Rico was $51,780 and $163500 respectively; which were income derived from increase in number of fruit boxes by 6,747 and 18009 respectively (Ricado et al. 1995). In another case, Azhar et al.

(2011) evaluated Daphar Irrigated Plantation in Punjab, Pakistan; they found the project profitable because it has a net present value of Rs 13,302226. 9 with a benefit cost ratio of 1.29. Crops in Africa which can benefit from this type of drip irrigation include cocoa, oil palm, plantain and banana, cotton, soya bean. Drip irrigation on oil palm is one of the technologies that made Malaysia a major palm produce supply to the world market. It is a common knowledge that Malaysia developed their oil palm economy from seedlings derived from Nigeria. But today, Nigerian oil palm economy is still very much less developed and in no way comparable to that of Malaysia which was developed from it.

It can be deduced that the drip irrigation of technology will be economical on relatively large scale farming enterprise. Thus, the small scale farming of about two hectares as currently dominant in Africa (Mkpado, 2012) cannot yield desirable result. Fortunately, sub Saharan Africa has the largest uncultivated arable land. For 2009/2010, sub-Saharan Africa possessed 45.2% (201,546 ha) of the total world uncultivated land; while Latin America and the Caribbean had 27.7% (123,342) and the rest had very negligible proportions (Klaus et al 2011). This is apparently why land grab in Africa is high. Given the abundant land, it is possible for government of different countries in Africa to use their land tenure system to release land for large scale farming.

Green house technologies

Everyone knows that potatoes grow underground. A new technique called 'aeroponics' involving growing potatoes in mid-air (spore February 2008 P.4). Researchers at the International Potato Center (CIP) have developed the system, hanging potato plants on specially adopted frames so that roots and tubers grow suspended in the air, without touching the soil. As a result there is no need to disinfect the soil with harmful chemicals and tubers have a better chance of staying healthy. The frames are covered with black plastic sheets to keep out the light and the plants are sprayed with a solution of nutrients to allow them to

grow. CIP scientists are of the view that the system is adaptable to small scale farmers and it is particularly suitable for producing seed potatoes, since it improves yields and cuts costs. It can be recalled that quality of output mainly depends on quality of seeds.

Trials have shown the method to be up to ten times more effective than conventional seed potato production. Another advantage is that seeds can be harvested at any size users need as growers can watch the development of the potatoes seeds/fruits. Spraying fertilizers directly on the roots allow the growth phase to continue uninterrupted for more 180 days which does not happen with conventional techniques (spore February 2008 P.4). It is suitable for small-scale farmers to produce clean and disease free seeds. Materials needed are small bench, some black plastic sheets, tiny pump, plastic rubbish bin to hold the nutrient solution, some tubing and wiring and switch to turn the pump on and off.

Sweat water green house can be used for farmers in semi arid region of Africa. It is because the greenhouse produces its own fresh water, and uses no fossil fuels or pesticides; its operating costs are 10 to 25 percent less than those of a traditional greenhouse. Its fixed costs are 10 to 15 percent less because it doesn't need to purchase cooling, heating, or desalination equipment, and because it is usually built on cheap land where little can grow (Blogs, 2011)

A seawater greenhouse produces crops year-round in hot dry areas using only seawater and sunlight. Tomatoes, cucumbers, peppers, lettuce, strawberries, herbs—anything that can be grown in traditional greenhouses—can be grown in seawater greenhouses. The award-winning technology, invented by Seawater Greenhouse Ltd. founder Charlie Paton, was inspired by the natural water cycle where seawater heated by the sun evaporates, cools to form clouds, and returns to earth as precipitation.

POSSIBLE STRATEGIES FOR INCUBATION AND DEVELOPMENT

The discussion explored the use of contact farming, value chain financing, Group financing approach, River Basin Authorities, small medium scale enterprises funding and school to land agriculture as well as restructured farm settlement scheme as strategies for incubation and development. These approaches will allow the use of group dynamics which include group formation and management for effective implementation and adoption of the innovations. In order to avoid failure due to human elements, there is need to have a sound reorientation programme and motivation packages of existing and new staff towards achievement of the goals. The participants will have to note that they are not just working to earn a living nut to contribute to preservation and conservation of natural resources for the future generations.

Contract farming is an arrangement between farmers and organization to produce certain crops. In some cases the organizations facilitate farmers' activities by providing critical inputs. Contract farming has been expanded in Uganda due to the promotional efforts of various actors namely private, public, and/or international aid agencies (agribusiness firms included (Nile Breweries Limited, Mukwano Industries, and Tilda Limited), their agents, and support organizations). It has aided the commercialization of smallholder agriculture in Uganda by using sunflower, sorghum, and rice (Wiegratz et al., 2007; Nalukenge, 2005a&b; and Tulip and Ton, 2002). Contract farming can be used to incubate and develop green technologies such as drip irrigation for cash crop production and or green house technology facilities. The facilitating organizations can provide the facilities which the farmers will put to good use.

National Directorate of Employment (NDE) was was established in Nigeria to pursue employment policy of the Federal Government of Nigeria. It has established a new agricultural program for youth employment to complement the

existing employment opportunities. It can integrate school to land agriculture. The school to land agricultural programme offers employment opportunities to young agricultural graduates who are passionate about their profession. Arrangements can be made with institutions of higher learning in agriculture to recommend graduates who will use their certificate and institutional reputation as collaterals to access the facilities and fund for incubation and development of the green technologies. In Botswana, South African Region, the school enterprise programme is offering graduates especially those in faculties of agriculture opportunities to access funds and other resources to practice what they have learned (Aganga, 2012). In fact, employment opportunities and wealth must have been created through this medium.

Whither value chain financing?

Cash flow problems rank as one of the major obstacles for smallholders to increasing investment, adding values to products and obtaining higher revenues from sales. But value chain financing deals with this type of problem because the approach involves linking specialised financial institutions to the value chain so they can offer services that build on business relations until the objectives are accomplished (Spore, 2010). Agricultural Development Fund (ADF) is another facility that be used for this purpose. The National Agricultural Development Fund can provide the necessary impetus for the sustainable development of the agricultural sector. It will support both public and private sectors in carrying out activities that will boost agricultural and rural development, with an emphasis on the green technologies. The ADF can take advantages of the Nigeria Agricultural, Cooperatives and Rural Development Bank (NACRDB). This could offer opportunities of improved funding for the programmes.

Another funding source is the Small and Medium Enterprises Equity Investment Scheme. The Small and Medium Enterprises Equity Investment scheme is a

voluntary initiative of the Bankers' Committee approved at its 246th Meeting held on 21st December, 1999. The initiative was in response to the Federal Government's concerns and policy measures for the promotion of Small and Medium Enterprises (SMEs) as vehicles for rapid industrialisation, sustainable economic development, poverty alleviation and employment generation (CBN 2008). The Scheme requires all banks in Nigeria to set aside ten (10) percent of their profit after tax (PAT) for equity investment and promotion of small and medium enterprises. The 10% of the profit after tax (PAT) to be set aside annually shall be invested in small and medium enterprises as the banking industry's contribution to the Federal Government's efforts towards stimulating economic growth, developing local technology and generating employment(CBN 2008). The funding to be provided under the scheme shall be in the form of equity investment in eligible enterprises and or loans at single digit interest rate in order to reduce the burden of interest and other financial charges under normal bank lending, as well as provide financial, advisory, technical and managerial support from the banking industry. Every legal business activity is covered under the Scheme with the exception of trading/merchandising and financial services.

On a small scale level, the funding arrangement can adopt Self Help Group approach. The Self-Help Group Linkage programme was launched under the Agricultural Credit Guarantee Scheme (ACGS) in 1991 and became operational in 1992. Under the programme, farmers are encouraged to form themselves into groups of between 5 and 15 on the basis of common purpose (informal and informal). The groups are encouraged to undertake regular savings with a partner bank of their choice. After operating such savings for six months, they could then apply to the partner bank for loan. The amount saved provides part cash security for loans to saving groups (CBN 2008). This funding arrangement can take the form of Value chain finance. Like large producers and traders, small-scale producers also need access to appropriate financial services to get the

most out of the products they have to offer. Cash flow problems rank as one of the major obstacles for smallholders to increasing investment, adding values to products and obtaining higher revenues from sales. Farmers want to be paid immediately, but traders do not have the ready cash to buy their produce. Traders need working capital so they can buy and transport produce, but lack the collateral to get loans. Processors cannot get the money they need to buy equipment or ensure a steady supply of inputs. These difficulties are compounded by the reluctance of most banks and microfinance institutions to become involved in rural finance, perceiving it as risky and costly, with cash flow requirements that are irregular and difficult to manage. Value chain finance can offer solutions to such dilemmas. This approach involves linking specialised financial institutions to the value chain so they can offer services that build on business relations. A bank may loan money to a trader because the trader has a regular supply of produce from a farmers' group and a supermarket as a loyal customer. With examples to show how this innovative system can work in practice, chapters include financing rice farming in Rwanda, financing the honey chain in Kitui, eastern Kenya and the soybean value chain in Ethiopia (Spore, 2010). This value chain approach will enable framers to gain the most benefits from their products.

River Basin Authorities

The Federal Government of Nigeria establishment River Basin Authorities in 1976 and charged with the following functions: (a) to undertake comprehensive development of both surface and underground water resources for multi-purpose use; (b) to provide water from reservoirs and lakes under the control of the Authority for irrigation purposes to farmers and recognized association as well as for urban water supply Authority concerned; (e) the control of pollution in rivers, lakes, lagoons, and creeks in Authority's area in accordance with nationally laid standards; (f) to resettle persons affected by the works and schemes specified under special resettlement schemes; (g) to develop fishes and improve navigation

on the rivers, lakes, reservoirs, lagoons and creeks in the authority's area; to undertake the mechanical clearing and cultivation of land for the production of crops and livestock etc. (i) to undertake large-scale multiplication of improved seeds, live stock and tree seedlings for distribution to farmers and for afforestation schemes; (j) to process crops, livestock products and fish produced by farmers in the authority's area in partnership with state agencies and any other person; (k) to assist the state and local governments in the implementation of rural development works (construction of small dams, provision of power for rural electrification schemes, establishment of grazing reserves, training of staff) in the Authority's areas (Akindele and Adebo, 2004) . The network of eleven RBDAs established in 1977 still remains the major institution for water resource development and irrigation in Nigeria. However, the RBDAs were partially commercialized in 1992 as a result of which some of the subsidy on irrigation water supplied to farmers was removed. Thus the River Basin Authorities can serve as incubation and development centre of the innovation. This can adopt farm settlement scheme with reorientation and motivation packages for the beneficiaries to work efficiently. The use of river basin development authorities will reduce Land tenure constraint/problems because the government usually allocates the land for such projects.

Fadama Community Associations and their member Fadama User Groups

The national Fadama programme is a project for development of agriculture jointly funded by Nigerian Governments and the World Bank (Fadama 2011). The programme has witnessed phase I, II and III. Fadama III's main objective is to support the growth of non-oil sectors through the development of productive infrastructure that will enhance agricultural productivity and the diversification of livelihoods. It involves building participating communities' social capital and their capacity to provide rural services to the poor. It also promotes the socially

inclusive and environmentally sustainable management of natural resources. Fadama III will finance and implement four main components, which are designed to transfer financial and technical resources to the beneficiary groups, the Fadama Community Associations (FCAs): (a) institutional and social capital development, (b) physical infrastructure, (c) income-generation and livelihood improvements, and (d) development and advisory services of production and marketing technologies.

The project will cover up to 20 Local Government Authorities (LGAs) in the states that did not benefit from Fadama II and up to 10 new LGAs in the Fadama II states. Fadama II covered up to 10 LGAs and these LGAs will participate in Fadama III if they fulfil certain performance criteria. Hence there will be a maximum of 20 LGAs in both the Fadama II states and the new Fadama III states. The selection of LGAs for participation in the project was determined prior to the baseline survey. Within each of the LGAs participating in Fadama III, the project invites the formation of Fadama Community Associations or FCAs, which must satisfy certain criteria, including ensuring a degree of minimum representation of women and vulnerable groups. Once these FCAs are formed, a certain number of FCAs are funded as part of Fadama III depending on the budgetary allocation for the corresponding LGA. In these funded FCAs, the full set of project interventions will be implemented (Fadama 2011).

In addition to meeting basic community productive investment needs, a major achievement of Fadama II to date has been to foster social capital formation within rural communities. The project has significantly augmented the community's stock of social capital, especially of the bonding type as indicated by the large number of functioning FCAs and FUGs, and adhering to the principles of inclusion and to basic minimum democratic transparency and accountability norms. The project's focus on the poor, intensive facilitation and capacity building efforts, and extensive use of the network of Facilitators for social mobilization and

continuous training have contributed to the growth of bonding social capital (Fadama, 2006b).

The apex Fadama Community Associations (FCAs) and their member Fadama User Groups (FUGs) created under the project have generally performed well. Presently, a total of 1,470 FCAs have been formed across the states under Fadama II, with over 11,968 FUGs consisting of 217,210 members spread across gender lines. Some of the associations assisted their members in the purchase of inputs (inorganic fertilizer and credit, and, until the projects Mid-Term Review, in obtaining title to land). The social groupings have improved internal re-engineering in the communities and also engender healthy competition among groups and communities for efficiency and effectiveness of subproject execution. With capacity building and access to advisory activities, the FCAs now participate actively in project management, monitoring and evaluation. In all communities, several committees (including management, procurement, monitoring and evaluation, maintenance and environmental screening) have been developed and are operational. A culture of paying of counterpart contributions (through cash, materials or labor) has been developed and the LDP preparation process has integrated the principles of transparency and inclusion and significantly improved group cohesion. Also the communities are learning good governance by adopting a system of peer pressure and oversight to ensure integrity of funds flow at the community level (Fadama 2006b). Thus, the Fadama programme can be used to incubate and development the innovations.

CONCLUSION

Green technologies for African agriculture and energy production can be a reality. African development in agriculture along the roots science technology and innovations (STI) is not only desirable but achievable. The paper has explored some technologies for this agricultural development. Building resilience capacity

to climate change can be achieved through adaptation technologies and mitigation processes. The ongoing call for African agricultural transformation can adopt the approached presented in order to create wealth, alleviate poverty and contribute to climate change mitigation and low carbon energy production. Special emphasis is on use of group dynamics which include group formation and management for effective implementation and adoption of the innovations. Possible reorientation programme and motivation packages of existing and new staff towards achievement of the goals were presented. The adoption of school to land agriculture will enable many youth to be employed. The proposed strategies offer opportunities for practicing privatisation and commercialization of enterprises as well as entrepreneurship and public-private partnerships (PPP) in innovation incubation and development. Africa needs to adequately face the challenges of climate change and now is the time to act.

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