

Reverse Engineering of Agricultural Machinery: A Key to Food Sufficiency in Nigeria

Williams S. Ebhota, Virginia Chika Ebhota, Samuel A. Ilupeju

Abstract—Agriculture employs about three-quarter of Nigeria's workforce and yet food sufficiency is a challenge in the country. This is largely due to poor and outdated pre-harvest and post-harvest farming practices. The land fallow system is still been practised as fertiliser production in the country is grossly inadequate and expensive. The few available post-harvest processing facilities are faced with ageing and are inefficient. Also, use of modern processing equipment is limited by farmers' lack of fund, adequate capacity to operate and maintain modern farming equipment. This paper, therefore, examines key barriers to agricultural products processing equipment in the country. These barriers include over-dependence on foreign technologies and expertise; poor and inadequate manufacturing infrastructure; and lack of political will by political leaders; lack of funds; and lack of adequate technical skills. This paper, however, sees the increase in the domestic manufacturing of pre-harvest and post-harvest machinery and equipment through reverse engineering approach as a key to food production sufficiency in Nigeria.

Keywords—Agricultural machinery, domestic manufacturing, forward engineering, production reverse engineering, technology.

I. INTRODUCTION

AGRICULTURE is a key to accelerated economic growth and an enhanced standard of living of the citizenry. This sector has a lot of challenges in developing countries of Africa with Nigeria inclusive. Food insufficiency is a common trait to countries of Africa and a major issue in Nigeria. Globally, agricultural sector is a priority in national planning and national annual budget as food sufficiency is a measure of the economic development of a given country [1].

Despite the fact that Nigeria is massively endowed with agricultural resources, the country's agricultural sector has been growing at a very low rate. Less than 50% of cultivable agricultural land in the country is cultivated. The greater part of the cultivated land is based on smallholder and farmers use of traditional and rudimentary production techniques which lowers yields [1]. In addition, the farming system is monotonous, boring and uninteresting. The slow growth of food production results in growing food insecurity and food imports. Most households in Nigeria spend up to 70% of their income on food and yet close to 50% of the children less than five years are malnourished [2]. The amount of the total food

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imported into the country from 1990–2011 was about 74,487.37 USD and the average food imported per day was put at about 9.28 USD [3]. Nigeria imported agricultural produce worth of N630 billion in 2012 and the country is ranked number one importer of rice globally, former Nigeria President, Goodluck Jonathan revealed [4]. Apart from rice importation, wheat, sugar, fish and poultry products are equally imported to Nigeria massively.

II. AGRICULTURAL PRODUCTIVITY IMPEDING FACTORS

The barriers that impede the growth of agricultural production in this country can be classified into technological constraints, environmental, sociocultural and socio-political barriers.

A. Technological Constraints

Use of Traditional Method

The structure and methods of production for the past four decades (over 40 years of independence) have relatively remained the same. Over 90% of Nigerian farmers still depend on cutlasses, holes and sticks for pre-harvest operations and sell their farm produce without post-harvest process [5], [6]. This is the foremost barrier to agricultural sector growth. The farming population is made up of small-scale, subsistence peasants, farming on an average about two hectares of land and usually on scattered holdings. Farming activities are also carried out mainly with traditional, rudimentary technology consisting mainly of hoes and cutlasses, as shown in Table I.

TABLE I
ESTIMATES OF AREAS UNDER DIFFERENT POWER SOURCES IN NORTHERN STATES OF NIGERIA [5]

	Power sources		
	Hoe	Animal	Tractor
Number of farmers (million)	7.5	0.1	0.015
Size of land cultivated (ha/farmer/yr)	1.0	5.0	50.0
Annual total area cultivated (million ha)	7.5	0.5	0.75
Total area percentage (%)	86.0	5.5	8.5

Poor Storage Facilities

Presently, the available storage technology is grossly inadequate and not complimenting the efforts of the small holders to carter for their produce during season. The annual crop loss is about 20% of the harvest and this is a huge loss. This challenge should be of concern to all the stakeholders in the sector; from research scientists, engineers to the extension workers in the field to the farmers on the farm and to the government policy formulators [7].

Poor Post Process Facilities

A wide range of agricultural products found in formal markets requires post-harvest processing and this makes processing facilities equipment relevant in agricultural sector. Consequently, this creates a lot of business opportunities for local manufacturers of agro-allied processing machines (both "pre" and "post" harvest machinery). Domestic agricultural equipment production is pivotal to food sufficiency production and national food security [8]. Every region in Nigeria is blessed with different economic endowments such as cultivable soil, solid minerals, and crude oil. These endowments remain economically useless (with exception of few) if additional values in form of post-harvest operation are not added. Capacity constraint in manufacturing, due to poor infrastructure, is a key limiting factor threatening agricultural growth and food security in Nigeria. The endowments become less economical and worthless, in some cases they are taken away cheaply when there is insufficient post-process operation. The discovery of crude oil in Nigeria contributed to the dwindling and abandoning of agriculture sector by many people [9].

B. Sociocultural and Socio-Political Barriers

Non-Involvement of Elites

The small-scale farmers' low level of education, particularly women who form the majority of the agricultural labour force has remained a major challenge to the adoption of modern farming techniques and the ability to access other inputs necessary for increase productivity in the sector.

Inadequate Government Policy and Lack of Government Political Will

Nigeria returned to democracy in 1999 and the government then itemised various factors that are hindering national economic growth. These barriers include mono-economy (reliance on only oil), inadequate manufacturing infrastructure, agricultural neglect and over dependence on foreign products [8]. As a result, the government came up with a policy to make the development of agriculture a priority to tackle poverty, improve standard of living and boost the economy. In this policy, there were plans for new technology, improved seedlings, better storage facilities and access to funds at reduced lending rates. Also, it was reported that the government would diversify the economy, move the country away from mono-economy and an import dependent country. Subsequently, there were plans of incentives and encouragement for agro-allied industries development under small and medium-scale enterprises (SME) act [10], [11]. However, the same government failed to show sincere commitment in the policy implementation. Consequently, billions of naira was reportedly spent and insignificant achievement was recorded.

Over Dependence on Petroleum

Before Nigeria got her independence in 1960, agriculture was the main source of income for the country (more than three-quarter of export earnings) which accounted for more

than one-half of gross domestic product (GDP) [12], [13]. In Nigeria, agriculture provides food, employs nearly three-quarter of Nigeria's workforce in the rural areas and creates wealth. Agriculture was the main source of foreign exchange and mainstay of the Nigeria economy before independence in 1960 and in the 1970s. This shows the status and relevance of this sector to the Nigerian economy before the discovery and the subsequent exploitation of oil in commercial quantity at Oloibiri in 1956 and 1958 respectively [14]. This relevance has since been overtaken by crude oil exports, which presently accounts for over 90% of export earnings [2]. The country has made huge earning from the export and sales of crude oil but this enormous revenue profile has not impacted on lives positively, coupled with the abandonment of other sources of revenue earnings to the country.

Neglect of Agricultural Research Institutes

Political and institutional instability is a factor that has affected the management and performance of Nigeria agricultural research institutes, established to assist farmers and to develop new ways of finding solution to agro-related problems. These institutions are grossly under coordinated and underfunded.

Instability of Government Policy

The drawback in public policy was the absence of long-term consistency and predictability. Successive government neglected and failed to implement previous policy strategies and instead established new ones. Examples of previous agricultural policies are Operation Feed the Nation (1976), the Green Revolution (1980), Directorate of Food, Roads and Rural Infrastructures (1986), fertilizer subsidies removal in Mid 1990's, 25% fertilizer subsidies restoration between 1999 and 2000 and Cassava Initiative (2002) [8].

Population Factor

Agricultural production and population growths are not proportionate. Oyewole and Oloko reported that since 1980, the population of Africa has risen by 53% while food production increased by 45% [7].

Insecurity

Many farmers that live in the rural areas in the northern part of Nigeria have abandoned farming and relocated for safety due Boko Haram insurgence. In 2012, National Emergency Management Agency (NEMA) reported that Boko Haram insurgency and disasters in the North-East may lead to famine because most of the small-scale farmers and big-time farmers in the North are threatened by the Boko Haram activities. Over 65% of the farmers have already migrated to the southern parts of Nigeria due to insecurity to human lives, livestock and farmlands pose by this terrorist group [15].

Environmental Hazards

The challenges of drought/desertification, coupled with soil erosion and oil spillage have remained very serious challenge and threat to Nigerian agriculture. Human activities such as overgrazing, oil exploration, bush burning, over-cultivation,

and deforestation and natural forces are responsible for these problems. Soil degradation and deforestation are some of the ways that the problems often manifest [15].

III. AGRICULTURE AND TECHNOLOGY

Agricultural technology can be categorised into three classes:

- i. Traditional Agricultural Mechanization Technologies
- ii. Draught Animal Technology
- iii. Engine Powered Machinery Technology

For national food sufficiency and sustainability purposes, the drudgery traditional and draught animal agricultural technologies must be advanced to engine powered machinery technology. This means that the subsistence farming system needs to be upgraded to a commercial farming system. Efforts should be geared towards the replacement of human and animal efforts with motorised mechanical and automated systems. This transformation involves the increase of the use of tractors as prime movers and electric based modern harvesting and post-harvest equipment for different farming operations. Some of these equipments are grinders, threshers, aircraft (for spraying), mills, irrigation pumps, and self-propelled machines for production, and various kind of harvesters [16].

A. Manufacturing of Agricultural Machines

Local fabricators in some African countries are still in the "cut and weld" stage of production technology. The peddling of low or substandard machines continues to thrive in the agro-allied market in the continent. Consequently, a reasonable number of the imported machines are not optimised in their operation and in some cases they are not working at all. Most farmers cannot afford farm machines due to the high acquisition and maintenance costs. Mechanisation is a big issue in the small-size farm because it is against the "economies of scale" [1].

Post-harvest processing operations are required in most agricultural products that sold in the formal market. The market for processing machines is of significant economic importance and offers great opportunities for local companies which specialise in the fabrication of agro-allied machinery (both "pre" and "post" harvest machines). A vibrant domestic agro-allied machinery fabrication is pivotal to food security and industrialisation in Nigeria. Local fabrication of agricultural processing equipment will significantly reduce cost production, and downtime and will ultimately increase productivity. These machines include cassava processing equipment (grater, press, dryer, chipper, etc.), rice processing machines (mill, de-stoners, etc.). Other equipment are honey press, maize sheller, hammer mill, plate mill, planters, feed mill mixers, graders, multi-purpose grain thresher, etc. Postharvest operations are needed for storage, breakdown into smaller units for packaging and workable units as source of food and raw material [8].

The development in the agricultural sector that will enhance food security largely depends on modern scientific and technological approach to farming. This includes the use of

machinery in all the sections of agriculture for effective all-encompassing growth in the sector. These types of machinery include general planting process machines (ploughing, tilling, etc. machines), harvesting machines, and post-harvest machines (cassava chipper and grater, juice squeezer, leaf drying machine, yam chipper and pounder, maize Sheller and grater, etc.) [17].

B. Methods of Manufacturing Agricultural Machines: Forward and Reverse

Basically, there are two principal engineering approaches to manufacturing:

- **Forward engineering (FE)** – This is the conventional step of moving from a high-level model of logical abstractions and, implementation-independent designs to the physical implementation of a system.
- **Reverse engineering (RE)** – This could be described as a production process which depends on the understanding of an existing component, device or product either mechanical, electrical or software. The existing product is disassembled, and analysed for the purpose of producing the same thing or something similar without really copying the original [18]. It is the attainment of learning curve from an existing product for the purpose of manufacturing the same or similar product. RE often involves taking components of a product, and analysing the components relations, and other functional properties [19].

IV. RE FOR DOMESTICATION OF FOREIGN TECHNOLOGIES

The application of indigenous technologies has the potential of rapidly making positive sustainable growth in the sector. The local participation should include effective funding and coordination of agricultural research and to disseminate the research results to the farmers who are mostly in the rural areas [9]. Generally, infrastructure plays a critical role in economic development and infrastructure interacts with the economy in multiple and complex ways. Technological advancement is the main thrust of present global competitiveness. To be able to compete, it requires well-articulated and coordinated nation-wide strategy for agricultural development and training of engineering and science personnel [20].

Agricultural machinery problems in Nigeria can be overcome through the building of indigenous capacities in agricultural machinery technologies of both human and manufacturing infrastructure. Domestic development of agricultural machinery will be economically rewarding to Nigeria and her neighbouring countries. Postgraduate academic programmes to compliment the efforts of the various agriculture research institutions can be exploited to develop domestic design and fabrication of agricultural machinery capacities.

Adequate domestic production of agricultural machinery will positively provoke food production and agribusiness. For rapid development of agricultural machinery, RE approach should be the choice in developing economies like Nigeria.

The reason behind this is because of its immense design and production time benefits. Fig. 1 shows the various RE steps for machine production.

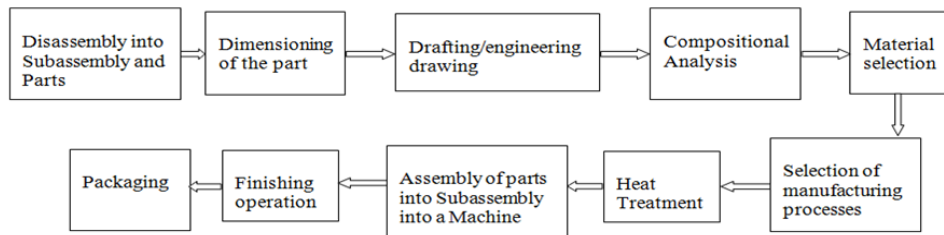


Fig. 1 RE steps for machine production

V. CHALLENGES OF REVERSE ENGINEERING IN NIGERIA AND THE WAY FORWARD

A. Inadequate Functional and Accessible Laboratory

Functional laboratories for basic science and engineering tests and analyses are fundamental for RE to be effective. It is disheartening that the trend in the dynamics of the global technological advancement is not being reflected in Nigeria's research institutions 56 years after independence. The country's research activities are being bedevilled with inadequate research infrastructure, qualified personnel and grossly inadequate funding and support. Technology never thrives in the absence of effective science and engineering R&D [21]. For a viable and dependable R&D, the following factors must be enhanced: R&D skilled personnel, research facilities and equipment, research grant/fund and management of research resources (human and materials). R&D programme should include both generation of new products and production processes [22], [23]. Production industries (especially multinationals) through government policy should be made to contribute and give research grants to institutions. Collaboration between tertiary institutions, manufacturing sector and research institutions should be harnessed and encouraged. This synergy is vital for optimising opportunities and efforts and in keeping up with the ever short technology and innovation cycles [24].

B. Power/Electricity Supply

The Manufacturers Association of Nigeria (MAN), in its MAN Economic Review 2003-2006 has noted poor performances of some sub-sectors. It attributed such low performance to among others, "deficient and depleting state of infrastructure". It further said that the poor performance of the manufacturing sector, especially in relation to its low contribution to GDP and the high cost of production, is attributed mainly to the epileptic and deteriorating power supply to industries [25]. In Nigeria and some other countries of Africa, localized or dedicated electric plants are used to operate agricultural processing plants. This increases the cost power production by 5 if compared to the use of national grid. This adds to the overall cost of production and ultimately the selling price of these machines. Small hydropower that will not be connected to the national grid can be used to develop agricultural industrial estates across the country since the

small hydropower potentials are also spread across the country. This will ensure that there is a regular power supply to agricultural for machinery and post process industries in the various estates.

C. Poor and Uncoordinated Engineering Material Market

There is a very strong correlation between material, manufacturing process and design process. In fact, the design process is strongly controlled by material and production facilities available. It is a common occurrence in Nigeria that the specifications of most structural materials are hardly known and a reasonable number of engineering materials are bought as fairly used popularly called Belgium materials. For instance, the properties of available second hand used medium and high carbon steel materials are very difficult to guarantee. The foundry sector dwindles and lacks adequate attention from the government. The engineering market in Nigeria is predominantly associated with the following issues [24]: Poor standard control, Influx of substandard and fake engineering materials, Poor engineering market directory and nonexistence of well controlled specialised engineering market [9].

D. Advanced Manufacturing Technology (AMT)

No matter the manufacturing approach adopt, apart from the dynamism that exists in technology, globalisation has made the competition stiffer. Manufacturers should know that they are competing with the rest of the world, in whatever agricultural product that they are producing, irrespective of their location. This means, whatever concept that you have, if you do not develop it well, someone else in anywhere can do it better and ship it to your domain for sale. This is one global trend that is killing local manufacturers in Nigeria.

Inadequate manufacturing personnel and infrastructures are major economic growth and sustainability barriers in Nigeria and pose a strong challenge to technological advancement. Consequently, the economic potentials of the abundant natural resources could not be optimally harnessed due to lack of value addition, leading to poverty, unemployment and low standard of living [9]. To compete in the global market, therefore, the cost of production, quality of product and time of delivery must be optimised. The world is already experiencing a sophisticated computer-based design and production system, called, advanced manufacturing technology (AMT). The key advantages of this high-tech manufacturing system are quality, low cost and fast rate of

production which makes products globally competitive. AMT excellence lies in the fact that it has transformed engineering and conventional manufacturing from the era of slow, monotonous and error prone to the era of more convenience, accurate, faster, product consistency and computer-aided machines. This is obvious in virtual manufacturing where an appropriate software is used to design, and modelled a product for simulation, analysis and optimization. These can be carried out in the comfort of the individual's home.

The AMT programme of National Agency for Science and Engineering Infrastructure (NASeni) is very critical in advancing manufacturing of agriculture and production machines. To meet the current agricultural and manufacturing challenges, the scope of the programme needs to be expanded and enhanced adequately. AMT is the key to food sufficiency and technological advancement in Nigeria. Human and infrastructure capacities building through training and acquisition of existing AMT technologies are vital in stimulating domestic technologies participation through RE. This will boost indigenous capacity in AMT equipment design, production, operations and maintenance [24], [26].

E. Government Policies and Decision

Explicating the reasons for the successful and rapid industrialization witnessed in some Asian Countries, Etukudo noted that the protection of the home markets at the early industrialization stage provided Japan, the Republic of Korea and other emerging markets of East Asia a "captive market", which resulted in high profits and allowed domestic companies to make greater investment and learn-by-doing to improve product quality [27]. The government should concentrate on the development of local industries genuinely rather than wooing foreign companies at the expense of local ones.

Nigeria government should as a matter of urgency identify the nation's key areas in manufacturing and strengthens these areas further by any of the following ways:

- Import tariff and other charges reduction on raw materials and services
- Government's technical and financial assistance in acquiring state of the art manufacturing facilities and skills.
- Bound and enforce the importation of goods the nation has the capacity to manufacture.

IV. CONCLUSION

Nigeria is a country rich in agriculture; the country's economy cannot be strong and vibrant without growth in this sector. Agriculture that is a key determinant of national economic growth must be developed consciously to give room for food sufficiency and sustainability. Massive manufacturing infrastructural development and human capacity development in the manufacturing of agricultural machinery through RE should be encouraged by Nigeria government. AMT is indispensable to national technological growth especially the growth of the manufacturing industries in any nation. To have

agricultural machinery that can meet international standards and compete globally, there is need to develop AMT.

REFERENCES

- [1] Faleye T, Adebija J. A. and Farounbi A. J. (2012). Improving Small-Farm Productivity through Appropriate Machinery in Nigeria. International Research Journal of Agricultural Science and Soil Science. (ISSN: 2251-0044) Vol. 2(9) pp. 386-389
- [2] Emmanuel Ukeje (2004). Modernising Small Holder Agriculture to Ensure Food Security and Gender Empowerment: Issues and Policy.
- [3] Vaughan Ignatius Olusoji, Afolami Carolyn Afolake and Oyekale Tolulope Olayemi, (2014). An Analysis of Nigeria Food Imports and Bills. International Journal of Economics, Commerce and Management Vol. II, Issue 9
- [4] Sunday Michael Ogwu (2013). 'Nigeria Imported Food Items worth N630bn in 2012'. Daily Trust Published on Wednesday, 11 September 2013.
- [5] Ajav E. A. (2000). Animal Tractor as a source of power for Agricultural Development in Nigeria. <http://www.atnesa.org>
- [6] Azogu I. I. (2009). Promoting Appropriate Mechanization Technologies for Improved Agricultural Productivity in Nigeria: The Role of the National Centre for Agricultural Mechanization. Journal of Agricultural Engineering and Technology (JAET), Volume 17 (No. 2) December 2009.
- [7] Oyewole B.A. and Oloko S A (2006). Agricultural and Food Losses in Nigeria – the Way Out. Forum for Agricultural Risk Management in Development. <http://www.vri-online.org.uk/ijrs/April2006/Nigeria%20-%20the%20way%20out.pdf>. Retrieved 5/10/2016
- [8] Omobowale Mobolaji O (2010). Problems facing Local Manufacturers in the Nigerian Agro-Allied Machine Fabrication Industry. ATDF Journal Volume 7, Issue 3/4 2010
- [9] Ebhota, W. S. and Ajuwa, C. (2012). Infrastructural Capacity Development in Manufacturing: A Key to Industrial Explosion in Nigeria. Nigerian Institute of Industrial Engineers (EIIE), 2012 International Conference, Benin City.
- [10] National Orientation and Public Affairs (1999). "Nigerian Economic Policy (1999-2003)"- Federal Ministry of Information and National Orientation, Abuja.
- [11] Adelaja A.O. (2000): The Importance of Small and Medium Scale Industries in a Developing/Underdeveloped Economy: Nigeria as a Case Study; Proceedings of 6th Africa-USA International Conference on Manufacturing Technology.
- [12] Linda, V.B. (2001). Economy: Africa South of the Sahara. 30th Edition (London: Europe Publications) pp 876-904.
- [13] I. Oji-Okoru, "Analysis of the Contribution of Agricultural Sector on the Nigerian Economic Development," World Review of Business Research, vol. 1, pp. 190-200, 2011.
- [14] Robert O. Dode (2012). Nigeria, Mono-Product Economy and the Global Economic Recession: Problems and Prospects. Global Journal of Human Social Science Sociology, Economics & Political Science, 12(11-C)
- [15] Emmanuel Mayah (2012). Boko Haram Terror War: Food Scarcity Looms in Nigeria. Africa Review. April 1, 2012. [Http://Www.Africareview.Com/Special-Reports/Boko-Harams-Food-Threat/-/979182/1377876/-/7v1v8kz/-/Index.Html](http://www.Africareview.com/Special-Reports/Boko-Harams-Food-Threat/-/979182/1377876/-/7v1v8kz/-/Index.Html).
- [16] Onwualu, A. P, C. O. Akubuo and I. E. Ahaneku (2006). Fundamentals of Engineering for Agriculture. Immaculate publications limited, Ogui N/L, Enugu, Nigeria.
- [17] Hahn S. K. (14/11/2016). An Overview of Traditional Processing and Utilization of Cassava in Africa. Available: <http://www.fao.org/wairdocs/LLRI/x5458E/x5458e05.htm>
- [18] Rouse M. (2007). Reverse Engineering. Available: <http://searchsoftwarequality.techtarget.com/definition/reverse-engineering>
- [19] Shooter, S. (2008). Reverse Engineering to Design Forward: An Introduction to Engineering Experiential Learning Module with Video Podcasts. Paper presented at 2008 Annual Conference & Exposition, Pittsburgh, Pennsylvania. <https://peer.asee.org/3716>
- [20] Mbonu O. J. 2000, Practical Training of Engineering Personnel–Challenges Ahead. Proceedings of COREN 10th Engineering Assembly, Abuja, Nigeria, pp30-36

- [21] Paul, N. (2015). Research in Tertiary Institutions in Nigeria: Issues, Challenges And Prospects: Implication for Educational Managers. IOSR Journal of Humanities and Social Science (IOSR-JHSS), 20(6), 45-49.
- [22] Lucky Osaretin Odi and Samson Imasogie Omofonmwan (2013). Research and Development Initiatives in Nigeria: Challenges and Prospects. Mediterranean Journal of Social Sciences, 20(6)
- [23] Chikwe, C. K., Ogidi, D., Reuben, C., & Nwachukwu, K. (2015). Challenges of Research and Human Capital Development in Nigeria Journal of Education and Practice, 6(28), 44-47
- [24] Ebhota W. S. (2011), "Technical Vocational Education and Training (TVET); A Panacea for Africa Development", National Association of Teachers of Technology (NATT) Conference, Umunze 2011.
- [25] Umar Ibrahim (2008). Analysis of Strategic Factors Affecting the Performance of Small and Medium Industries (SMIs) In Borno State, Nigeria. <http://stclements.edu/grad/Graduma.pdf>
- [26] Naseni. (14/11/2016). Advanced Manufacturing Technology. Available: <http://www.naseni.org/advanced-manufacturing-technology-amt.html>
- [27] Etukudo Akpan (2005). Issues in Privatisation and Restructuring in Sub-Saharan Africa. Retrieved 07/06/2005: http://www.nigerdeltacongress.com/iarticles/issues_in_privatization_and_rest5.htm