# The Role of Technologically Based Extension Services in Building Capacity of Smallholder Farmers for Mitigation and Adaptation to Climate Change in Nigeria

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## Abstract

Depletion of soil fertility and the shortage of quality water due to climate change effects in Nigeria if well-addressed will change the narrative of food security in the face of population explosion and a fast-changing climate. The study analysed the role of agricultural extension in building systemic capacity and developing ecosystem resilience to the vicissitudes of climate. It assessed how developing farmers' capacities can help them establish mitigation and adaptation capabilities. It is important to direct extension teaching methods toward the current needs to raise farmers' capacities to developing climate change mitigation and adaptation capabilities. Soil fertility conservation in the face of declining soil fertility and decreased arable soil area is of uttermost importance as land is a limited resource given the multiplicity of uses it is put to and the number of human populations competing for it. The objective of agricultural extension targeted toward climate change mitigation and adaptation is to ensure that the maximum crop yield capacity is obtained from the limited area of arable land available for farming. The study found that biological improvement of crop, improvement of infrastructure and organic amendments were reliable methods of raising production in Nigeria. It is recommended that a judicious irrigation framework should be established to ascertain quantity and quality of water use in the smallholder-based farming in Nigeria. There has to be efficiency in water use and a systematic approach to land management for higher productivity.

**Keywords:** Technology, extension service, climate change, mitigation, adaptation, smallholder farmers

## INTRODUCTION

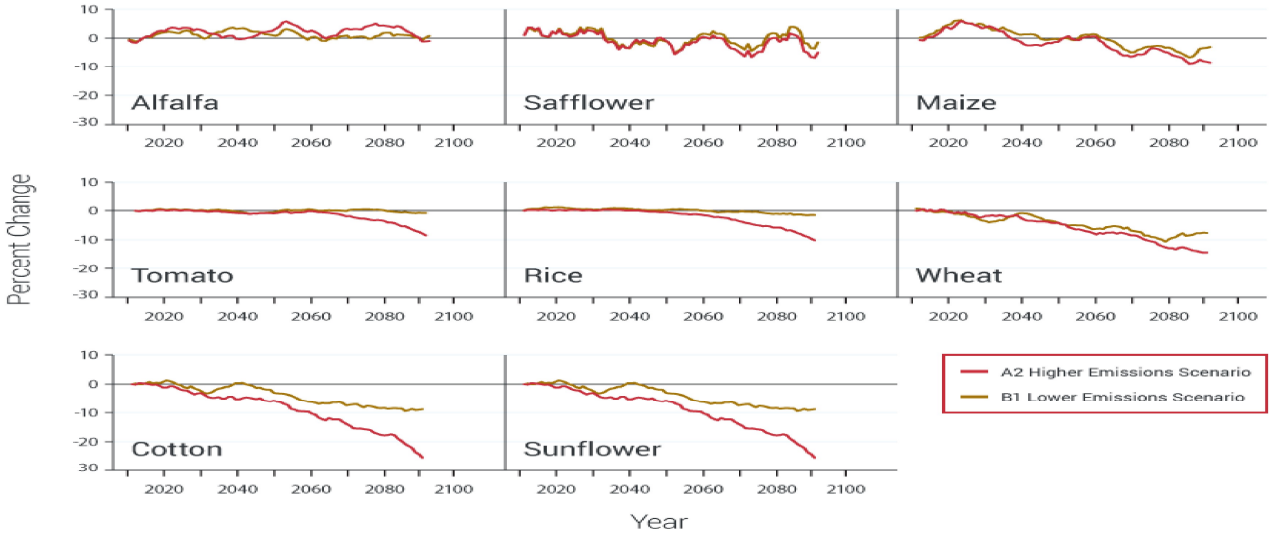
The fundamental purpose of agricultural extension is to transfer information and related technologies based on carefully identified problems of farmers so as to increase their productive capacity, discover their covert needs and develop leadership skills among farmers. Extension, therefore, requires redirection and fine alteration of farmers' activities in order to achieve the desired goals. In the tropics, crops grown by the majority smallholder farmers are already at their maximum tolerance levels due to the extreme temperatures prevalent in the tropics. With climate change, the crops grown in the tropics are tipped above the tolerance levels they can survive. The tropics are defined as the geographical area lying between $23.5^0$ N and $23.5^0$S latitude, while the temperate regions are found above these parallels.

Climatologically, the tropics are characterized by high year-round temperatures and weather is controlled by equatorial and tropical air masses (Rosenzweig and Liverman, 1992).

The objective of this review paper is to elucidate on the significance of agricultural extension in building the adaptive and mitigative capacity of smallholder farmers in response to climate change by building farmers' knowledge base and capacity for conservation agriculture and optimum water management through modern agricultural extension methods. The paper analysed technical literature to achieve the research objective through careful review of relevant secondary literature.

The United Nations Framework Convention on Climate Change (UNFCCC) in 2007 defined climate change as "a change of the climate which is attributed directly or indirectly to human activity that alters the composition of the global and/or regional atmosphere and which is in addition to natural variability observed over comparable time periods". The IPCC (2001) defined climate change as the statistically significant variations in weather that persists for an extended period, typically decades or longer. The IPCC, further, in 2007 concluded that 90-95% of these climate changes are likely to have been caused by human action. Climate changes are said to reflect variations within the earth's atmosphere, processes in other parts of the earth such as oceans, and the effects of human activity (Miller and Edward, 2001). Human economic activities have, in the last 100 years, contributed to an increase in the concentration of 'greenhouse gases' in the atmosphere leading to 'enhanced' greenhouse effect (IPCC, 1998) which in turn is expected to result in climate change, arguably the most important and dangerous, and certainly the most complex, global environmental issue to date (Holdren, 1992; Kandlikar and Sagar, 1998; Hamilton, 1999).

Agriculture and fisheries are highly dependent on climate. Increased temperatures and carbon dioxide levels are predicted to increase yields in certain places; nonetheless, for this to be achieved nutrient levels, soil water, water availability and a number of other conditions must be met(USGCRP, 2014). However, intense and increased incidents of droughts and floods could be detrimental to farmers and ranchers as well posing a challenge to food security and safety. Increased water temperatures can cause habitat changes and migration of many fish and shellfish species which could disrupt the ecosystem. On the overall, climate change will make it difficult to grow crops, rare animals and catch fishes in the same places and specific seasons and periods as we were used to in the past (USDA, 2014).




**Source:** ResearchGate.net

**Building adaptive capacity**

Nigeria has an estimated population of 200 million people with over 70% depending directly or indirectly on agriculture for their incomes and livelihoods. The smallest climate change impact on agriculture can have significant influence on the entire population and especially those directly benefitting from the agricultural sector. Although the country has huge food deficits, the rural-based smallholder farmers are responsible for over 80% of the country's local food production. There have been clear evidences of climate change effects in Nigeria especially indicated through change in rainfall patterns and quantity as well as the increase in incidence of extreme weather events such as floods and droughts. Extreme temperatures have also had deleterious impacts on the food systems in Nigeria. In 2019, floods were common place in Nigeria. The country also experienced a particularly extensive rainfall season in 2019 which was detrimental to crops which had already completed their lifecycles.

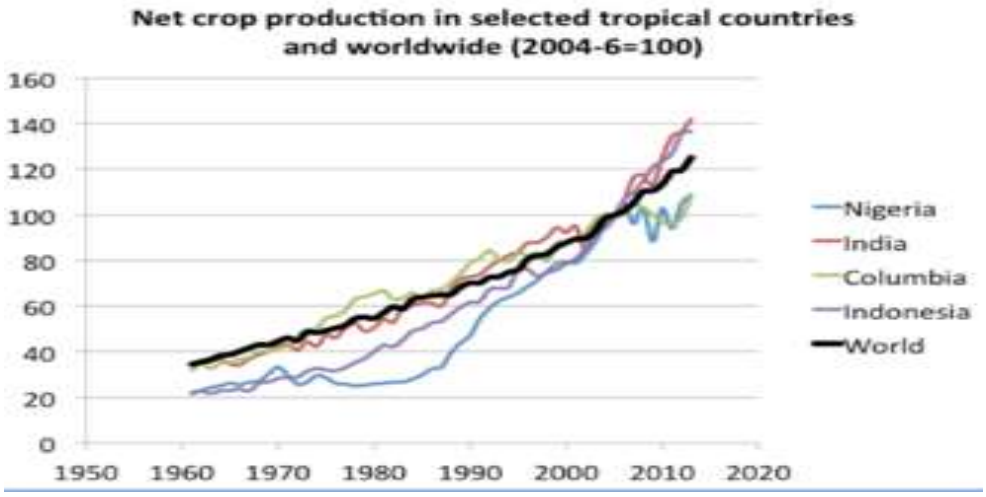
The IPCC's 2018 report clearly stipulates that climate-related risks to livelihoods, food security and water supply are expected to increase as global warming reaches 1.5$^{o}$C and even become worse as it reaches 2$^{o}$C. Nevertheless, with all projections the world would have warmed by 3$^{o}$C in 2100 (IPCC, 2019). Our food production is greatly at risk because while there is projected population increase on the one hand, farmers are one of the most vulnerable groups on the other hand. This put food systems to be at great risks especially in the developing world. While risks cut across farmers in both the developed and developing world, smallholders are a particular interest group because they are more vulnerable. Increased magnitude and incidence of extreme weather events will cause shocks in food supply around the world; therefore, it is pertinent to develop farmers' coping abilities both responsively and futuristically (IPCC, 2019).

Adaptation is the most basic direction in response to climate change but climate change mitigation actions to reduce emissions of greenhouse gases are also urgently required within Agriculture, Forestry and other Land Use (AFOLU), these contribute about 23% of all anthropogenic greenhouse gas emissions, the biggest culprit being livestock and enteric

fermentation that release huge volumes of methane and overall contribute 50% of the emissions from agriculture (IPCC, 2019). To achieve success over these daunting impacts of climate change requires formulation of deliberate new technologies and building skills and change in attitude that can engineer improvement in adaptive capacities and lead to mitigation of climate change effects.

Nyong (2008) described climate change as a moving target and hence it is important to achieve adaptation strategies but more important to establish adaptive capacity since the presence of adaptive capacity is a necessary precursor for the design and development of effective adaptive strategies. Development of adaptive capacity may include; education, income, health, institutions, knowledge, technology and levels of national development (Nyong, 2008). The adaptive capacity can be seen as a framework of institutional, technical, social and economic balance upon which climate change adaptation can thrive feasibly to the benefits of the under-developed rural populace.

To achieve a base line adaptive capacity in Nigeria a number of adjustments and implementations must be put in place. Firstly, Nigeria's weak infrastructure and inconsistency in government policies which impede agricultural development (Aster, 2007) must be improved to international competitive standards. An upgrade of scanty and ill-equipped weather stations and agricultural infrastructure (Odjugo, 2010) is pertinent to enable accurate weather forecast and predictions thereby preventing weather related disasters through early warning and effective response/adaptation system. Investment on improved agricultural technology by government and other stakeholders are very necessary for agriculture to be able to cope with climate change, improving research institutes and decentralizing research finding policy framework. Garba (2006) regards low endowment of human capital as one of the major causes of poverty in Nigeria, basically a better educated farmer would, for instance, be able to absorb new information faster. Hence the need to make agriculture more professionalized with educational training incentives and development of human capital in the direction of crop and livestock production (Enete and Amusa, 2010). They also suggested the integration of successfully developed indigenous adaptation strategies into formal climate change mitigation and adaptation strategies. There is no form of development that supersedes human capital development and in agriculture the most useful but latent tool is information. At these times of inconsistent climate vicissitudes, the national extension services must be strengthened by devolving the bulk of the service down to the local council, which is closer to the farmers, and encouraging farmers to form farmers groups for enhanced capacity through group efforts. This may help them take advantage of the internet (Enete and Amusa, 2010).




**Source:** ResearchGate.net

**Status of agricultural extension in Nigeria**

The predominant form of extension practised in Nigeria is the public-based extension. Over the years the extension delivery in Nigeria has been criticized as paternalistic and lacking the penetrative power of reaching farmers in the remote areas of the country's rurality. Delivery of the extension to the rural farmers, for which they are intended and designed, has been marked with a number of recurrent problems (Okwu and Ejembi, 2001). In several quarters, and with provable evidence, the Nigerian agricultural extension has been described as the most research-based and scientific in Africa.

Nevertheless, extension delivery is a far-cry from what is the standard required extension contact that can drive the attitudinal and perceptive change required to transform smallholder farmers with very low productive capacity, low incomes and poor saving and investment culture to more productive and higher income earning farmers with greater saving and reinvestment capacity. Several studies have reported that most of smallholder farmers across the country do not have access to extension services and that the few that have access to extension receive only one or two contacts per annum. Key informant interviews also show that most contacts are in fulfilment of the statutory mandate upon the staffers rather than a well-articulated course of action targeted at specific goals and results.

Arokoyo *et al*. (2002) identified a number of extension agencies working in Nigeria. Among the categories constituted, Sasakawa-Global 2000 which is an international organization was an exception as theys worked closely with the local extension body in the country (the Agricultural development programme, ADP) and had staffers of the ADP seconded to the programme. Most other private, faith-based and NGO-based for-profit organizations operating in the agricultural advisory services subsection of Nigeria's agriculture are profit-oriented, commercial extension service systems.

Private companies have also been involved in some form of extension in Nigeria; companies like Agip, Ciba Geige and Olam Nigeria limited have made significant livelihood impacts on communities (Isife and Madukwe, 1999; Akele and Chukwu, 2004). Their extension methodology is more of a community-driven development approach including farmers'

participation in planning and implementation, input delivery and marketing to spur technology adoption. There are also informal private extension actors in the subsector. The informal extension has a simple structure comprising friends or relatives and usually retired civil servants (Okoro *et al*., 2006). They combine extension services with input delivery such as agro-seed, chemicals, processing, microfinance administration consultancy and sales of farm machinery but charges on the extension are not directly paid by the farmers, they may be paid in an all-inclusive manner in the inputs delivered.

**The new paradigm: Private extension services**

The subject of privatizing extension services in Nigeria has since been debated among thinkers and policy-makers. The core area of concern remains the question of the capacity and willingness of poor smallholders to pay for private extension in Nigeria as the cost of public extension expenditure is too high to be sustainable and results of public extension. But there are other concerns such as quality of the services provided the degree to which the services have been able to solve the overt needs of the clientele, timeliness of service delivery and payment plan of the services. Greater inclusivity of farmers in extension process is suggested for development of market linkage, raw materials and income options (Farrington *et al*., 2002). Umali and Schwartz (1994) noted that the central objective in privatised extension system is in getting the right message to the right user(s) at the right time through a demand-driven service system that is cost effective and efficient.

Theoretic assumptions of extension make the business structure simple – services or advice are offered and fee is paid depending on the factors of demand and supply. This depends on how extension services can be transformed to a commercial product where it was previously perceived as a public service (Umali and Schwartz, 1994). Agricultural information can spread through farmer-to-farmer communication and retains its value despite wide access, and thus considered a public good. Agricultural information with private good characteristics is specialized often associated with particular input, field or individual farmer. Commercial agriculture is not a precursor for commercial extension.

**Extension for climate change mitigation and adaptation**

Importantly, the form of extension suited for building adaptive and mitigative capacity of Nigerian smallholders has to be an innovative form of extension leveraging fully on technology. The incorporation of precision farming through carefully designed experiential teaching of farmers and setting up of infrastructure and technological gadgets in that can support agriculture would be a step in the right direction. The fundamental objective of precision agriculture is optimizing returns on inputs while preserving resources through the use of satellite imaging technology (GPS and GNSS) it is possible to observe, measure and respond to intra and inter-field variability of crops. The elaborate procedure would require full scale alteration of a lot of farmers' perceptions and behaviours. This is goal of the modern form of extension in leveraging technology to provide extension services that can build the responsive capacities of the smallholder farmers in Nigeria towards climate change impacts.

Remote sensing has recently gained popularity in agriculture; the pin-point accuracy of remote sensing has seen the technology achieve fine and delicate cases in agriculture otherwise impossible. Remote sensing has been used in crop identification on basis of its cost

and benefit to the farming system and country as well as the projected period of planting and harvesting where the optimum yield is achievable (Sharma *et al*., 2017). Remote sensing has also found use in identification of stressed plants, detection, diagnosis and control of plant diseases, yield estimation, yield maps, plant breeding research, soil analysis, soil mapping and land cover mapping. The predictions of abrupt and intense alterations in the climate and weather regimes suggest that agriculture in Nigeria must be armed with such technology in order to survive and increase its productivity in the face of climate change and population explosion (Sharma *et al*., 2017).

Weather forecast technologies are especially required in the face of these daunting vicissitudes of climate. Technologies are currently available for projection of weather conditions with up to 70 – 79% accuracy of a period of 2 months. The same technologies offer daily forecast as well as weekly forecasts. The daily forecasts are however more precise and accurate. Some weather forecast companies give up to 48 hours forecast with very high accuracy over specific geographical areas. With weather forecast optimum input use efficiency can be achieved. For instance, it will be a waste of resource and harmful to the environment if a farmer goes to apply agrochemicals to his cornfield 6 hours before rainfall as the rain will simply wash off the chemical into water bodies causing a waste of the resource as well as health hazards to the people who will consume water from that water body into which the chemicals have been washed.

Other ways modern extension can leverage on technology would be in the areas of biological improvement of crops using conventional breeding techniques, bio-stimulation of crops to give them the resilience needed to overcome external stress, improved use of local varieties of crop cultivars fully adapted to the environment over thousands of years, funding and incorporation of indigenous innovations and agro-ecological/organic farming (Cho, 2013).

**Soil conservation and water management**

In the recent 3 decades world corn and wheat production has dropped by 3 to 5 percent due to climate change. It also projected that maize production will drop 30% by 2030 as a result of climate change (Cho, 2013). This is the extent of climate change impact and the need to build comprehensive capacity in the entire agricultural ecosystem. Although the quality of arable land is dependent on the type of land in the area and the climatological factors prevailing there, soil management and maintenance of soil fertility. In the smallholder-type farming,as is typical in Nigeria's agriculture, soil management should take into account the risks in farm area and its location, choice of crop, cultivation methods and stocking rates, strategies for minimising erosion (Taddeo, 2017).

The knowledge and skill of farm design and management should also be taken as equally very important. Similarly, road designs, drainage systems, fencing and soil-stabilization vegetation, attention to locate planting area away from bottom of slopes. In the event of mixed farming, risks arising from animal grazing. Terracing, contour farming and strip-cropping, irrigation design are technologies to be incorporated into smallholder farming. Reduced tillage, conservation tillage, direct-drilling of crops can minimize soil structure destruction through the use of heavy machinery and help maintain soil quality as tillage has a negative effect on physical, chemical and microbiological properties of the soil; conservation tillage practices improves the microbiological and physicochemical properties of soil(White *et al*., 2012;

Taddeo, 2017).White *et al*. (2012) also posited that organic amendments improve productivity and nutritional repository of soil. Further, phytoavailability of essential mineral nutrients, reduction of phytoavailability of toxic mineral elements, improvement of soil physical properties, and promotion of a beneficial soil biota can be achieved through the use of crop residues.

**Water management**

In the light of the fact that 70% of global freshwater resources are utilized by agriculture, the significance of water as the world tries to increase food production by 50% in 2030 and a further 100% increase from that level in 2050 cannot be overemphasized (OECD, 2010). By 2050 the world's population would be 50% of what it was in the year 2000 (about 9.1 billion people). FAO (2019) suggested a number of measures for making water more available to crops capture water –rainwater harvesting, soil and water conservation–, and using it –deficit irrigation; supplementary irrigation etc. The FAO forecasts that by 2050 global water requirements for agriculture will increase by 50 per cent to meet the increased food demands of a growing population. Global freshwater is becoming increasingly scarce, due to improper management, indiscriminate use and a changing climate. Water can also be managed by using more improved crop varieties, on-farm water management to reduce losses due to evaporation and studying rainfall patterns to determine quantity and quality available for agriculture use and rescheduling crop production dates.

A framework for judicious irrigation is necessary. Excessive irrigation will lead to rapid fall of water tables. Development of financial frameworks to provide incentives for the adoption of best practices and new technology among smallholders in Nigeria would be suitable. In Nigeria, the indiscriminate water use associated with drilling boreholes without limitation or authority can be a huge detriment to the quality and quantity of groundwater in the future. IAEA (2018) suggested the employment of advance nuclear and isotopic techniques. Isotopic signatures of oxygen-18 and hydrogen-2 in the water taken from field crops allow the separation of irrigation water into soil evaporation and crop transpiration, thereby providing information essential for improving the water use efficiency of crops.

**Conclusion**

From this study, it can be concluded that an innovative, technology-driven agricultural extension delivery system is needed to help Nigeria's typically smallholder farming systems. The study has found that advance technology of water management and soil conservation will need to be imbued into the farming system of Nigerian farmers. Timeliness in relying upon the full engagement of scientific agricultural production technologies built specifically for Nigeria's environment will enable farmers establish dynamic adaptive and mitigative capacity in soil conservation and water management for climate change.

**Recommendations**

1. A judicious irrigation framework should be established to ascertain quantity and quality of water use in the smallholder-based farming in Nigeria. There has to be efficiency in water use and a systematic method of ensuring that.

2. In Nigeria, we must transform the paternalistic public extension system into a system that fully incorporates science and technology in offering experiential teaching to smallholders to build farmers' climate change mitigative and adaptive capacities.
3. Extension systems must be firmly established that they can transmit the technologies of precision farming and remote sensing for the benefit of farmers as climate change rages further.
4. To achieve certain levels of agricultural extension Nigeria must improve on infrastructure, from weather stations to roads and satellite systems that can assist in furtherance of extension technology. Proper extension depends on a network of technologies and interrelated systems.
5. Conventional biological improvement of crops and dependence on organic amendments for the improvement of phytoavailability of essential soil nutrients.
6. Farmers must be made aware the importance of organic farming and that local crop varieties are more important than genetically improved crops. The capacity and knowledge to incorporate and discern these must be taught to farmers.

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