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A review on prospect of wheat in Nigeria: Technological Advancement in Focus

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ABSTRACT

The main issue affecting domestic wheat production in Nigeria is environmental incompatibility— the fact that wheat, being a temperate crop, requires cold climates during the growing season to thrive especially during the critical developmental stage between tillering and grain filling. This has limited the wheat growing season in Nigeria, to the cool harmattan period starting from November to March, and the wheat growing areas in Nigeria, along latitude 10°N to 14°N. Unfortunately, the harmattan period itself is also challenged by the absence of a rainy season, which typically starts after the period from April to September with unfavourable high temperature and humidity. Nigerian government policies over the years have centred on accelerating primary production (farming) instead of focusing on addressing the main issues, through research and development of cultivars that will be adaptable in Nigeria's heat-stressed growing environment, build more irrigation areas along the harmattan latitude, strengthen extension services to ensure farmers adherence to Good Agronomic Practices (GAPs) and ease farmers access to market for fair prices. As a result, the national average ton per hectare output is abysmally 1.3 MT, prepared irrigation area is less than 10% of planned area and a near-complete disconnect between farmers and the off-taking flour milling industry, who are currently fully reliant on imported wheat. The peculiar situation is like in other tropical countries like Egypt, Ethiopia and the warm and humid Bangladesh. The paper recommended the adoption of molecular breeding technologies to strengthen the breeding processes and shorten the seeds generation time.

Keywords - Wheat, Nigeria, Production, Constraints, Opportunities, Breeding, Irrigation

INTRODUCTION

Wheat (*Triticum Species*) is one of the most widely cultivated crops in the world today. According to the Food and Agriculture Organisation, the global area harvested under wheat in 2019 accounted for about 216 million hectares and the global wheat production in 2019 accounted for about 766 million metric tons. But its production in Nigeria is plagued with challenges that have limited production area to less than 75 thousand hectares and reduced harvests to a mere 55 thousand metric tons (Boluwade, 2022).

The low productivity has since been ascribed to several factors, which the Lake Chad Research Institute in the 1980s grouped into the following: environmental incompatibility

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that is the fact that wheat requires cold climates during the growing season to thrive especially during the critical developmental stage between tillering and grain filling, poor farm management practices, lack of suitable farm equipment, and lack of investment in research. These issues have not been resolved and have continued to thwart any plan for self-sufficiency, as a result the average ton per hectare output of wheat harvest in Nigeria is shockingly 1.3 tons per hectare (Boluwade, 2022), while the global average ton per hectare output is 8 tons (Dikko, 2012).

The 1981 GAIN report posits that "barring any extraordinary technological breakthrough, Nigeria will never be a significant wheat producer"; their reason is due to natural constraints because "neither the climate nor the soil is suitable". However, Wheat production has been increasing remarkably in the warm and humid climates like in Bangladesh where between 1970-71 and 1980-81 the cropped area under wheat cultivation jumped from 126,000 hectares to 591,000 hectares and production rose 10-fold from 110,000 tons to 1,070,000 tons, a 25% annual mean growth rate (BARI, 2020).

Recently in Ethiopia, a tropical country with very similar environmental conditions like Nigeria, both the area of wheat production and the crop productivity has doubled during the past decade as compared to the period from 1970 to 1990 (Tadesse, 2019). The country's average annual production is 3.6 million tons on an average area of around 1.6 million hectares during the 2010-2014 seasons. Ethiopia was able to achieve this record feat by expanding local production to their highland regions for rainfed cultivation, doubling it up with their over 1.4 million irrigation capacity.

Wheat production capability in Nigeria has not progressed beyond the 80s as it is still stuck with limited production area, a lack of investment in crop improvement and general lack of policy direction. There has not been a focus on research and development to make new adaptable cultivars nor efforts to expand the production areas or a coherent plan for farmers to accelerate production.

Many programs aimed at increasing local production of wheat in Nigeria have failed to achieve any results. The Accelerated Wheat Production Programme (AWPP) that was launched in 1980s reached its peak in the 1988/1989 season, when production covered a record 218,881 hectares with an estimated total harvest of 427,762 tons (OLUGBEMI, 1990), virtually representing a woeful crop productivity of less than 1 ton per hectare, but then it collapsed after the ban on wheat imports were lifted. The current Anchor Borrowers

Programme (ABP) was designed by the CBN and launched at the inception of the current administration in 2015. Although it is a monetary-support, farmer-centric plan for increased food production, with noticeable impact on rice, the ABP has no provision for crop improvement and hence there is no increase in crop productivity.

The consumption of wheat in Nigeria over the years has been increasing exponentially due to population growth and the increasing demand for quick and easy to make fast foods. Despite evidence of pre-colonial wheat consumption especially in present Borno state, the consumption of wheat bread had been introduced —through importation, on a modest scale in the colonial period when it began as a luxury but later transformed into a staple because of pressures on urban food supplies (Isitor, 1990).

Wheat imports started from an average level of 75,000 tonnes per annum in the first half of the 1960s, the imports then trebled by the first five-year period of the 70s. By the early 80s the annual three-year average reached 1,350,000 tonnes. It reached a peak year in 1981 with over 1.5 million tons imported. Then the rate of expansion slowed down due to import restrictions generated by receding oil prices but increased to the level of 1.8 million tons by 1984 (Andræ and Beckman, 1985). Current data of the National Bureau of Statistics (NBS) showed that wheat importation to Nigeria has maintained its trebling pattern and increased to a staggering 5.6 million metric tons by 2021, increasing by an annual mean growth rate of 19% within the last 7 years. The milling industry today depends entirely on imports.

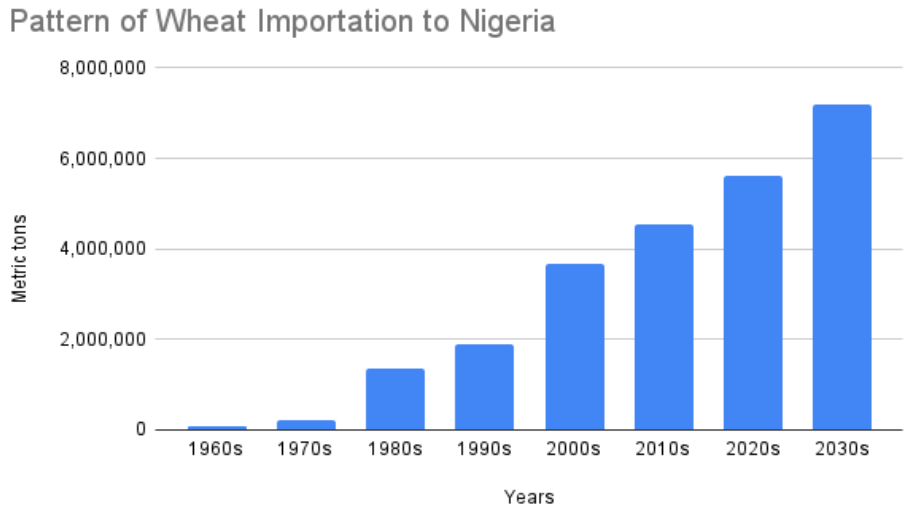

Figure 1: Trending pattern of wheat importation to Nigeria, up to date data by NBS and our projected figures up to 2030s (*Source data copied from:* The Wheat Trap and The National Bureau for Statistics)

This trend of wheat importation to Nigeria, currently estimated to be worth about $2 billion per annum (CBN, 2021), has become untenable for the Central Bank of Nigeria (CBN) to continue to finance with hard earned foreign currency. In addition to an existing import tariff of 5% and a levy of 15%--earmarked for an unknown national wheat development program (Boluwade, 2022), the CBN planned to exclude wheat importers from accessing their foreign exchange window, a policy change with far reaching consequences that will compound food inflation in a sector that was already suffering from the repercussions of Covid-19, Russia-Ukraine war and the Climate change phenomena (CBN, 2021).

Over the years, domestic wheat production in Nigeria has been unable to keep pace with the growing demand for wheat. Harvest across the wheat growing areas for 2021/2022 season were officially projected by the Wheat Value Chain Team at the Ministry of Agriculture and Rural Development to be 360,000 metric tons, despite government's intervention and support for farmers, but actual numbers are likely to be less than half of this.

The government is now forced to revive domestic production to augment the shortages from global supply, decrease dependence on foreign wheat, as well as exposure to external shocks that may emanate from global events. But to do so, it will have to solve the long-identified challenges affecting local production. In the subsequent sections of this review, the paper will discuss the main issues, recommend technological solutions and seek to guide policymakers and researchers on how to achieve the long-desired self-sufficiency in wheat production.

CHALLENGES AFFECTING LOCAL PRODUCTION

Wheat Crop Improvement

The most important wheat species in Nigeria is the Common wheat or Bread wheat, scientifically known as *Triticum aestivum* and is generally used to make flour-bread. Pasta wheat is mainly used to make Semolina then Spaghetti, Macaroni and Noodles. It is also known scientifically as *Triticum durum* but represents only about 10% of wheat consumption in Nigeria (Sall *et al.*, 2019).

Wheat is also classified based on its adaptation to different growing climates. Winter wheat requires a cold temperature to induce flowering, over a period of dormancy known as vernalization. While, spring wheat can grow well under higher temperatures. Hence the reason why spring wheat is the only type that can grow optimally in tropical and subtropical regions like Nigeria.

Wheat growing environments with high temperatures have a mean temperature in the coldest month of the year of more than 17.5º C. **Fischer** further sub-divided these environments into hot (17.5º - 22.5º) and very hot (>22.5º), each of which can have sub-regions that are humid or dry sub-regions. Most of the current wheat growing areas in Nigeria fall into the hot-stressed environment, due to lack of rainfall during the growing period (Rajaram, 1990), because the average annual temperature for those areas is 26.9°C, with average monthly temperatures ranging between 24°C (December, January) and 30°C (April) (World Bank, 2022) and unfortunately when the temperature decreases in the harmattan period the rainy season has already end.

Drought and high temperature are the abiotic stress that critically affect wheat production in Nigeria (Dikko, 2012). This necessitated the breeding of wheat cultivars for heat and drought tolerance especially as the global phenomena of climate change intensify. It requires the genetic improvement of the crop through selection, breeding and even transformation if necessary. The Lake Chad Research Institute (LCRI) was created in 1962 with the mandate for the improvement of the productivity of the entire farming system of Wheat (*Triticum aestivum*), its close cousin Barley and Millet (LCRI, 2022). Ideally, such activities will cover genetic improvement and breeding, seed production, processing, marketing and distribution to farmers, primary production/cultivation by farmers, liaison with National Agricultural Extension and Research Liaison Services (NAERLS) to educate farmers on good agronomic practices as well as ensuring they can easily access markets and get fair prices for harvested grain.

However, the LCRI has reduced itself to domestication of imported, foreign varieties that are bred elsewhere. These varieties were never planned for the ecologies in Nigeria and hence the high rate of crop failures. These are some of the following varieties released by the LCRI.

1. LCRIWHIT-1 (Seri M82) in 1998
2. LCRIWHIT-2 (Cettia) and LCRIWHIT-3 (Linfen) in 2005
3. LCRIWHIT-4 (Attila-Gan-Attila) in 2008
4. LCRIWHIT-5 (NORMAN) and LCRIWHIT-6 (REYNA-28) in 2015

Most of these cultivars were bred at the International Maize and Wheat Improvement Center (CIMMYT) in Mexico and the International Center for Agricultural Research in the Dry Areas (ICARDA) in Syria, now Lebanon. Although some countries like Australia, Ethiopia

and Sudan are successful with accessions from these centers, our failures further buttress the lack of scientific capability and poor national food policy.

However, the establishment of breeders act. 2021 has opened breeding activities to individual scientists, researchers and companies. The private sector can now invest in breeding programs to develop novel cultivars, produce seeds, market and distribute. This has ushered in a new era for not only wheat but all crops in Nigeria.

Olam, one of the largest flour milling companies in Nigeria is already ahead, as it launched a community-based seeds enterprises for pasta wheat (*Triticum durum*) in the 2021 dry-season (Olam, 2022). FMAN, an association of wheat milling companies also released two bread wheat varieties and two durum wheat varieties ahead of the 2023/2024 planting season.

The Production Systems

The wheat production system in Africa has been divided into two major mega environments; Irrigated and Rain-fed (Tadesse, *et al*., 2019). In Nigeria, commercial production is 100% by the irrigation system as the rain-fed system remains unexplored, even though it has been experimented on and shown to perform very well in the Mambilla plateau under rainfed conditions (Adamu, 1990).

***Irrigation* System**

Wheat production in Nigeria is entirely under irrigation during the cool harmattan season between November and March. Although several large-scale irrigation projects were planned in parts of Northern Guinea, Sudan and Sahel Savanna zones characterised by cool harmattan season (Latitude 10º - 14º N) that cover over one million hectares of land, but only about 10 percent of the land has so far been developed since the 1980s (Falaki, 1990).

The first irrigation project is the Kano River Project (KRP) (Phase 1) with headquarters in Kadawa, along Zaria Road in Kano state. It was planned to draw water from the Tiga dam which was completed in 1975 with an irrigation area capacity of 70,000 hectares. By 1977 only one quarter of the project area (5,000 out of the phase one target of 20,000) was claimed to be developed for irrigation (Palmer-Jones, 1981) and five years later, the area available for irrigation was still less than one third of the expected phase one total . There is neither evidence to believe the prepared irrigation area is being used at full capacity, nor talk of completing other phases of the project, which is located at one of the most suitable areas for wheat in Nigeria.

The second irrigation project is the Bakolori Irrigation Project (BIP) which was completed in 1978 with its headquarters in Talata Mafara. Contract for feasibility studies were awarded to a Fiat subsidiary Impressit. It draws water from the Bakolori Dam along the Sokoto River and has an irrigation capacity of 30,000 hectares. This area is the most disadvantaged of the three large-scale irrigation projects (KRPP, BIP and SCIP) for few reasons; the rainy season were shorter and unreliable, the risk of high temperatures was said to reduce the probability of high yields and MRT, a british firm of consulting engineers that was awarded contract for supervising the construction of the project, also said that wheat was only marginally suited for this area. Today, the established irrigation area has decayed, sediments have filled the drainage ditches and hence increased the salinity levels of surrounding farmlands –this might have been caused by salts already in the soil profile due to water logging (Oiganji *et al.*, 2015). Peasant farmers in the area rioted against the project "it was a protracted struggle, a confluence of many grievances which had built up since the italian contractors first entered the area in 1975" **(Andræ and Beckman, 1985**) and it was generally believed that the rejection of the project by the farmers also affected the success of wheat production in the area in addition to the environmental incompatibility.

The third irrigation project is the South Chad Irrigation Project (SCIP) with its headquarters at New Marte, off the Maiduguri-N'djamena Road, Sir M. McDonald & Partners, a member of the British MRT group, was awarded the feasibility studies and the construction. The phase 1 of the project, which roughly has almost the same size as the first two, 22,000 hectares, was completed in 1983. This project is different from the other two both in its environment and in basic design (Andræ and Beckman, 1985) the SCIP draws its water from the Lake Chad—a natural water body that has now lost over 90% of its surface area due to climate change, most of the land has heavy clay soil. Unlike the other two projects, the SCIP has taken over ownership of the whole project area, through the parent body, Chad Basin Development Authority (CBDA), an important arrangement in which farmers are allowed to grow wheat on quasi-tenancy; this sustains wheat cultivation in the area to date. In the 1993 season, CBDA reported harvest of 2,000 tons of wheat for the second consecutive year on a little over 5,000 hectares and realising N11 million (Zanna, 1993). However, Boko haram insurgency has brought wheat cultivation in the region to a complete halt (Bloomberg, 2017).

These large-scale irrigation projects were intended for local wheat production in Nigeria. With their combined total prepared area of about 75,000 hectares and a national average wheat productivity of 1.5 tons per hectare, local wheat production in Nigeria will continue to

be insignificant. Although there are so many small-scale irrigation schemes across the country, such schemes are outside the harmattan latitude that is favourable for spring wheat growing season between November to March

Table 1: Comparative Analysis of Wheat Production Areas and the Crop Productivity in Egypt, Ethiopia and Nigeria. *Source:* GAIN reports 2022

	EGYPT	ETHIOPIA	NIGERIA
Population (Million)	102	115	206
Consumption (Million MT)	23	6.7	5.7
Area (Million Ha)	3	1.7	0.075
Production (Million MT)	9	5.18	0.055
Tons per Hectare	3	3.04	1.5

There is a huge potential to increase wheat production area under irrigation in Nigeria, but for this to happen, favourable policies and strong commitments are required from the government to build the infrastructures (irrigation projects), attract investments (from large-scale commercial farmers) and create access to markets (Tadesse, 2019), by linking farmers with off takers.

Rain-fed System

Wheat cultivation during the rainy season is still not practised commercially in Nigeria despite positive results of trials in the past. Avoiding the negative effect of high temperature and humidity on tillering ability of rainfed wheat is the priority in selecting a suitable growing environment for wheat. Hence, the reason why wheat production was initially reduced to dry-season irrigation cultivation during the cool harmattan season. Later, the highlands regions were very suitable for rainfed cultivation after a series of experimental trials.

Trials were carried out at Gembu in the Mambilla Plateau of Taraba state between 1987 and 1989 (Ikwelle, 1990). This Plateau is an extension of Mount Cameroon that sloped into Nigeria, it lies between Latitude 6° to 7° N and Longitude 10° to 11° E. The altitude of the whole plateau ranges from 1,360 to 1,800m above sea level, the trial site of Gembu is specifically 1,600m above sea level, on the medium. The mean annual rainfall 1,800mm spread over a period of 8 to 9 months. In the first year, 23 different varieties were planted on July 25th at a seeding rate of 100kg per hectare. In the second year, 10 out of the 23 that gave yields above the mean grain yield in the first-year trial were planted in a replicated trial. The experiment was repeated at the same location in the third year. Results showed average grain yield of 1,027kg/Ha, mean plant height of 74.3cm and mean heading date of 50.5 days after planting. The plants were clean, and no disease incidence was observed in the field during the season.

In another trial, to check the effect of sowing date on the growth and grain yield in the same place, Gembu, (Onyenwe, 1990) recorded an average yield of 2 tons per hectare under a mean temperature of 19°C.

The current mean daytime temperature at Gembu during the proposed rainfed growing period (July to October) is 20°C and mean nighttime temperature is about (15.3°C), despite global warming (https://www.weather2visit.com/africa/nigeria/gembu.htm). The mean rainy period is about 280 mm and relative humidity is 80%. Nigeria needs to expand the area of wheat production and the highlands of Mambilla in Taraba state, Obodo in Cross River state and those of Jos in Plateau state offer suitable environmental conditions for commercial wheat production under rainfed conditions.

Government programs and policy misdirection

Past government policies were largely focused accelerating primary wheat production (farming) instead of investing in breeding research and development to develop improved and high yielding varieties. (Andræ and Beckman, 1985) are convinced that politicians in Nigeria are obsessed with wheat import substitution without knowing the actual costs of it or even worse - solving the problems that have rendered wheat a marginal crop.

Government's initiatives such as the Accelerated Wheat Production Programme (AWPP), the Wheat transformation Agenda (WTA) and the current Anchor Borrowers Programme (APB) are example. Seeds productivity is central to increasing the rate of gain and therefore

maximises the ton per hectare output, of which the national mean was abysmally 1.1 under AWPP and still less than 2 under ABP.

The Central Bank of Nigeria re-launched its Anchor Borrowers Programme, after the failure at the first attempt 7 years ago, for wheat in two selected towns of the Jos Plateau (Kwall and Bassa) in November 2022. The CBN said it has disbursed ₦41.2 billion for the Programme dubbed 'The Brown Revolution' and claims to be the first ever major wet season cultivation but was carried out in the dry season. About 50 farmers were given some 2,000 tons of imported seeds from Mexico.

The milling industry

As the primary raw material for making flour and flour-based products like bread, pasta, macaroni, semolina, snacks and cakes, the market for harvested wheat grain in Nigeria is essentially the milling industry.

The Nigerian flour milling industry is saturated with foreign owned companies that serve as 'bridgeheads' for international wheat trading interests and are thus entrenching the importation of foreign wheat grains (Andræ and Beckman, 1985). They seem to prefer imported grain with premium qualities over the Nigeria grown wheat. These are mostly the hard red winter wheat from the US, Canada and Russia. However, a 2017 study by team from the Nigerian Institute of Industrial Research and the Lake Chad Research Institute did a comparative evaluation of five of the eight varieties released by the LCRI and generally being cultivated by Nigerian farmers namely, *Atilla*, *Cettia*, *Reyna-28*, *Seri MSH* and *Norman* with imported wheat flour which served as the Control.

The study which took place at Crown Flour Mill factory in Lagos, revealed that bread loaves of good and acceptable quality can be produced by these varieties, with only Cettia scoring the least value for water absorption and dough development time, indicating its inability to build the gluten network due to low protein content, making it the only poor variety (Adetokunbo *et al.*, 2017). Since then, the flour miller's association of Nigeria (FMAN) have committed to supporting and off taking locally grown wheat.

The wheat milling capacity is estimated to be 8 million metric tons, with an average capacity utilisation of about 50% (Ajansı, 2022). Importation ability of indigenous companies like BUA and Dangote flour mills have been weakened by the disastrous Naira to USD exchange rates, making it difficult for them to operate and eventually were forced to sell-off in 2016 and 2019 respectively. Honeywell Flour Mills attempts to hold-on through dubious means

were later exposed and rebuffed by the CBN (Olowogboyega, 2021). The company was then hurriedly acquired at the verge of bankruptcy by the Greek-US majority owned Golden Penny, now renamed as the Flour Mills of Nigeria PLC.

The industry is very competitive between the FMN and the Olam international of Thailand, an East vs West Oligopolistic struggle that will also shape the future of wheat farming in Nigeria. In 2021, Olam unveiled a 300 million Naira, 10-year community seed system that will increase the production of Durum wheat, while the FMN is championing an out-grower scheme, in a collaboration with the Wheat Farmers Association of Nigeria (WFAN) based on the CBN's failed Anchor Borrowers Programme, now rehashed into The Brown Revolution.

The Future of Local Production in Nigeria

Expansion of the Production area

To increase wheat production in Nigeria, two broad options should be considered. The area under production can be increased and/or productivity should be improved on existing farmland and these two options are not mutually exclusive (Edgerton, 2009).

The current area for wheat production, the harmattan latitudes, span from the Hadejia-Jama'are, Sokoto-Rima and the Lake Chad Basins. These areas, which have over 1 million hectares reserved for irrigation projects but only about 10% were prepared, must be developed in order to increase production by irrigation, which is the most efficient and high yielding of the two wheat farming systems.

We must also expand our production area by exploring suitable areas in the highlands of Obodo in Cross River state, Jos Plateau and the Mambila plateau in Taraba state which provide the optimum growth temperature for rainfed cultivation during the rainy season. Although rainfed wheat production is prone to fungal infections due to high humidity, it is way cheaper and the wheat that can be harvested will not be insignificant.

Molecular Breeding Technologies

The Lake Chad Research Institute (LCRI), as the centre for wheat genetic research and development in Nigeria, should be equipped with the speed breeding facility and a gene bank that will serve as the repository for germplasm exchange between the institute and scientific community (researchers, breeders and academics).

It should also be upgraded with modern technologies such as genotyping, marker-assisted selection, high-throughput phenotyping, genome editing, genomic selection and de novo

domestication that are galvanised with speed breeding protocols to enable crop breeders to fast-track new variety development. The speed breeding technique uses optimal light quality, light intensity, day length and temperature control to accelerate photosynthesis and flowering, coupled with early seed harvest to shorten the generation time (Hickey *et al.*, 2019). Marker Assisted Selection allows for phenotypic selection based on DNA markers, this tool helps plant breeders to select more efficiently for desirable traits (FAO, 2015).

Increasing the productivity of the wheat crop simply means improving the tons per hectare (T/Ha) output of farmlands by improving the wheat crop through genetic improvements. Therefore, we must also prioritise the training of members of the scientific community on molecular breeding techniques that will facilitate the continuous development of heat-tolerant cultivars whose growth and reproductive phases are more adapted to our hot-tempered climates.

A Growth Plan to Accelerate Local Production

With over 200,000 wheat farmers, Nigeria has the required human capital to confront the daunting task of producing 7 million tons of wheat by 2030. However, these farmers are small holders with farm sizes of less than 5 hectares. A robust plan and strategy must be devised for the country to achieve self-sufficiency in wheat production.

The current ABP has limited farmers participation to just one hectare at most. However, progressive farmers will be increasing their cultivation area every year, so it is very important to have a prudent plan that will guide farmers on good agronomic practices (GAPS), provide them with incentives and high-quality inputs, link them with offtakers and most importantly enable their growth, because the farmers will be motivated by the increased harvest and thus increased income. The NAERLS should be engaged to strategize and implement a yield gap reduction plan, which will automatically result in increasing farmers rate of gain as well as increased yield output.

CONCLUSION

External issues like the COVID-19 pandemic, the Russia-Ukraine conflict as well as climate change have compounded and exposed the fragility of Nigeria's wheat value chain. As such, it has become imperative for the government and the private sector to invest and strengthen the wheat production system in the country. To do so, investments should be channelled to address the issues discussed in this essay—starting from the breeding research and development, to the seeds system, to the farming as well as the processing industries.

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