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Boosting rice production through increased mechanisation





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Nigeria's Rice Industry at a glance Production 3.7 million Consumption tonnes* 6.4 million tonnes* Largest rice producer in West Africa ord **2**nd Largest importer Largest rice in the world producer in Africa 0.3hp/ha Mechanisation rate 80% Production segments Small holder farmers % Commercial Top 5 trade partners for rice imports farmers % of rice imports 35.6 3.3 India Thailand **Republic** Brazil China All data as at 2017 except mechanisation rate, production segments and top five trade partners which are 2016 of Benin Sources: USDA, GEMS4, UNCTAD, PwC Analysis, BOI

*Please note that milled rice is used in this report

Executive Summary



Rice is one of the most consumed staples in Nigeria, with a consumption per capita of 32kg. In the past decade, consumption has increased 4.7%, almost four times the global consumption growth, and reached 6.4 million tonnes in 2017 – accounting for c.20% of Africa's consumption. As at 2011, rice accounted for 10% of household food spending, and 6.6% of total household spending*. Given the importance of rice as a staple food in Nigeria, boosting its production has been accorded high priority by the government in the past 7 years. Significant progress has been recorded; rice production in Nigeria reached a peak of 3.7 million tonnes in 2017.

Despite this improvement, comparatively, Nigeria's rice statistics suggest there is an enormous potential to raise productivity and increase production. Yields have remained at 2 tonne per hectare, which is about half of the average achieved in Asia. In addition, as population increases, along with rural to urban migration, ensuring food security in key staples becomes critical. However, food security cannot be achieved by a system that depends almost entirely on human muscle power and other manual methods.

Nigeria's mechanisation has remained low at 0.3 hp/ha, relative to 2.6hp/ha in India and 8 hp/ha in China. The number of agricultural tractors is estimated around 22,000, relative to 1 million and 2.5 million in China and India respectively. Low income, limited access to affordable financing and the lack of technical skills have limited the adoption of mechanisation across the rice value chain.

We estimate that increasing the mechanisation rate in Nigeria from 0.3hp/ha to 0.8hp/ha in the next 5 years, can double rice production to 7.2 million tonnes. To achieve this, we estimate that Nigeria will need to at least triple its current stock of machinery over the same period. In addition to raising production, adequately increasing mechanisation has the capacity to raise yields, increase labour productivity, reduce post-harvest losses, increase income generated by farmers and deepen import substitution.

How will this be achieved?

In recent years, government has changed its approach to mechanisation from providing machinery through subsidised sales to private-sector led hiring services. This model facilitates the establishment of hiring centres, enabling farmers' access machinery without an outright purchase. In addition, subsidies are provided to small-scale farmers who require agricultural machinery.

The hiring services model, if successfully implemented has the potential to change the agriculture mechanisation landscape in Nigeria as it did in India. The hiring services scheme in India increased mechnsiation from 0.63hp/ha to 1.96 hp/ha, promoting self-sufficiency in rice production and placing the economy as the 2^{nd} largest rice producer in the world.

Nigeria's mechanisation gap provides numerous opportunities for investment across the agricultural value chain. To attract the required investment, the government needs to create an enabling environment that ensures mechanisation is profitable. In terms of priorities, the government should concentrate on: addressing challenges around land tenure and ownership, providing rural infrastructure and extension services, and ensuring incentives are transparent and accessible to all investors.

Global Context



Rice is a common food staple consumed by over 50% of the world's population¹. It provides 19% of global human per capita energy and 13% of per capita protein². Hence, rice production is critical to global food security.

Rice is grown on more than 144 million rice farms, mostly smaller than 1 hectare³. This makes rice an important source of employment and income, particularly for the rural people.

Rice production continues to rise, driven by mechanisation

Global rice production has grown at an annual average of 1.0% over the past decade, reaching 486.7 million tonnes in 2017. Most of this growth has come from Asia, accounting for 89% of global output. China and India are the largest producers, each with a share of 29.6% and 22.6% of global production respectively.

In the rest of the world (ex-Asia),rice production has risen steadily over the past decades, accounting for 15% of total production by 2017, a marginal increase from 12% in the last two decades.

Rice production by region (million tonnes)



The application of modern rice cultivation techniques, including mechanisation has been key to improving rice production. In Asia, hiring services increased access to agricultural machinery which enhanced yields and increased rice production.

Top rice producers in Asia by regions South Asia – India, Pakistan, Bangladesh, Nepal East Asia – China, Japan, South Korea Southeast Asia – Vietnam, Indonesia, Thailand In contrast, the pace of mechanisation in Africa has been slow and insufficient to raise rice production. Expansion of land under cultivation for rice which has increased by over 30% in the last decade, has been the main driver of increases in rice output³.

Rice consumption continues to increase, albeit slowly

Global rice consumption remains strong, driven by both population and economic growth in Asia and Africa. Over the past two decades, rice demand increased at an annual average of 1.2% to reach 481.6 million tonnes in 2017⁴.

Rice consumption growth by region



Source: USDA PwC Analysis

Consumption per capita is highest in Vietnam and Bangladesh at 224.8kg and 210.2kg respectively⁵. In recent years however, increasing health awareness has resulted in a slowdown in consumption in Asia as households substitute rice for more nutritious food such as dairy foods, vegetables and other protein rich foods⁶.

Africa's annual average consumption growth has averaged 4.8% in the last decade, outpacing the global rice consumption growth of 1.2%. Nigeria and Egypt account for most of this growth, consuming 30% of Africa's rice, but only 2% globally. Africa ranks the second largest rice importing region the world, with its share of imports rising from 7.6% to 34.1% between 1961 and 2017⁴.

Review of Nigeria's Rice Industry



Gains in rice production have been driven by land expansion

Rice is a predominant staple crop in Nigeria, produced in over 18 states of 36 states⁷. Production has increased at an annual average of 3.7% over the past decade, reaching 3.7 million tonnes in 2017⁴. Growth has been facilitated by an increase in area under cultivation for rice. The area under rice cultivation expanded from about 2.4 million harvested hectares in 2010 to 3.2 million harvested hectares in 2017 – the highest in the last 5 years⁴.

Rice mechanisaton is however low, negatively impacting rice yields and production. Nigeria's rice yield is one of the lowest globally at 2 tonne per hectare, relative to 4 – 7 tonne per hectare in Asia³.

More than 80% of Nigeria's rice is produced by small scale farmers, while the remaining 20% is produced by commercial farmers. In addition, most of the processors are small scale with low capacity (less than 300kg/hr) and obsolete mills.

Production constraints within the rice value chain include low mechanisation, limited supply of agrochemicals and fertilisers, low adoption of modern varieties and inadequate extension services.



Consumption continues to rise, though at a declining rate

According to the National Bureau of Statistics, annual household expenditure on rice accounted for 10% of household food spending and 6.6% of total household spending in 2011. Similarly, the annual consumption per capita of 32kg on rice is the highest of any staple in Nigeria.

Rice consumption slowed in the last decade, advancing at a modest average annual of 4.7% "

Between 1961 and 1990, rice consumption increased from 240,000 tonnes to 2.1 million tonnes, growing at an annual average of 7.8% per annum⁴. The rapid increase in rice demand began in the 1970s, coinciding with the discovery of crude oil. The increase in economic growth as a result of the oil discovery raised per capita incomes, and consumption. In addition, the focus on the oil sector led to the neglect of the agriculture sector, resulting in slower growth in production.

Income and rice consumption per capita



Nigeria continues to rely on rice importation to meet growing rice demand. Moreover, urban consumers generally have preference for imported rice as a result of the perceived higher quality.

In the past 5 years however, rice imports have declined 33.3% reaching 2.7 million tonnes in 2017⁴. This decline has been attributed to reduced demand as a result of Government's policies on import substitution – import tariffs and inclusion of rice in the list of 41 items ineligible for forex in the official market. Despite these, Nigeria remains the single largest rice importer in Africa and the world's third largest, with Thailand and India as its largest import sources.

Government policies provides a boost to rice production

The growth recorded in rice production has been facilitated by government policies towards achieving self-sufficiency in rice production. Government intervention in rice production has leaned towards providing inputs such as improved seedlings and fertilizer to small holder farmers. Also, some state governments have granted land concessions as an investment incentive to large commercial farmers. Towards improving irrigation, government is investing in various irrigation projects. The Zauro irrigation project for instance is targeted at developing water reservoir for the production of 42,000 tonnes of rice.

In addition, through the Central Bank of Nigeria, funding has been made available to rice farmers at affordable rates through the Anchor Borrower's Programme. Also, favourable trade policies by the government – zero tariffs on machinery and equipment, quotas and licenses - have positively impacted domestic rice production.



Machinery and Equipment requirements across the Rice Value Chain



Source: PwC Analysis

Current State of Mechanisation across the Rice Value Chain



Agriculture infrastructure development is lagging with respect to irrigation facilities, feeder roads, rice storage and processors

Source: PwC Analysis

Estimating the Impact of Mechanisation on Nigeria's Rice Production



Nigeria's mechanisation is low relative to other countries

Nigeria's mechanisation rate is low at 0.3 hp/hectare, relative to India 2.6 hp/hectare, Vietnam 2.2hp/hectare and China 8hp/hectare. The FAO identified mechanisation as a key input for developing the agriculture sector in Sub-Saharan Africa, recommending a minimum of 1.5 hp/hectare⁸.

In Africa, 80% of agricultural area is cultivated by human power, with only 5% by tractors⁹. According to Pham (2016), only 7% in rice production is mechanised. The remaining activities are facilitated by draft animals and manual processes, accounting for 15% and 78% respectively¹⁰.

The impact of Government's intervention in agricultural mechanisation has been limited

From the 1980s till date, the Federal Government has sought to enhance mechanisation through several agriculture policy interventions. These range from the establishment of National Centre for Agricultural Mechanisation (NCAM) in 1990, to the recent Mechnisation Implementation Programme (MIP)¹¹.

Similarly, many States have attempted to increase mechanisation through the provision of subsidies for tractor hire. However, the adoption of mechanisation is still low as a result of the bureaucratic processes and inadequate agricultural mechinery

Low income and lack of technical skills limit the adoption of mechanisation

Smallholder farmers, who account for 80% of the agricultural production in Nigeria, have low income and limited access to credit facilities. Hence, high acquisition and maintenance cost of agricultural machinery has limited their capacity for investment in agricultural machinery.

Also, low technical skills have constrained the adoption of mechanisation¹². Without training, smallholder farmers do not have the technical capabilities to operate machinery and equipment.

Mechanisation can double rice production in the next five years

Empirical evidence suggests that mechanisation promotes rice production. According to a study conducted by Sultana et al (2015), which analysed the drivers of increased rice production in 5 Sub-Saharan African countries, including Nigeria, farmers who ploughed with a tractor increased their production by 51% relative to those who utilised manual methods¹³.

An increase in mechanisation rate from 0.3hp/ha to 0.8 hp/ha in the next 5 years, can double rice production to 7.2 million tonnes ,,

In addition, mechanisation reduces production costs and post-harvest losses. Uprety (2010) identified that the introduction of mechanisation in rice farming reduced production costs by 27% and increased profits per hectare by 36% in Nepal¹⁴. Also, the AfricaRice policy stated that the use of appropriate technologies could reduce a country's rice imports by 17%¹⁵.

Based on our analysis*, we estimate that an increase in mechanisation rate from 0.3hp/ha to 0.8hp/ha in the next 5 years, can double rice production to 7.2 million tonnes.

^{*}To estimate the potential impact of mechanisation on rice production, first, we selected four top rice producing countries – China, India, Indonesia and Brazil. Second, we analysed the impact of mechanisation on rice production in these countries. From the results, we obtained a range of coefficients which we used to triangulate the impact of an increase in Nigeria's mechanisation rate on rice production.

The hiring services model is evolving in Nigeria with a potential to change the agriculture mechanisation landscape

Recently, Nigeria changed its approach to increasing mechanisation from providing machinery through subsidised direct sales to private sector hiring services. Through the MIP introduced in 2014, hiring centers were set up to enhance mechanisation within the smallholder famers through hiring services. The scheme was funded by a partnership with government, financial institutions, agromachinery vendors, and service providers. Commercial funding is provided directly to the service providers at an interest rate of 9% payable over 4 years. Also, subsidies are provided to small-scale farmers who require tractor services.

By 2015, the scheme had facilitated the establishment of 118 hiring centres across 28 states with an estimated 400 tractors, 500 power tillers and other machinery. In 2016, the government announced that it had added another 295 tractors to the scheme.

To meet our projected rice production target of 7.2 million tonnes by 2022, we estimate that Nigeria will need to at least triple its current stock of machinery** over the next five years. This would require increased investments in agricultural mechanisation by development agencies, financial institutions and other private sector investors. Thus, the government needs to create an enabling environment that ensures mechanisation is profitable. In terms of priorities, the government should concentrate on: addressing challenges around land tenure and ownership, providing rural infrastructure and extension services, and ensuring incentives are transparent and accessible to all investors.

The role of technology in advancing mechanisation

Technology holds tremendous potential to positively impact

agricultural performance and enhance farmers' income. Mobile coverage in rural Nigeria is estimated at 24%***, and this provides an important platform to raise mechanisation through technology. For instance, in India, one of the leading producers of tractors and farm equipment, Mahindra & Mahindra (M&M) developed a mobile-based app enabling farmers to rent tractors. It also set up call centres so that farmers can place orders by telephone, considering most farmers in the rural areas do not have access to the internet. Similarly, the company established "smartshift", load exchange platform that connects small commercial vehicle owners with people looking to transport their goods. This suggests that technology has the potential to fast-track farm mechanisation by making agricultural machinery available in more rural regions, and connecting smallholder farmers' to markets.



^{**}Following our analysis on impact of mechanisation on rice production, we utilized tractors as a proxy for "stock of agricultural equipment" to estimate the number of machinery required to double Nigeria's rice production. Current stock is estimated at 22,000

*** Data as at 2013

Potential Impact of Agricultural Mechnisation



Enhancing Mechanisation – Case Studies

Learning from California: Mechanisation enhances rice production

Mechanisation drives rice production in California, USA

The United States of America (USA) ranks as the 12th largest rice producer and accounts for 8% of global rice exports. In 2017, USA produced 5.67 million tonnes and exported 3.37 million tonnes of rice, using only an area harvested of 0.97 million hectares – 30% of Nigeria's area harvested⁴. As a result of the USA's high level of mechanisation however, rice production was 50% higher than Nigeria's output in 2017.

	🕕 Nigeria	JUSA	
Production tonnes	3,654,000	5,670,000	
Area Harvested/ha	3,200,000	968,000	2017
Yield - tonnes/ha	2	8	
Mechanisation - Agricultural Tractors	24,800	4,389,812	2007

Rice Production and Mechanisation data (Nigeria vs USA)

Source: FAO, USDA

California is the second largest rice producing state in USA, accounting for 20% of the rice production¹⁶. Prior to 1930s, rice harvesting in California was highly labour intensive with limited use of machines. The process was tedious requiring 4.5 hour/tonne of rice with 2 - 3men to operate a binder. This tedious process resulted in low rice production at less than 0.25 million tonnes annually.

Between the 1930s and 1940s, the introduction of combine harvesters and windrows reduced harvest costs. Prior to the introduction of combine harvesters, rice harvest costs accounted for 63%-67% of total cost of production. However, with combine harvesters, the cost reduced to 27% of total costs. With this, rice production increased from 0.25 million tonnes in 1930 to 0.4 million tonnes by 1940.

By the early 1940s, the advent of World War II negatively impacted labour supply. This facilitated the switch to mechanisation, specifically direct combiners and air dryers, which resulted in a reduction in harvest labour requirements from 4.5 hour/tonne in 1930 to 1.2 hour/tonne by mid 1940s. Following this, rice output reached 0.8 million tons/ year by mid 1940s.



Subsequently, the increased adoption of mechanisation led to an increase in rice production to 2 million tonnes in the mid-1990s. Manufacturers have continued to

1940

Source: Thompson and Black (2000)

1950

1960

1970

Labour-hour/tonne (LHS) Rice Production (RHS)

1980

1990

2000

0

1930

improve the capacity of their machines, with harvest labour hours reducing to as low as 0.15 hour/tonne in the mid-1990s.

0



Learning from India: Boosting the adoption of mechnisation

Like Nigeria, India's rice industry is dominated by small holder farmers accounting for 80% of land holdings with an average farm size of 1.33 hectares¹⁷. Faced with low mechanisation of 0.63hp/ha in the 1980s, the country focused on improving its mechanisation rate to increase agricultural production. Over the years, India has transited from manual farms operations to mechanised operations, achieving a mechanisation rate of 1.96 hp/ha in 2005. As a result, rice yields have doubled to 4 tonne/hectare with rice production increasing by over 80% to 110 million in the last 3 decades.

Key mechanisation and rice production indicators in Nigeria and India

		🕕 Nigeria	💼 India
*	1981	<i>N/A</i>	0.63
Mechanisation rate (hp/ha)		0.27	1.96
	0001980	8,400	382,869
Tractor per hectare (1980 vs 2003)	2003	22,000	2,532,900
<i></i>	1980	1	2
Rice Yield (1980 vs 2017) tonne/ha	2017	2	4
	1980	523	53,631
Rice Output (1980 vs 2017) 1000 tonnes	2017	3,654	110,000

Source: Gummert et al (2013), FAO, USDA

Improving small-holders access to mechanisation: Custom Hiring Approach

In India, custom hiring was a key initiative that accelerated the adoption of mechanisation among small-holders farmers. This approach facilitated the rental of appropriate machines for a specified period of time, usually accompanied with an operator. It enabled farmers access required machinery without purchasing it.

Custom hiring facilitated the transition from low mechanisation in the 1980s (0.63hp/ha) to 1.96 hp/ha in 2005

The National Initiative on Climate Resilient Agriculture (NICRA) set up custom hiring centres across 100 villages in India. With a focus to institutionalise mechanisation at the village level, these centres rented agricultural equipment to small scale farmers. The centres were managed by committees who determined the price and operational model, considering socioeconomic factors and the crop intensity of each village.

Custom hiring facilitated the transition from low mechanisation in the 1980s (0.63hp/ha) to 1.96 hp/ha in 2011. Specifically, tractors per 100 sqkm increased at an annual average of 10% between 1980 and 2000, reaching 130 tractors per 100 sqkm– one of the highest in the world. Also notably, the number of combine harvesters increased from 12,000 to ~350,000 in the same period.

The implementation of custom hiring facilitated other benefits including timely sowing operations with the availability of direct seeders, efficient and timely harvesting operations using threshers, improvement of grain quality using grain cleaners and higher farm produce prices. Also, the scheme addressed fodder and water problems in villages by the introduction of chipper shredders and the use of zero tillage machines saving water and energy. With this, India has been able to consistently produce, meet selfsufficiency and ranks as the 2nd largest rice producer globally.

Lessons from other countries suggests that the adoption of the hiring services model could impact mechanisation significantly

The route to agriculture mechanisation in Asia, for example, provide insights on how Nigeria can mechanise its agricultural sector. From these experiences, it is apparent that the best way to mechanise is for farmers to own their machinery or have a system that enables them hire from others. Also, where mechanisation has been successful, the role of government has in most cases been that of creating and supporting an enabling environment for private sector players to provide mechanisation services.

As farming in most countries in Asia is dominated by non-commercial farmers operating on a small scale, an important component of their agriculture mechanisation programs was making farm machinery available at an affordable price through private-sector led hiring services. This ensured the availability of all machinery required for an entire life cycle of a crop, resulting in a rise in yields and production, as demonstrated in India's rice industry.

Abbreviations

AEHE	Agricultural Equipment Hiring Enterprises
FAO	Food and Agriculture Organisation
hp/ha	horsepower/hectare
MIP	Mechanisation Implementation Program
NBS	National Bureau of Statistics
NCAM	National Centre for Agricultural Mechanisation
NICRA	National Initiative on Climate Resilient Agriculture
USDA	United States Department of Agriculture



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Acknowledgement

We will like to thank the following for their contributions to the development of this report: Dr. Tony Bello, Razaq Fatai, Adedayo Bakare, David Meres, Ibrahim Akanni and Yemi Akoyi



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