Rice-Self Sufficiency and Farmhouseholds: the Role of Climate Change and Technology Response in Nigeria

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Abstract
While the production of rice has shown increasing trend both in area cultivated and output in the last 5 decades, yield appears very low and below the average potential for the major rice producing ecologies. Changes in climate and atmospheric composition can negatively affect food supply at the household level because c**limatic factors are believed to be the strongest elements influencing crop yield.** While Nigeria's government recognizes climate change adaptation as an important developmental issue and the mainstreaming in economic planning begun, there is little evidence of the integration in the National rice development strategy programme. Climatic conditions can be detrimental or beneficial depending on the level of feasible technology and management choices that are in turn mediated by factors related to the biophysical condition of the farmland, financial resources of the farmer, socio cultural, institutions and information technology. Realization of rice self-sufficiency at the household level stands at risk because majority of the farmers are economically, socially and politically alienated.
Keywords: climate change, agriculture, adaptation, technology and food security

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Overview

Climate change induced by the increasing concentration of greenhouse gases in the atmosphere is likely to affect crop yields, agricultural productivity, and food self-sufficiency in rice production through changes in temperature, precipitation and extreme climate conditions such as drought, storms, and flooding. Agricultural technology (AT) plays a central role in mitigating the effect through adjustments that support stable and higher productivity per unit land cultivated. Both AT and CC relate with each other because climate is a major ingredient of agricultural production and motivates autonomous or planned adaptation responses from economic agents seeking to maintain optimum conditions for higher productivity and income. Yet the effectiveness depends on whether it allows "farmers to substitute capital or other inputs for climate in which case the ability of farmers to use AT will result in climate change having less effect on agricultural production". (Mendelsohn et al., 2001). This article focuses on technology at the farm level which involves engaging in production activities that are resistant to temperature stresses as well as activities that make efficient use and take full advantage of the prevailing water and temperature conditions. Also included are crop management practices geared towards ensuring that critical crop growth stages do not coincide with very harsh climatic conditions such as mid-season droughts. (See Loë et al. 2001, Orindi and Eriksen 2005).

AT development in Nigeria involves institutions broadly grouped into developers, disseminators and users. (Mogues et al., (2008) and Bientema and Ayoola (2004)). The developers of technology are the international and national research centers domiciled in Nigeria. The international research center includes international institute for tropical agriculture (IITA), international livestock research institute (ILRI), African rice center (WARDA) and international crop research institute for semi-arid tropics (ICRISAT). The national research centers referred to as NARS consists of 15 agricultural research institutes and a large number of universities in Nigeria that have faculties of agriculture involved in agriculture related research. The government substantially drives technology development through the department of Agricultural Sciences (DAS) of the Federal Ministry of Agriculture; however, much of the technology development is skewed to crops and livestock while soil management, water management, and other natural resources research are negligible. To buttress the lag in certain areas of technology development in Sub-Saharan Africa, Alcadi et al., (2009) points out that the development of varieties adaptable to drought, heat, flood and salinity is generally slower than disease- and pest- resistant varieties. In terms of diffusion of technology, the government also leads using the state agricultural development programme (ADPs). ADPs are state-level parastatals involved in establishing demonstration farms, identifying lead farmers, providing lead farmers with information about improved farming practices, facilitating access to improved technology and inputs and helping lead farmers teach other farmers. Also act as implementing agencies for agricultural technology diffusion projects funded by the federal government and the international donor agencies. There are few private sector participants.

If improved technologies are developed; but farmers are not able to access them, demand side problem becomes an issue. Although climate change adaptation is recognised in Nigeria's development programmes and mainstreaming plans already begun, many policy analysts are of the opinion that policy statements declaring government's intensions are not new and the major limitation is whether appropriate mechanisms are put in place to ensure that the poorest farmers benefit from government's plan. While previous studies have addressed the role of policy and markets, little is known about how climate change will interact with these factors to influence farmers' technology response in the twenty first century. The aim of this article is to synthesize ideas about how farmers might be included or excluded in the promotion of adaptation programmes at the farm level. To understand the aim, the article is divided into sub-sections. In the first section, the policy and institutional framework for rice development is examined followed by the implication on rice self-sufficiency. A conceptualization of climate change and adaptation in agriculture in relation to self-sufficiency in rice is developed and finally the determinants of adaptation are examined.

Policy and institutional framework context

The United Nations framework convention on climate change (UNFCCC) to which Nigeria is signatory to and adopted at the Rio Earth Summit in Brazil in 1992, aims to achieve stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent anthropogenic interference with the climate system. The convention specifies that all SSA countries are to pursue adaptation programme and embraced it economic planning and development. Examples include vulnerability assessment, prioritization of actions, financial needs assessment, capacity building and response strategies. (Odingo, 2008: p18). Several follow up plans have come on board in Nigeria such as the existence of a draft national adaptation plan of action. Thus Nigeria's government recognises climate change adaptation as a developmental problem. Yet there is little evidence of the integration of climate change adaptation process in the National rice development strategy programme. According to Odingo(2008:p16) "Any economic assumptions which have so far being made omitting the likely impacts of anthropogenic climate change will need to be revised". Although in the rice development programme, there is provision for making some technologies like fertilizer, seeds available to farmers, a general consensus amongst policy analysts is that policy statements declaring government's intensions are not new and the major limitation is whether appropriate mechanisms are put into place to ensure that the poorest farmers benefit from government's plan. It is noted that the mechanism of access and utilization is not clear in the programme.

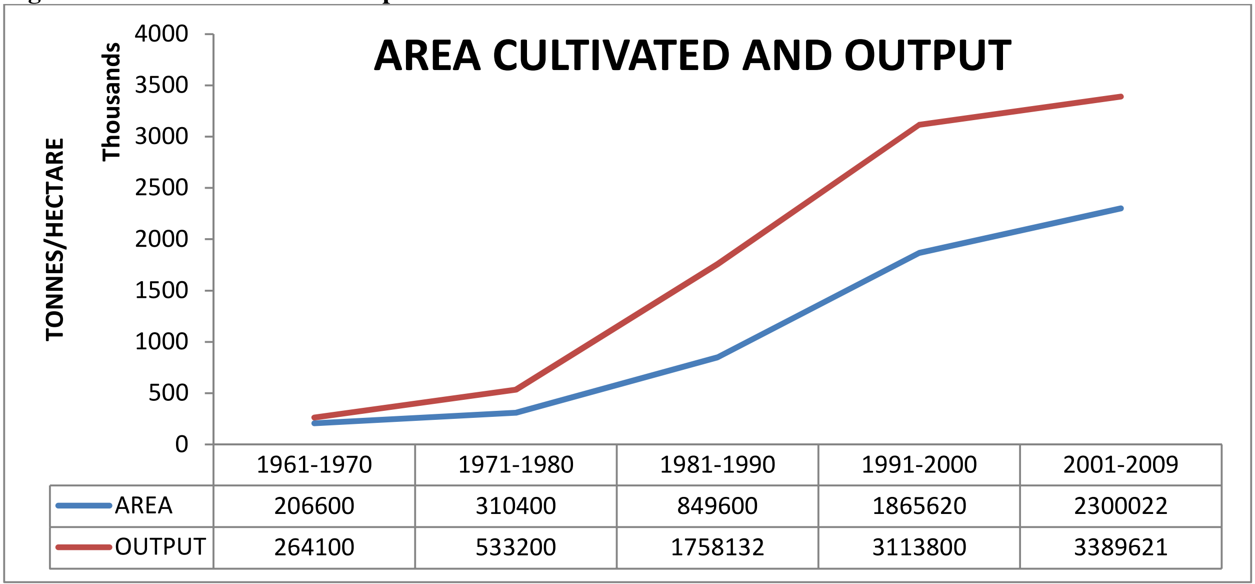
Rice development falls under the broader National food security policy as contained in the National Food Security Programme (NFSP) document released in August 2008. The objective is to ensure sustainable access, availability and affordability of quality food to all Nigerians and for Nigeria to become a significant net provider of food to the global community. Rice is listed as the second food security strategic commodity. Other supporting policy documents include the New Agricultural Policy Thrust (NAP) of 2001 and Vision 2020. NAP was adopted in March 2002 and the main objectives include: attainment of self-sufficiency in basic food commodities with particular reference to those which consume considerable shares of Nigeria's foreign exchange and for which the country has comparative advantage in local production; increase in production and processing of agricultural raw-materials to meet the growth of an expanding industrial sector.

Motivating the National rice development strategy (NRDS) is the observed burden of high import bill on imported rice and the crowding out of local initiative. Secondly while the Presidential Initiative on rice implemented from 2001 to 2007 spurred a 4.5% increase in paddy it is argued that not much was achieve (interreseaux, 2010). Thus in 2009, NRDS was set up with the same self-sufficiency goal. It is expected to boost rice production from 3.4 million tonnes to 12.8 million tonnes in 2018. The three priority areas of focus include (i) improving post-harvest processing and treatment; (ii) developing irrigation and extending cultivated lands; and (iii) making seed, fertiliser and farming equipment more readily available. Other key measures include subsidies for inputs (50% for seed and 25% for fertiliser) and reduced custom tariffs on imports of agricultural machinery such as tractors, and on processing equipment. (NRDS/FGN, 2009). Beyond public driven initiatives is the emerging private initiative that includes multinational corporations contractual arrangements whereby farmers are given inputs and ready markets in exchange for high-quality paddy and white rice. (Interreseaux development rural, 2010)

Nigeria's rice food Sub-Sector and the drive for self sufficiency

Rice is a strategic food security commodity in Nigeria produced in virtually all of Nigeria's agro-ecological zones, from the mangrove and swampy ecologies of the River Niger delta in the coastal areas to the dry zones of the Sahel in the north. More than 90% of rice is produced by resource poor small-scale farmers and about 95% of processors are small-scale using low capacity and obsolete mills. (NRDS/FGN, 2009: 1). Farm size scale ranges from 1.1 to 5 ha while only an insignificant percentage cultivate between 5.1 – 10 ha. The land mass used for rice cultivation increased from 150,000 hectares in the 1960s to about 1.8 million hectares currently. ((NCRI/NBS/NISER/UI (2009). Since the 1960s, production of rice has shown increasing trend both in area cultivated and output as shown in the figure 1 below.

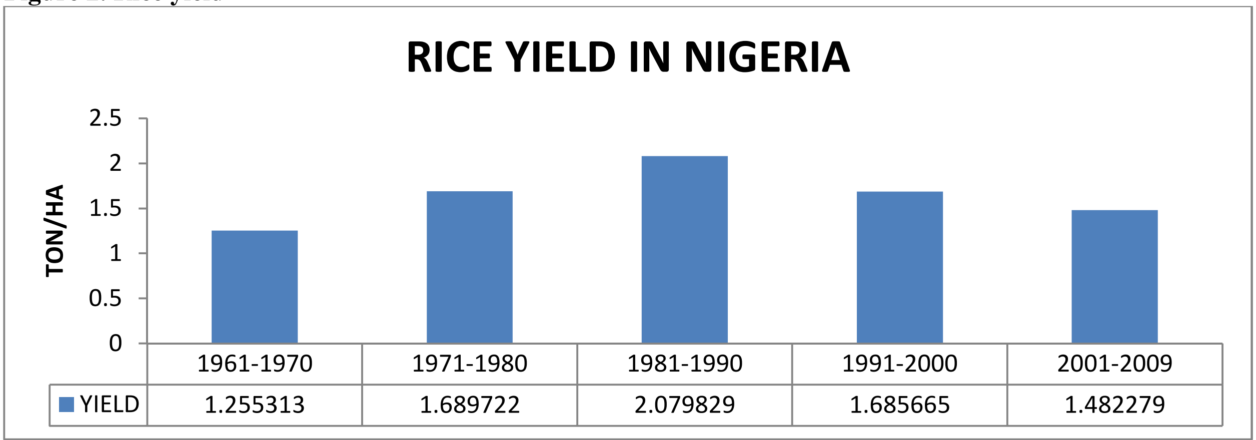
Figure 1. Area cultivated and output



	1961-1970	1971-1980	1981-1990	1991-2000	2001-2009
AREA	206600	310400	849600	1865620	2300022
OUTPUT	264100	533200	1758132	3113800	3389621

Source: Underlying data FAOSTAT (2011)

Figure 2. Rice yield

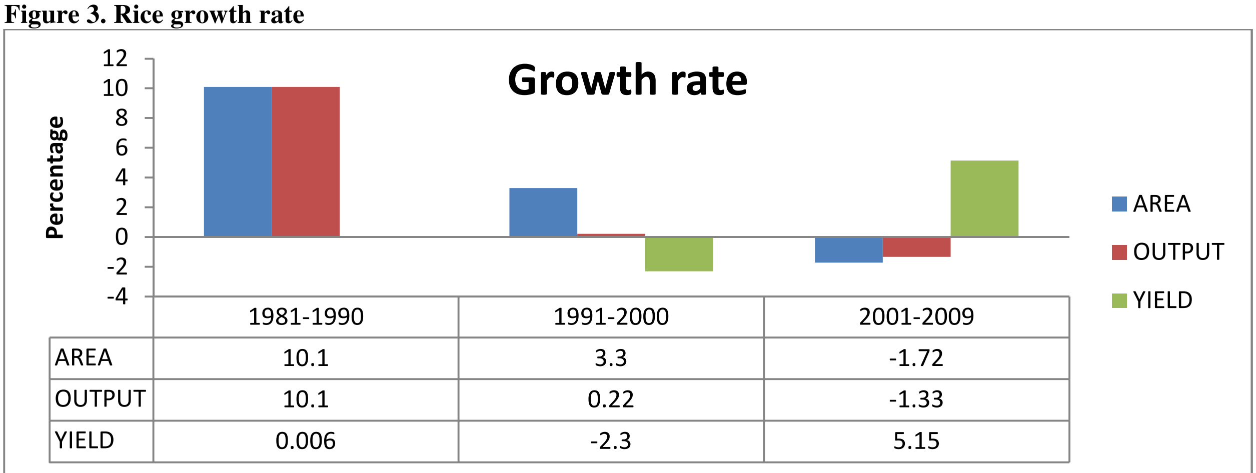


	1961-1970	1971-1980	1981-1990	1991-2000	2001-2009
YIELD	1.255313	1.689722	2.079829	1.685665	1.482279

Source: Underlying data FAOSTAT (2011)

Notwithstanding, as shown in figure 2 above, rice yield appears very low and below the average potential for the major rice producing ecologies. For example average potential for lowland is between 3-6 tonnes/ha and between 2-4 tonnes/ha for upland ecology. As figure 2 shows, yield in rice from 1.2 ton/ha between 1961-1970 periods, peaked during the 1981 – 1990 period at 2 ton/ha and thereafter declined since the 2000s. Also as shown in figure 3 below, growth in production, yield and area cultivated appears unimpressive.

Figure 3. Rice growth rate



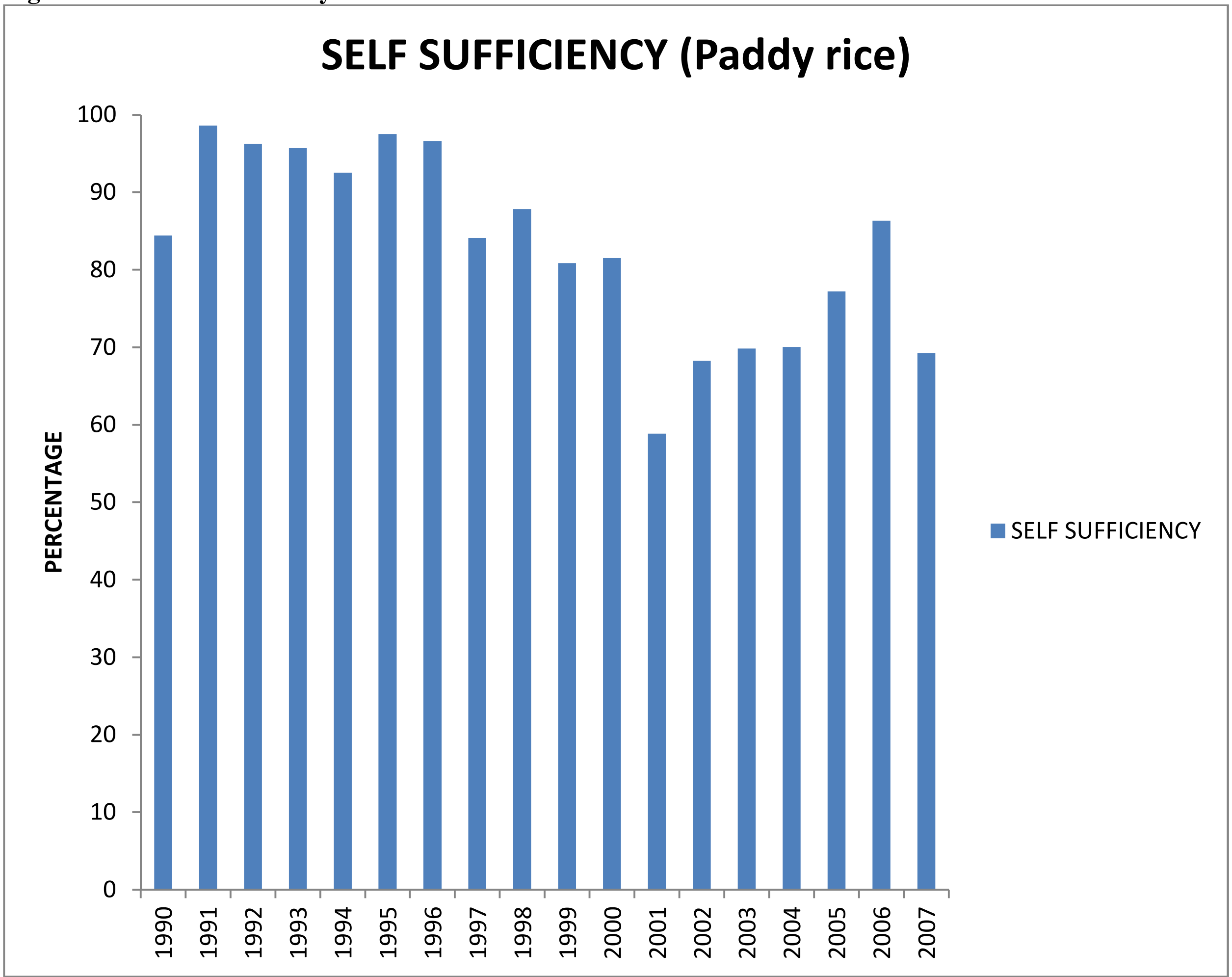
	1981-1990	1991-2000	2001-2009
AREA	10.1	3.3	-1.72
OUTPUT	10.1	0.22	-1.33
YIELD	0.006	-2.3	5.15

Source: Underlying data: FAOSTAT (2011)

Growth in yield was negative for the period 1991-2000. Also that of land area put into rice cultivation and output.

The only significant change is the impressive yield of about 5 tons/ha achieved during the period 2001-2009. At the demand side rice consumption is growing faster than other major staples, with consumption broadening across all socio-economic classes, including the poor. Rising consumption is linked to urbanization and changing patterns of employment. Secondly rice is easier to prepare than other traditional cereals, and fitting more easily in urban lifestyles of rich and poor alike such that rice is no longer a luxury food.(CIDA/World Bank, 2006:). Domestic production is augmented with imported rice. Nigeria's 2007 rice import bill was about $200 million and this significantly increased with the global price hike of 2008. (Liverpool et al, 2009). Thus as shown in figure 4 below computed from most available FOASTAT data, self-sufficiency in rice production declined from 80 percent in 2000 to 75% in 2007.

Figure 4. Rice self-sufficiency



Source: underlying data FAOSTAT, (2011)

Climate change in Agriculture:

Climate simply describes the atmospheric component of the climate system but in a broad sense describes a complex, interactive system comprising the Earth's atmosphere, the Earth's surface, snow and ice, oceans and other bodies of water, as well as people and other living organisms. We follow the narrow definition which ascribes climate to atmospheric properties such as temperature, precipitation and relative humidity. The Intergovernmental Panel on Climate Change (IPCC) defines CC as the change in the state of the climate that can be identified by changes in the mean and /or the variability of its properties and that persists for an extended period typically decades or longer.(IPCC, 2007). Thus closely tied to CC is climate variability which connotes the short term dynamic nature of climate in monthly, seasonal, annual or decadal scales as against CC which connotes long term dynamic nature. **Smith et** al.,(1996: 9&10) puts up two arguments for the case of climate variability and extremes as climate change stimuli in agriculture. First, climate is inherently variable, with or without climate change and agricultural systems, as with other human activities, evolve not in response to average conditions, but in response to variable and largely unpredictable conditions, including occasional extremes. Climate change includes not only long-term changes in average temperature, but also the year-to-year variation in growing season conditions, and the frequency and magnitude of extreme weather events. Also of recognition is that farmers seldom attribute their adaptive actions to climate stimuli but in aggregation with other shocks. Belliveau et al., (2006: 1) points out that climate obviously represents just one of many sources of risk (and opportunity) to which farmers are exposed and respond. Thus in this article the concept of climate change in in agriculture is understood to include climate variability and its extremes and other shocks as perceived by farmers.

Understanding Adaptation:

The degree to which an agricultural system is ultimately vulnerable to long term changes in temperature or precipitation, or changes in the frequency and magnitude of extreme weather events, depends on its adaptive capacity; it is for this reason that the literature on climate change and agriculture has increasingly directed attention to the issue of adaptation (Belliveau et al., 2006: 1). Secondly compared to the large advances in climate mitigation science and policy, the knowledge of adaptation by human and natural systems is weak particularly for developing countries and especially about observed and potential adaptation responses of vulnerable systems and populations such as Africa's agriculture and its rural people.(Hassan, 2010). The definition of adaption varies across disciplines as well as within discipline. From the ecology point of view, adaptation refers to adjustments by which an organism or species becomes fitted to its environment while in social sciences; it refers to adjustments by individuals and the collective behaviour of socioeconomic systems. (Smith et al., 2000)

The Inter-governmental panel on climate change (IPCC) merges these views into one and defines it as the adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities. (IPCC, 2007: p750 chap18). However, practical understanding of adaptation can be seen in the light of three prop-up questions as proposed in Smit and Pilifosova (2001):: "adaptation to what", "who adapts" and "how does it happen" as well as the effectiveess. Adaptation to what can refer to climate change, to change and variability or just to climate. It can be in response to adverse effect or in response to opportunities. Who or what adapts refers to such things as people, social and economic sectors and activities, managed or unmanaged natural or ecological systems, practices, processes or structure of systems. Thus tied to adaptation are propensities such as adaptability, vulnerability, viability, resilience, sensitivity, susceptibility, and flexibility. Also in an attempt to capture the question of how adaptation happens, literature comes out with various attributes and dimensions of adaptation such as reactive or proactive or passive, autonomous or planned, ex ante or ex post, long term or short term.

Adaptation strategy and agricultural technology use in Nigeria

Adaptation options can be seen as interventions put in place in order to manage the losses or take advantage of the opportunities presented by climate change. The distinction among livelihood option, coping options and adaptation options is not too clear in literature, they are often used inter-changeably. Dinar et al., (2008) defined adaptation strategies as measures used beyond a single season that are needed to respond to a new set of evolving conditions (biophysical, social and economic) not previously experienced while coping strategies have evolved over time through people's long experience in dealing with the known and understood natural variation that they expect in seasons combined with their specific responses to the seasons as it unfolds. Nonetheless adaptation options at the macro level consists of broad goals of incorporating and mainstreaming long-term climate change adaptation strategies in agricultural development planning, management and governance while at the micro level consists of different strategies used by farmers. Within the broader perspective of technology use in Nigeria's agriculture, the following technology components are identified in literature.

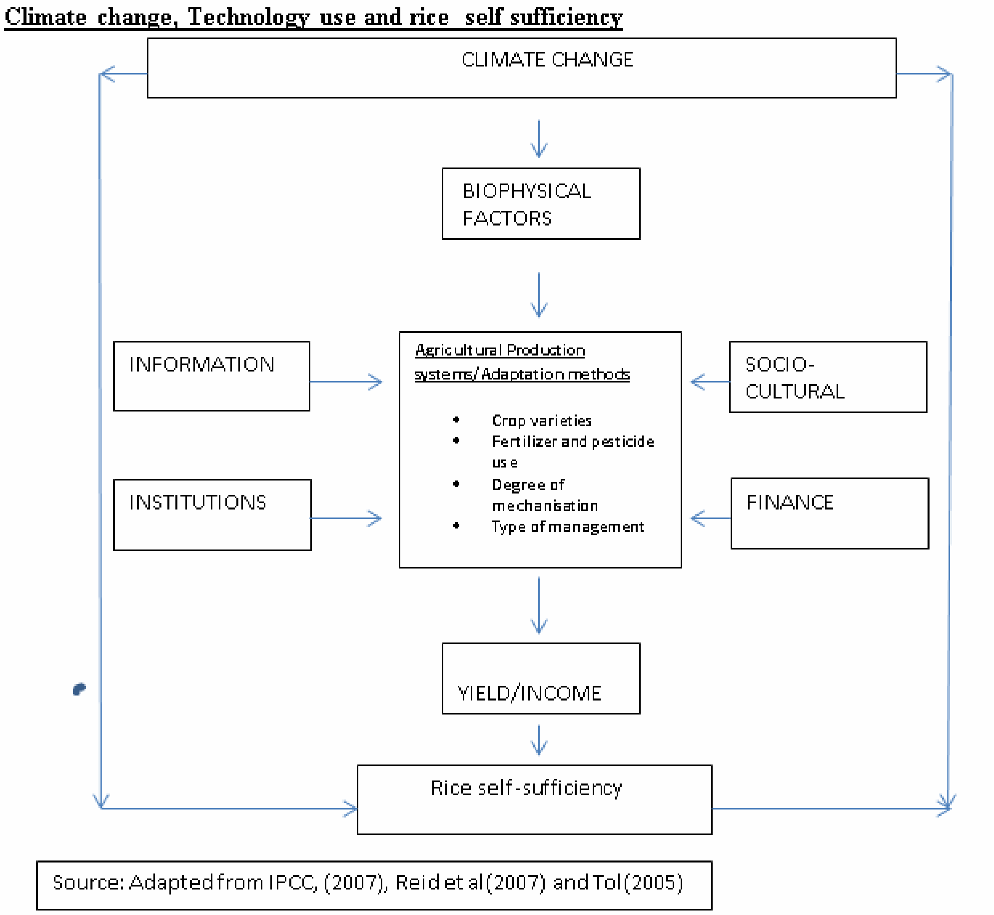
- Irrigation technology;
- Hybrid seed and livestock technologies
- Post-harvest processing and storage technologies;
- Simple mechanical equipment and technologies for soil preparation & seed planting;
- \Livestock feeding and management technologies;
- Information technology.

Irrigation technology: Estimates from the 2010 general household survey reveals less than 10% of plots were irrigated. This is also corroborated by the recent rice survey across rice growing ecological systems in Nigeria where only 3% of farmers cultivating rice actually used irrigation technology. Previous findings reflect a less than 10 percent use of irrigation amongst rice producers (Liverpool et al, 2009). Irrigated agriculture is a technological input and productivity enhancing investment that stands out strongly because of its role in stabilizing yields. It has proven to be effective in increasing food production, reducing poverty and enhancing regional development essential for achieving the millennium development goals. (Sakairi, 2004). **Improved seed varieties:** Much of the seed preference is traditional while the remainder is improved seeds preferred by farmers based on advice from extensions agents. Purchased hybrid seeds lag far behind traditional seeds while access to subsidized seeds is insignificant. Generally there is low use of improved seed by farmers (3-5%), due to inaccessibility and high costs.(NRDS/FGN, 2009: P8). **Storage facilities:** Much of storage facilities is private and traditional such as village granaries, according to Akinyosoye (2005: p431) 85% of national food output is held by the private sector. This includes the small scale farmers, medium scale, large scale, processors and merchants. 15% of national food storage is held as public stock. However this is limited by constraints as raised in Ajibola (2000) and cited by Akinyosoye (2005: 433). **Farm equipment:** Farm equipment ranges from simple affordable to large-scale complex ones. The vast majority of the Nigerian farmers still operate on small size holdings, using crude and antiquated traditional tools and farming methods. **Fertilizer/herbicides and pesticides** Fertilizer consumption steadily declined from the earlier growth path of the 1960s to the mid-1990s when its use by farmers was encouraged by availability and reasonable prices. This has since been reversed as farmers become hampered due to availability and affordability difficulties occasioned by government procurement and distribution inefficiencies. Generally, fertilizer consumption is too low in Nigeria being 10-12kg/ha while agrochemicals (pesticides, herbicides, etc) access is still luxury to farmers, being less than 10% of potential demand. (Azih, 2008: p23)

Climate change, technology and rice self-sufficiency interaction

The link from climate to food production has been well established in several studies looking at the impact of climate change on agriculture and farm lands. **Climatic factors are believed to be the strongest elements influencing high fluctuations in crop yield and ultimately food supply.** Adejuwon (2005: 53) finds that during years with unusually low precipitation, crop yield sensitivity becomes more pronounced. Changes in climate and atmospheric composition can negatively affect food supply at the community, household and national levels through the biophysical conditions of farm lands that include excessive moisture and heat, drought, pests, diseases and weeds. These conditions can be detrimental or beneficial depending on the level of feasible technology; management choices that farmers make that are mediated by factors related to the biophysical condition of the farmland, financial resources of the farmer, socio cultural, institutions and information technology influences all acting together to influence crop yield. Food supply is influenced by yield which is in turn influenced by climate conditions directly through damages on crops harvested or still on fields waiting for harvesting or indirectly through biophysical conditions such as excessive moisture (abiotic stresses) which washes away soil nutrients and weeds and pest (biotic stresses) which causes postharvest losses. All of these could result in lower crop yields and reduced total production, as well as considerable management problems. (Kulshreshtha, 2011:34)

Farmers are known to be rational and driven by goals of optimal allocation of resources as a means to achieving self-sufficiency goal in food production or maximum marketed supply to achieve access to purchase food as the need arises. Thus management choices that will raise productivity and yield are constantly evaluated and taken by farmers. However, farmers' decisions are constraint by the environment under which they operate. Therefore, food self-sufficiency realization at the household level particularly for the poor stands at risk because the poor are economically, socially and politically alienated. To be food sufficient at the household level is not just a matter of food availability or food production, there is also the dimension of access and availability and it is well acknowledged that in smallholder farmers in Sub-Saharan Africa depend to a large extent on purchases from the market than own production particularly in drought years.



DETERMINANTS OF ADAPTATION TO CLIMATE CHANGE

Availability and use of adaptation methods at the farm level are determined by a host of factors and therefore policy built on notion of autonomous adaptation by farmers may fail to promote actual adaption at the farm level. The decision by farmers to use one or more methods of adaptation is rarely made relative to one risk alone, but in light of the mix of conditions and risks such as climate, trade, government policies, and social norms that influence decision-making. Second, adaptation process is not made in a 'once-off' manner, but in a dynamic, on-going 'trial-by-error' process. (Smith and Skinner (2002): 104). Thirdly technology to climate impact depends on whether technology allows farmers to substitute capital or other inputs for climate. (Mendelsohn et al., 2001). What this means is that not all adaption methods might be acceptable to farmers. Thus it is important to understand the determinants of adaptation at the farmers' side. This can be approached from two interrelated angles.

Supply side: The supply side determinants of the adaptation process can be seen in the light of those factors that influence sustained availability and quality of adaptation strategies. For example, the mainstreaming of climate change adaptation strategies in agricultural development planning, management and governance (UNFCCC, 2007, World Bank, 2008, IPCC, 2007). Others include funding of climate change research, climate information systems and forecasting, geographic information systems, satellite observations and remote sensing, agricultural knowledge systems and agricultural and marketing services. Extension services are essential link to inform and train farmers in the agricultural adaptation to climate change. Their role includes the provision of a vast range of necessary information and advice on crop agriculture, adaptation to climate change including changing crops and crop varieties to crops of greater resilience, changing planting dates and cropping patterns for a better match with seasonal variability and productivity in relation to temperature and rainfall.

Demand side: The demand side factors determine access and utilization of feasible adaptation options at the farm level. This paper focuses on the demand side factor but not in isolation since both sides work together for the ultimate goal of strengthening farmers' ability to use appropriate technologies. Following insights from the literature on technology adoption, the adaptation process at the farm level finds meaning in the theory of expected utility or cost-benefit maximization. It is reasoned that farmers use adaptation methods only when the net benefit outweighs the cost within a space of constraints. Benefits in this case can be different objectives and goals of the particular farmer. It can be the goal of profit, household food security or food self-sufficiency. These goals are not observed what is observed are the actions of economic agents through the choices they make.

A choice for investment in irrigated agriculture is expected to make some adjustments in the biophysical conditions of the farm towards improved productivity and self-sufficiency goals. Understanding those factors that help to include or exclude farmers in the use of adaptation strategies will help to influence feasible adaptation policy and the modification and strengthening of those measures that farmers have developed in response to identified climate or non-climate stimuli. According to Asafu-Adjaye (2008:p79) "there at least five major factors that limit the extent to which people can adapt to climate change and variability: information, institutional, biophysical, socio-cultural and financial". These factors influence the choices that farmers make.

Information conditions: Lack of trained and skilled personnel can limit a nation's ability to implement adaption options. Farmers must have access to information about farming practices before they can consider adopting them. Since extension services are one important means for farmers to gain information on this, access to extension (both government and farmer-to-farmer) can be used as a measure of access to information. Particularly relevant in this setting is that farmers received information on climate. Availability of better climate and agricultural information helps farmers make comparative decisions among alternative crop management practices and this allows them to better choose strategies that make them cope well with changes in climatic conditions (Baethgen et al. 2003).

Institutions

The new institutional economics view institutions and institutional arrangement as the key to economic performance. It is argued that institutions are key in explaining and influencing economic behaviour. Institutions consist of formal rules such as constitutions, laws and property rights that constrain political, economic and social interactions. One important formal rules related to agriculture is probably the issue of property rights over land and water. Carrying out long term irrigation investment or other soil management practices may be limited because of lack of property rights and legal enforcement. Without the 'right' institutional environment, farmers are unlikely to be concerned about how their farming operations affect the future quality of the land and soil. Therefore Institutions can be seen as exerting influence on the choices individuals, households, as well as smallholder farmers make. The ability of farmers to take advantage of opportunities whether ecological (agriculture), information technology or transportation infrastructure, is directly connected to the efficiency and effectiveness of institutional organisations. For instance, in many cases, the use of desirable crop variety or low cost irrigation technology for poor farmers would depend on how effective government and private organisations make them available to farmers.

As cited in Asafu-Adjaye(2008:p78), in a case study of response to multiple stressors in a rural community in KwaZulu-Natal, South Africa, Reid and Vogel (2006) identified institutional organization and governance as being among the factors that reduce the ability of farmers to secure sustainable livelihoods and cope with multiple stresses including climate. Also Brooks et al (2005) show that adaptation can be successful and sustainable when linked to effective governance systems, civil and political rights and literacy. Fan et al (2009:23-25) operationalized institutional deficiencies as weak legal institutions, low quality government, and lagging market development. Measured weak legal institutions as an index reflecting the frequency of lawsuits and the efficiency of courts in each province. The measure of local government development is based on a set of government services quality indicators. Market development is measured in each province using the percentage of workers in the province officially registered as employed in the private sector – that is, as employed in private enterprises or self-employed individual because it is expected that a high degree of private sector employment is associated with a vibrant general market activity.

Institutional deficiencies such as lack of support mechanisms, poor functioning markets and poor or inadequate infrastructure frustrate farmers' efforts to cope with climate variability. For example, resource limitations and poor infrastructure limit the ability of most rural farmers to take up adaptation measures in response to changes in climatic condition. With resource limitations farmers fail to meet transaction costs necessary to acquire adaptation measures and at times farmer cannot make beneficial use of available information they might have (Kandlinkar and Risbey, 2000). Farmers with access to both input and output markets have more chances to implement adaptation measures. Input markets allow farmers to acquire the necessary inputs they might need for their farming operations such as different seed varieties, fertilizers, and irrigation technologies. On the other end, access to output markets provides farmers with positive incentives to produce cash crops that can help improve their resource base and hence their ability to respond to changes in climatic conditions (Mano et al., 2003)

Biophysical conditions.

The literature has identified several channels through which changes in climatic elements impact on ecosystems and human development. For example both heavier rains and persistent droughts increase soil erosion and vegetation damage through run off with effects on agriculture and sustainable livelihoods. Higher temperatures also mediate faster loss of soil moisture, and prolong droughts and increasing temperatures create favourable conditions for pests and diseases to multiply (Hisali et al (2011:1245)). Temperature variations affect many functions of the plant, such as respiration, transpiration, and photosynthesis. Increasing temperature leads to increasing respiration intensity, which requires a higher intake of carbohydrates and, consequently, a loss of biomass. **In** the tropics precipitation is the most important influence of plant growth and this is determined by the amount of rainfall and distribution. Crop plants are sensitive to the moisture situation both during their growth, development and especially as they reach maturity. Thus climate through its elements not only aid plant growth but also influence biotic and abiotic conditions within which plants grow and therefore influences what adaptation options farmers should use. Biotic stresses are associated with living organisms such as pests and diseases while abiotic stresses are associated with physical factors like excessive moisture and poor soil quality. **Odjugo, (2010) finds** farmers shifting from long duration crops to short duration in North east due to drought. Di Falco et al., (2010: p840) looking at the relationship between adaption choices and productivity included current climatic factors (e.g., rainfall, temperature) as well as the experience of previous extreme events such as droughts and floods (in the last five years) as determining the probability of adaptation. Finds that farm households with highly fertile soils are less likely to implement some adaptation strategies. Also finds rainfall displays an *inverted U*-shape behavior in the *Meher* season among farm households that did not adapt while it does not affect the productivity of farm households that adapted. Rainfall in the long rainy season displays an *inverted U*-shape behaviour. Mendelsohn et al (2007) in a study of climate effects on the United States, India, Brazil and Africa used the Ricardian methodology to compare the relative effects of average climate conditions and climate variability in terms of temperature and rainfall on farm income. They found that in the United States, the average climate was more important than climate variability and temperature was more important that precipitation for explaining farm income. In Brazil, climate variability was more significant than average climate conditions and precipitation was more important than temperature. In India, average climate condition and precipitation were more important determinants of farm income.

Socio-cultural conditions constitute informal constraints such as sanctions, taboos, customs, traditions, and norms or codes of conduct that structure political, economic and social behaviour and interactions. For example, behaviours' at the individual and social levels are shaped in part by deeply-embedded cultural and societal norms and values which determine what is perceived to be a limit to adaptation. (**Adger et al., 2007:**p345**).** Informal constraints are commonly referred to as 'social capital', which is ''the shared knowledge, understandings, norms, rules, and expectations about patterns of interactions that groups of individuals bring to a recurrent activity'' (Ostrom, 2000, p. 176). It refers to ''features of social organizations, such as networks, norms, and trust, that facilitate action and cooperation for mutual benefit'' (Putnam, 1993, pp. 35–36). Virtually every commercial transaction has within itself an element of trust, certainly any transaction conducted over a period of time'' (Dasgupta, 2000, p. 329). Trust is perhaps the most important component of social capital and affects the costs of transacting: If one's confidence in an enforcement agency falters, one may not trust people to fulfill their agreements and fewer agreements are entered into. (Slangen et al., 2004: 247). Thus it is expected that low trust for government agency promoting technology use among famers may limit climate change adaptation and consequently affect the self-sufficiency goal of the government. Societal construction of gender roles in much of the developing world has important implications for the medium of delivery of climate change information (Broad and Petty, 2004). Gender discrimination may also make it difficult for some women to gain access to complementary inputs as well as relevant information (Tenge et al., 2004). Though some studies argue that the dominant role of women in Africa's agriculture gives them the relevant experience and information(Nhemachena and Hassan, 2008)

Financial resources: Whether it is expressed as the economic assets, capital resources, financial means, wealth, or poverty, the economic condition of nations, individuals and groups clearly is a determinant of adaptive capacity. Economic capital refers to the sum total of all of one's material possessions and investments, which can be converted into economic resources (money). One can use economic capital to acquire other forms of capital, including human capital (labour and knowledge), social capital (loyalty, networks) and natural capital (water, land). A well acknowledged fact is that resource poor farmers are often reluctant to invest in newly introduced improved agricultural technology because of limited cash resources and/or access to credit. Reviewed in Langyintuo and Mungoma (2008: 50-51), paradigms of innovation-diffusion, adopters' perception and economic constraints have shown the significant influence of access to cash (or credit), among other factors, on the adoption of improved agricultural technologies by smallholder farmers in developing countries. Economic theory also predicts relatively more resource- endowed households have a better ability to cope with production and price risks and consequently more willing to adopt new technologies than less resource-endowed households. Using data from several different countries Cancien (1967) finds that within any given farming community, households on the upper part of the wealth continuum are most likely to adopt new technologies because of their secure economic positions. Those on the lower wealth continuum, on the other hand, may be willing to adopt because of their greater desire for upward mobility in the economic group but unable to invest in new opportunities and therefore lowest in terms of adoption of new techniques. The model recognizes the existence of a small group between the two that is unwilling to invest in new techniques that may fail leading them to lose their relatively favourable economic positions and thus shows non-linearity between wealth and technology adoption. Access to cash (or credit), which promotes adoption of risky technologies through the relaxation of liquidity constraints as well as boosting the household's risk bearing ability is hardly available to resource poor farmers for varied reasons. Households that have limited access to credit can have less capital available to be invested in the implementation of more costly adaptation strategies (e.g., soil conservation measures). (Di Falco et al., (2010: p840). Financial constraint is one of the greatest obstacles to the use of adaptation measures.

CONCLUSION

Climate change induced by the increasing concentration of greenhouse gases in the atmosphere is likely to affect crop yields, agricultural productivity, and food self-sufficiency in rice commodity. Nigeria is particularly vulnerable to climate change because substantial number of the population is into agriculture and using less capital and inputs. This study synthesized ideas on climate change in agriculture and its adaptation in relation to rice self-sufficiency goal in Nigeria. Also explored those factors that are likely to exclude or include farmers from utilizing available adaptation strategies. Adaptation strategies such as increased use of irrigation and use of pesticides reduce the sensitivity of farmlands to the adverse impact of climate change and consequently improve on farm productivity and income. Yet these methods are constraint by the financial capacity of the farmers, institutions, information, culture and biophysical conditions of the land. It is argued that the magnitude and variation of climatic factors are important determinants of soil quality and productivity. Thus efforts to increase rice self-sufficiency must include complimentary efforts to increase extension activities to build farmer's capacity and to promote the use of soil management technology to ensure good soil structure and fertility in the long term. Increasing farmers' financial resources and access to information is likely to raise the probability of adaptation. In this regard, it is important to develop the credit markets to allow farmers to make important investments that can support farm productivity. Extension activities through radio programs and awareness to inform farmers when planting times are most critical and on how to use weather forecasting gadgets because information on climate change plays an important role in determining farmers' decisions to adapt. Both formal agricultural extension and farmer-to-farmer extension increase the probability of adaptation. The development of community institutions and peer to peer education is very important for increasing awareness within and between communities and to policy makers at local and state governments. Community institutions should be encouraged and strengthened to liaise with policy makers to support and to build community awareness of climate change impacts and adaptation options. However Further studies are need to evaluate the impact of those who use adaptation strategy on food security and those farmers who would not use adaptation strategies in order to design effective adaptation strategies to cope with the potential impacts of climate change.

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