

TECHNOLOGY IN AGRICULTURAL TRANSFORMATION AND FOOD SECURITY: HOW WELL HAS AFRICA DONE?

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Abstract

Technology plays essential roles in economic transformation of nations. Africa had long known the central role of technology in sectoral and overall economic transformation of nations. In article Science and Technology of Organization of African Unity (OAU) Charter, member states agreed to strengthen their scientific and technological capabilities to improve the quality of life of their population and ensure the proper application of technology in the development of agriculture, and other sectors of their economies. The study, therefore, sought to examine the progress Africa has made in the application of technology in its agricultural transformation; and the consequent effects of the application on food security in the region. The approach used in examining the subject matter is comparative analytics. Findings make it obvious that agriculture in Africa is not technology – driven, thus, it could not produce more food to reduce food insecurity. So, agriculture in Africa needs some state-of-the-art agricultural technologies for effective transformation. These technologies are: (i) Clustered Regularly Interspaced Short Palindromic Repeats (CRISPR) & Advanced Biotechnology- Gene editing. This technology stabilizes food supplies in areas hit hardest by climate change, and reduces the use of pesticides. (ii) Adaptive laser - weeding. Adaptive Laser-Weeding Machines reduce use of herbicides, and prevents the chemical runoff that changes soil health, and (iii) IoT – Driven precision irrigation - a smart agricultural method which uses networked sensors, cloud computing, and automated controls to deliver exact amount of water to crops.

Keywords: Technology, Agricultural Transformation, Food Security

Introduction

Technology plays essential roles in economic transformation of nations. It is the nucleus of industrialization upon which countries of the world are dichotomized into more-developed countries (MDCs) and less-developed countries (LDCs). Africa had long known the central role of technology in sectoral development and overall economic transformation of nations and regions. The Organization of African Unity (OAU) which was formed on May 25, 1963 sought to “pursue the unity and solidarity of the African States; coordinate and intensify efforts to achieve a better life for the people of Africa” among other objectives. In article 51: *Science and Technology* of OAU Charter, member states agreed to “strengthen (their) scientific and technological capabilities to bring about the socio-economic transformation needed to improve the quality of life of their population; ensure the proper application of science and technology in the development of agriculture, and other sectors of their economies”. They also agreed to “co-

operate in the development, acquisition and dissemination of appropriate technologies (among themselves)" (Africa Today, 1991:21, 46 - 47). Specifically, Africa had known the central role of technology in agricultural development, and the unrivalled role of agriculture in food security. In Article 46: *Food and Agriculture* of OAU Charter, member states agreed to: "co-operate in the fields of agriculture, forestry, and livestock and fisheries development". The aims of the co-operation were to: (a) achieve food security; (b) increase production and productivity in agriculture, livestock, fisheries and forestry, as well as improve conditions of work and generate employment opportunities in rural areas; (c) enhance agricultural production by locally processing animal and plant products, among others (Africa Today, 1991).

On July 9, 2002, OAU was replaced with the African Union (AU) with the objective "To promote unity and solidarity of African States, spur economic development, and promote international co-operation". The African Union seeks to drive development through the Science, Technology and Innovation Strategy for Africa (STISA – 2024/2034) aiming to boost agriculture, health and economic growth. Specifically, the AU regards technology as a critical, veritable and strategic tool to revolutionize key sectors like agriculture, education and health, and develop an African Space Policy and Strategy to enhance development in agriculture, climate forecasting, and disaster management. The main goal of the AU pursuit of technology is to transit Africa from a consumer of technology to a producer and innovator of digital tools.

It is about sixty-three (63) years (from 1963 when OAU was formed) since Africa officially declared its knowledge of technology in economic transformation, and member states agreed to apply technology to transform their agricultural sector to achieve food security. The study, therefore, seeks to examine the progress Africa has made in the application of technology in its agricultural transformation; and to assess the consequent effects of the application on food security in the region. It also seeks to identify some missing variables in agricultural transformation matrix in Africa with a view to raising some imperatives for consideration for technology-driven agriculture in Africa for food sufficiency. The approach used in examining the subject matter is comparative analytics. This method uncovers patterns, trends, and gives insights by looking at things side by side to make informed decision and develop effective strategies.

Conceptual Overview and Theoretical Literature

Technology: What is it?

Technology, simply, is a way of doing things in a society to better the lots of the people of the society. It is practical application of knowledge in art or craft. Technology involves the application of knowledge, thoughts, and skills on available resources to produce goods and services for man's needs. It can be conceived as a set of techniques and skills needed to carry out activities in a society for the benefit of man. It can also be conceived as practical application of knowledge in a particular area. In this case, we can say medical technology, drilling technology or agricultural technology.

Perspectives of Technology

There are two perspectives of technology – the narrow and the broad perspectives. The narrow perspective of technology involves the know-how, that is, information, skills and procedures needed for carrying out particular activities or doing particular things in a society (Akpakpan, 1996). In this perspective, we talk about hard drink production technology, garri production

technology, palm wine production technology, etc. (Essien, 2004).

From a broad perspective, technology involves the cultural traditions developed and applied in a given society for the purpose of meeting the needs of the people of that society (Akpakpan, 1996). In this perspective, we talk about American technology, Ghanaian technology, Italian technology, Japanese technology, Israel technology, Nigerian technology, etc. (Essien, 202)

Components of Technology

In the technology of any activity, there are two components: the design and fabrication technology and the process technology. The design and fabrication technology, involves the knowledge to design and fabricate the needed machines and tools, and to install and operate the productive system. On the other hand, the process technology involves the knowledge of the input combination, and the processing procedures necessary for completing the activity (Akpakpan, 1996). The two components of technology are necessary for development and advancement of technology in any society.

Sources of Technology

There are two broad sources of technology: the endogenous source and the exogenous source. Technology from the endogenous source involves the internally (or locally) generated (or invented) ways of learning, practicing and expressing traditional initiatives in activities. It is a way a society applies artistic and scientific knowledge for production of goods and services to meet the needs of the people of the society (Essien, 2015). It is roundly called endogenous technology. Technology from the exogenous (external) source is referred to as imported or foreign technology. It is commonly called transferred technology. It comprises the information, skills, know-how and procedures needed for doing particular things a society acquired from another country or other countries that originated or invented them. This implies that technology developed in a particular society (or country) for dealing with the problems of that society (or country) is transferred to another country.

Agricultural Transformation

Agricultural transformation is a process by which agriculture – crop production, fishery, forestry, and animal husbandry – shifts from a subsistence-oriented level to a more commercialized level. Agricultural transformation is synonymous with agricultural development, an umbrella concept which explains all positive changes, due to application of technology, for increased production in agriculture for human benefit (Essien and Essien 2025). Agricultural transformation in any society depends on the level of overall development of the society, which informs how the government and the private sector regard agriculture. If a society gives regard to technology-driven agriculture as the unrivalled source of food and raw materials, agricultural transformation to the society would mean the ability of the agricultural sector to yield adequate food to the citizens, and raw materials to the agro – based and agro – allied industries. It would mean the growth of the agribusinesses, including food processing, packaging and distribution, creating new jobs and economic opportunities in agro – allied industries outside the traditional agriculture (Essien and Essien 2025).

Food Security

The United Nations World Food Conference of 1974 conceptualized “food security” as “the supply of adequate food at all times at international and national levels (Simon, 2012). After 35

years, World Food Programme, in 2009, defined food security as “a condition that exists when all people at all times are free from hunger (WFP, 2009:170). This definition by WFP implies a condition of sufficient food supply, which matches food demand. Food security, according to FAO (2017:108) “is a situation which exists when all people at all times, have physical, social and economic access to sufficient, safe and nutritious food that meet their dietary needs and food preferences for an active and healthy life”.

Dimensions of Food Security

The 1996 World Food Summit, from its definition of food security, also identified four dimensions of food security which were subsequently reconfirmed in 2002. The four dimensions

are: (i) availability, (ii) access, (iii) utilization, and (iv) stability.

- i. **Availability:** This is “the amount of food that is physically present in a country or area through all forms of domestic production, imports, food stocks and food aids”. (WFP, 2009:170). Food availability addresses the supply side of food security.
- ii. **Access:** Food and Agriculture Organization, at the World Food Summit (2012) defined access as “having physical, economic and social access to food by all people at all times”. The availability of adequate amount of food in a country or region or in the world does not imply it is accessible and affordable at the household level. World Food Programme (2009: 170) consequently defined food access as ‘a household ability to access adequate amount of food regularly through a combination of purchase, barter, borrowing, food assistant and gifts”.
- iii. **Utilization:** The World Food Summit (2009:170) defined utilization as “safe and nutritious food which meets people’s dietary needs”. Utilization is generally understood as the body makes use of the various nutrients in food. Utilization, as given above is necessary because availability of, and access to, food on their own are not enough; people have to be assured of safe and nutritious food which is determined by food quality, nutritional values, preparation and storage methods (Matemilola and Elegbede, 2017).
- iv. **Stability:** Stability refers to the steadiness in food availability, food accessibility and food utilization at all times, and must occur simultaneously (WFS, 2009). A person needs to get access to food at all times to avoid decline in his nutritional balance. A person whose food intake is adequate today will be considered to be food insecure if he has inadequate access to food on a periodic basis. Instability in food availability will lead to instability in access to food, which will consequently reduce food utilization.

The most critical of the four dimensions is food availability (supply), as food must first be supplied, before it can be accessed; it must be available before it can be utilized; more so, food stability connotes steady food supply.

Theoretical Literature

Issues on food security have received considerable theoretical and empirical attention over the years. Some of such views are presented in this sub-section.

Malthusian Theory of Population and Food Supply

Thomas Robert Malthus (1766 – 1834) was the first, in relatively recent time, to address food scarcity as an issue in relation to growth in human population. In his work, *An Essay on the Principle of Production, as it Affects the Future Improvement of Society*, Malthus (1798), as contained in Blaug (1986), argued that the growth of population is ultimately limited by the food supply. In other words, he postulated that population, when allowed to increase without limit, increases in a geometrical ratio while the food supply can, at least, increase in an arithmetical ratio, thus, making it impossible for agricultural production to sustain growing population indefinitely. Malthus (1798), as contained in Samuelson and Nordhaus (2010), therefore, hypothesized that “The power of population is indefinitely greater than the power in the earth to produce subsistence for man (That is, growing global population will eventually eclipse the earth’s capacity to feed it. The Malthusian theory of population growth in relation to food supply was based on the law of diminishing returns which explains that output from farm land would decrease as more and more of the poorer lands were brought into cultivation (even repeatedly) as a result of population pressure (Essien and Essien, 2023).

Malthus maintained that “Whatever the plausible rate of increase of the food requirements, an unchecked multiplication of human beings would quickly lead to standing room only” (Blaug 1986). It seemed obvious to him that something had to keep the population in check to prevent wholesome starvation, that is, food insecurity. He said that there were two general kinds of check that limit population growth - preventative checks and positive checks. Preventative checks reduce the birth rate while positive checks increase the death rate. In other words, he labeled preventive checks as “manifestations of vice”, which could be achieved through abortion and infanticide, which hold down the birth rate, while the positive checks he labeled as “manifestations of misery”, and can be achieved through war, famine, pestilence, etc, which increase death rate (Blaug, Ibid). He further asserted that population could be checked by “moral restraint”, meaning postponement of the age of marriage accompanied by strict-sexual abstinence before marriage and sexual restraint by married couples.

Malthusian Population Theory over the years has instigated intense arguments; while some scholars, demographers and development analysts are in support of the theory, some are in disagreement and of differing views. Demographers today think that Malthusian view on population growth in relation to food supply was oversimplified despite his careful statistical studies. And that in his discussion of diminishing returns, Malthus did not anticipate the technological miracle of the industrial revolution; nor did he understand that the birth-control movement and new technologies would provide families with the capability to reduce the birth rate (Samuelson and Nordhaus, 2010:522) Malthusian Theory of Population and Food Supply, in the late 20th century, was criticized by some scholars, prominent among them was Boserup (1965)

Qays’s Theory of Food Supply

Qays’s theory of food supply is also known as theory of agricultural intensification. This theory was developed in 1965 by Ester Boserup. Qays’s theory is about the relationship between human population growth and food production. Boserup (1965), in her work “The conditions of agricultural growth: The Economics of agrarian change under population pressure” challenged Malthus’ conclusion that the size of the human population is limited by the amount of food it can produce. Qays’s theory in contrast states that “food production can and will increase to

match the needs of the population". For instance, where population grows rapidly, the theory argues that the threat of starvation and the challenge of feeding more mouths will motivate people to improve their farming methods and invent new technologies in order to produce more food. Boserup (1965) described this as "agricultural intensification". According to Qays's theory, a farmer who has four fields to cultivate and produce food for his family might cultivate three of the fields, and leave the fourth field empty probably due to the ground being very dry, and would not support his crops. However, if the farmer has two more children, the pressure to produce more food might drive him to build irrigation canal to bring water to the fourth field or to buy a different type of seed that will grow in drier ground. He certainly would change the way he farms so as to make sure that he has enough food to support a large family (Boserup, 1965).

Essien, Essien & Etang (2023) argued that Boserup's theory seems to provide a model for continuous population growth and that it failed to consider that growth in human population is continuous, while agricultural land is static. Essien and Essien (2023) observed that Boserup's theory ignored the aspect of population density, increased urbanization and erosion which reduce the size of crop land yearly. According to Pimentel, Huang, Cordova and Pimentel (1997), about 33 per cent or 1.5 billion hectares of world crop land has been abandoned due to erosion. They attributed global food shortage to lower land productivity, which is as a result of continuous environmental degradation theory.

The State of Agriculture in Africa: A comparative Assessment

Food and Agriculture Organization (2024: vi –vii) specified some dimensions for assessment of technology-driven (sustainable) agriculture in an economy. Four of such dimensions are (i) economic; (ii) sustainability and environmental; (iii) production, trade and prices of commodities; and (iv) food security and nutrition. These dimensions have indices. In this subsection, key indices have been selected from the first three dimensions (economic; sustainability and environmental, production, trade and prices of commodities) in the assessment of the state of agriculture in Africa relative to other regions. Key indices of the fourth dimension - food security and nutrition- are analyzed in sub-section 4.0 of the paper.

Economic Dimension of Technology-driven (Sustainable) Agriculture

Economic dimension of agriculture provides an overview of agriculture in a country or region from an economic viewpoint (FAO, 2024: xi). In this dimension, two indices are used for the assessment. They are: (i) share of area equipped for irrigation in cropland area (percent), and (iii) pesticide use per cropland area (tons).

Area Equipped for Irrigation (Thousand HA)/Share in Cropland Area (%)

Areas equipped for irrigation (Thousand HA)/Share in cropland area (%) in regions of the World, between 2000 -2023 are shown in Table 3.1.1.

Table 3.1.1: Area Equipped for Irrigation (Thousand HA)/Share in Cropland Area (%) in Regions of the World, 2005 - 2023

Region	2005		2010		2015		2020		2022		2023	
	'000 ha	%	'000 ha	%	'000 ha	%	'000 ha	%	'000 ha	%	'000 ha	%
Africa	14169	5.8	15123	5.7	16420	5.7	16954	5.6	17043	5.6	17524	5.7
Americas	49459	13.1	51712	13.9	54568	14.7	56946	15.4	57675	15.6	55389	15.0
Asia	217189	38.2	227477	39.8	237627	41.3	248128	43.0	248213	43.1	251093	43.7
Europe	26381	9.0	25824	8.7	26129	9.0	27202	9.4	27216	9.4	27657	9.7

Oceania	3093	10.8	3241	11.5	3298	9.8	3312	9.9	3323	9.8	3323	9.9
WORLD	310291	20.5	322837	21.2	338042	21.7	352543	22.5	353902	22.5	354972	22.6

Source: (1) Food and Agriculture Organization (2024), *The State of Food Security and Nutrition in the World*, pp. 96 – 101.

(2) Food and Agriculture Organization (2025), *The State of Food Security and Nutrition in the World*, p. 104.

From Table 3.1.1, Africa equipped 14169 '000 ha (5.8%) of cropland for irrigation in 2005. Americas in the same year equipped 49459 '000ha (13.1%), while Asia equipped 1217189 '000 ha (38.2 %) of cropland for irrigation. In 2022, Africa equipped 17043 '000 ha (5.6%) of cropland for irrigation, while Asia equipped 248213 '000ha (43%) of cropland for irrigation. In 2023, Africa equipped 17524 '000 ha (5.7%) of cropland for irrigation, while Americas and Asia equipped 55389 '000ha (15%) and 251093 '000ha (43.7%), In 2023, from a pool of five regions, Africa's share of cropland equipped for irrigation was the least – 5.7%. Asia got the highest (43.7%), followed by Americas (15%). A fall from 5.8% share in cropland equipped for irrigation in 2005 to 5.7% in 2023 in Africa indicates that agriculture in Africa is not technology-driven.

Pesticide Use Per Cropland Area (Kg per HA) in Regions of the World, 2000 -2023

Pesticides include insecticides, fungicides, herbicides, disinfectants and any substances or mixture of substances intended for preventing, destroying or controlling any pests in plants and animals (FAO, 2024:56). Table 3.1.2 has data on pesticide use per cropland area in regions of the world between 2000 and 2023.

Table 3.1.2: Pesticide Use Per Cropland Area (Kg per HA) in Regions of the World, 2000 -2023

Region	2000	2005	2010	2015	2018	2020	2021	2022	2023
Africa	0.32	0.40	0.49	0.56	0.65	0.71	0.70	0.69	0.69
Americas	2.41	2.91	3.50	3.92	4.16	4.66	4.62	5.11	4.92
Asia	1.33	1.52	1.97	2.02	1.94	1.67	1.90	1.87	1.86
Europe	1.47	1.56	1.55	1.77	1.72	1.74	1.77	1.64	1.51
Oceania	1.49	1.40	1.75	1.75	2.01	2.01	3.38	4.39	5.01
WORLD	1.47	1.69	2.01	2.16	2.18	2.22	2.29	2.37	2.40

Sources (i) Food and Agriculture Organization (2024) *The State of Food Security and Nutrition in the World*, pp. 96 – 101.

(ii) Food and Agriculture Organization (2025); *The State of Food Security and Nutrition in the World*, p. 159.

From Table 3.1.2, Europe in 2000 used 1.47 kg per ha on its cropland area. It increased pesticide use to 5.11kg per ha in 2022. Oceania used 1.49 kg of pesticide per ha of its cropland in 2000, and increased it to 1.87kg per ha in 2022. Africa in 2000 used 0.38 kg of pesticide per ha of its in 2000, which increased to 0.69 per ha in 2022 and 2023. Between 2000 and 2023, use of pesticide on cropland in Africa each year was not up to 1kg per ha. This, also indicates that Agriculture in Africa is not technology - driven.

Sustainability and Environmental Aspects of Technology-driven Agriculture

Sustainability and environmental aspects of technology-driven agriculture deal with the impacts of agricultural sector on the environment (FAO, 2024: xi). In this dimension, two indices are considered; they are: (i) cropland nutrient balance (kg per ha), and (ii) inorganic fertilizer use by nutrient (thousand tonnes).

Cropland Nutrient Balance (kg per ha)

Cropland nutrient balance is the difference between the quantities of synthetic and organic

nutrients (nitrogen, phosphorus and potassium) added to and withdrawn from cropland by the production of crops and livestock. An excess of nutrients can lead to environmental risks, such as leaching, while insufficient levels of nutrients constraint yield (FAO, 2024:42). Table 3.2.1 contains information on cropland nutrient balance in regions of the world between 2000 and 2021.

Table: 3.2.1 Cropland Nutrient Balance (kg per ha) in Regions of the World, 2000 and 2021

Region	Cropland Nutrient Balance (kg per ha)	
	2000	2021
Africa	8.6	12.6
Americas	35.2	48.3
Asia	79.3	85.4
Europe	40.6	32.9
Oceania	4.8	14.0
World	48.3	51.9

Source: Food and Agriculture Organization (2024) *The State of Food Security and Nutrition in the World*, p. 342.

Cropland nutrient balance is a key indicator of technology-driven agriculture. The higher it is, the more technology – driven agriculture is. In 2000, Oceania had the least cropland nutrient balance of 4.8 kg/ha followed by Africa (8.6 kg/ha). Asia had the highest (79.3kg/ha). In 2021, Asia had the highest cropland nutrient balance of 85.4kg/ha. Africa had the least (12.6kg/ha). This indicates that agriculture in Africa is yet to be technology-driven.

Inorganic Fertilizer Use by Nutrient (Thousand Tonnes), 2000...2023

Inorganic fertilizers are synthetic, man-made substances manufactured to provide plants with concentrated, readily available nutrients. According to FAO (2024:8) inorganic fertilizer use is expressed as the sum of the three nutrients: Nitrogen (N), phosphorus (P_2O_5) and Potassium (K_2O). They bypass the slow natural decomposition required by organic fertilizers and reach plants on demand. The manufacturing of inorganic fertilizers is technology-based. Table 3.2.2 shows regional application of inorganic fertilizers.

Table 3.2.2: Inorganic Fertilizer Use by Nutrient (Thousand Tonnes), 2000....2023

Region	Nitrogen A SN		Phosphorus AS P_2O_5		Potassium AS K_2O	
	2000	2023	2000	2023	2000	2023
Africa	2464.1	4475.1	927.6	1652.6	469.6	913.7
Americas	17433.3	25650.4	8152.3	11259.4	8247.4	14740.1
Asia	46723.3	65314.5	17698.1	23984.8	7864.5	17951.6
Europe	13213.8	13601.5	4092.6	2981.5	4814.1	3643.8
Oceania	1189.7	2550.1	1579.5	968.8	349.0	387.0
World	81024.2	111591.7	32450.2	40847.2	21744.6	37636.1

Source: Food and Agriculture Organization (2025) *The State of Food Security and Nutrition in the World*, p. 164.

From Table 3.2.2, Oceania used 1189.7 thousand tonnes of Nitrogen in 2000, while Africa used

2464.1 thousand tonnes. Asia used the 46723.3 thousand tonnes of Nitrogen, the highest, in 2000. In 2023, Asia used 65314.5 thousand tonnes of nitrogen, the highest. Africa used 4475.1 thousand tonnes. In 2000, Europe used 4092.6 tonnes of Phosphorus AS P_2O_5 , while Asia used 17698.1 tonnes of Phosphorus AS P_2O_5 . Africa used 927.6 tonnes of Phosphorus AS P_2O_5 , the least, the least among regions of the world. In 2023 Oceania used 387.0 while tonnes of Potassium AS K_2O , the least among regions, Africa used 913.7 tonnes of Potassium AS K_2O , while Asia used 17951.6 tonnes of Potassium AS K_2O . From this index, agriculture in Asia is the most technology-driven, while agriculture in Africa and Oceania is less-technology-driven.

Technology-Driven Agriculture: Production, Trade and Prices of Commodities

This dimension of assessment of technology-driven agriculture deals with the volume of Production of primary crops by group (thousand tonnes) and Food Exports, Food Imports and Food Net Trade of regions of the world. Technology-driven agriculture must meet the needs of present and future generations by producing more primary crops.

Table 3.3.1: Production of Primary Crops by Group, (Thousand Tonnes), 2023

Region	Cereals	Sugar Crops	Vegetables	Oil Crops	Fruit	Roots and Tubers
Africa	216.987	109.538	92.225	70.322	137.153	378.788
Americas	817.987	1054.124	80.168	394.497	169.843	80.256
Asia	1525.618	921.235	929.008	578.150	558.404	364.377
Europe	514.466	188.492	81.842	102.420	77.747	99.818
Oceania	60.039	34.497	3.439	18.239	8.759	4.465
WORLD	3134.294	2307.888	1186.682	1163.628	951.906	927.704

Source: Food and Agriculture Organization (2025) *The State of Food Security and Nutrition in the World*, p. 164.

From Table 4.3.1, in 2023, Asia produced 1525.618 thousand tonnes of cereals, the highest. Oceania produced 34.497 thousand tonnes of cereals followed by Africa which produced 216.987 thousand tonnes, the least among the regions. In production of sugar crops, Africa and Oceania produced the lease thousand tonnes of 109.538 and 34.497, respectively. Asia produced 921.235 thousand tonnes of sugar crops, the highest, in 2023. In the production of vegetables, 929.008 thousand tonnes of vegetable, while Americas and Oceania produced the least of 80.168 and 3.439 thousand tonnes, respectively. Africa produced 92. 225 thousand tonnes.

In the production of oil crops, Africa and Oceania produced the least quantities of 70.322 and 28.329 thousand tonnes, respectively. Asia produced 578.150 thousand tonnes of oil crops in 2023, the highest. In fruit production, Asia produced 558.404 thousand tonnes, while Africa and Americas produced 137.57 and 169.842 thousand tonnes, respectively. In tubers and roots production, Asia produces 364.377 thousand tonnes, the highest, followed by Africa, 378.788 thousand tonnes. By this index, Agriculture in Asia tends to be technology-driven among the five regions under consideration; followed by Americas' and Europe's. Agriculture in Africa and Oceania is not technology-driven.

The relatively low yield in primary crop production in Africa may be attributed to some factors. It is important to know that agriculture in Africa is largely rural, operating on subsistence-oriented level. Agriculture at rural, subsistence level in Africa faces some challenges. Farmers of primary

crops for instance usually face the challenge of weeding, which is done manually or by application of herbicides. If weeding by either way is not done on time for about three times before harvest, yield (harvest) will reduce. Also, seeds of some primary crops are not pest-resistant; this also reduces yield. Some years, extreme drought conditions reduce yield. The low yield, therefore, inhibits food exports, but prompts food imports.

Table 3.3.2: Food Exports, Food Imports and Food Net Trade in Regions of the World
USD Million, 2023

Region	Food Exports	Food Imports	Food Net Trade
AFRICA	66822	105335	-38513
AMERICAS	508427	359986	148441
ASIA	381639	642147	-260508
EUROPE	775411	736884	38527
Oceania	72002	23430	48572
WORLD	1803034	1890182	-87148

Source: Food and Agriculture Organization (2025), *World Food and Agriculture Statistical Yearbook*, pp. 234, 239– 244.

From Table 3.3.2, Africa in 2023 imported food worth USD 105335 million, and imported food worth USD 66822 million, which gave the region food net trade of USD –58513 million. Asia also had food net trade of USD -260508 million in 20223. Generally, the world recorded a negative food net trade of \$87148m in 2023.

Technology in Food Security and Nutrition in Africa: A Comparative Assessment

From the four dimensions of food security – availability, access, utilization and stability – the most important dimension is availability (supply), as food must first be supplied, before it can be accessed; it must be available before it can be utilized. Instability in food availability will lead to instability in access to food, which will consequently reduce food utilization. Application of modern agricultural technology will transform agriculture from a subsistence-oriented level to a more commercialized level capable of producing more food to meet the critical dimension of food security – availability – on which other dimensions hang. To analyze food security in Africa relative to other regions, we considered four measures of security. These are (1) Prevalence of Undernourishment, (2) Number of Undernourished People (iii) Prevalence of Food Insecurity at severe Level, and (iv) Number of People Experiencing Food Insecurity at severe Level. Table 4.1 presents prevalence of undernourishment in regions of the World between 2005 and 2024.

Table 4.1: Prevalence of Undernourishment in Regions of the World (%), 2005 -2024

Region	2005	2010	2015	2018	2019	2020	2021	2022	2023	2024
Africa	18.9	15.9	15.9	16.6	17.4	18.5	18.9	18.9	20.0	20.2
Asia	13.8	9.4	7.7	6.5	6.6	7.8	8.1	7.9	7.3	6.7
Latin America and the Caribbean	8.5	5.9	5.0	5.7	5.5	6.1	5.9	5.7	5.3	5.1
Oceania	6.7	7.4	7.1	7.4	7.4	7.0	7.8	7.5	7.7	7.6
Northern America and Europe	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5
WORLD	12.0	8.7	7.7	7.3	7.5	8.5	8.8	8.7	8.5	8.2

Source: Food and Agriculture Organization (2025) *The State of Food Security and Nutrition in the World*, p. 8.

In 2005, from Table 4.1, prevalence of undernourishment in Africa was 18.9%. It reduced to 15.9% in 2015. It increased to 18.9% in 2021, and further increased to 20.2% in 2024. Contrary,

prevalence of undernourishment which was 13.3% in 2005 in Asia reduced to 7.8% in 2020. In 2024, prevalence of undernourishment in Asia reduced to 6.7%. In Latin America and the Caribbean, prevalence of undernourishment which was 8.5 in 2005 reduced to 5.1 in 2024. In Northern America and Europe, between 2005 and 2024, prevalence of undernourishment was less than 2.5%. On a global scale, prevalence of undernourishment reduced from 12.0% in 2005 to 8.2 in 2024. From Table 4.1, it is observed that prevalence of undernourishment reduced notably in all the regions except in Oceania increase of which was mild. However, in Africa, prevalence of under nourishment notably from 18.9% in 2005 to 20.2% in 2024 indicates that agriculture in Africa is not technology-driven as prevalence of undernourishment reached 20.2% in 2024.

Table 4.2 has data on the number of undernourished people in the regions of the world. In 2005, Asia had 552.2 million undernourished people. In 2024, the number had reduced to 323.4 million; a significant reduction. In Latin America and Europe, 47.2 million people were undernourished in 2005; also, the number reduced notably to 33.6 million in 2024. However, in Africa, number of undernourished people which was 178 million in 2005, increased significantly to 306.5 million in 2024. At the global level, number of undernourished people reduced from 788.8 million in 2005 to 673.2 million in 2024. The steady rise in the number of undernourished people in Africa also indicates that agriculture in Africa is not technology-driven as it could not produce enough food to reduce the number of undernourished people in the region.

Table4.2: Number of Undernourished People in Regions of the World (Millions), 2005 -2024

Region	2005	2010	2015	2018	2019	2020	2021	2022	2023	2024
Africa	178.0	170.1	193.7	217.9	233.9	255.2	267.3	272.9	296.2	306.5
Asia	552.2	397.5	343.0	301.8	306.7	366.2	382.2	375.7	347.2	323.4
Latin America and the Caribbean	47.2	35.0	31.2	36.4	35.0	39.8	38.4	37.1	35.1	33.6
Oceania	2.3	2.8	2.9	3.2	3.2	3.1	3.5	3.4	3.5	3.5
Northern America and Europe	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.
WORLD	788.8	612.7	577.4	564.9	564.1	670.1	697.5	695.2	688.4	673.2

Source: Food and Agriculture Organization (2025) *The State of Food Security and Nutrition in the World*, p.9. Note: n.r. =not reported, as prevalence is less than 2.5 percent (FAO, 2025, P. 9).

Prevalence of food insecurity at severe level is one key index of assessment of food insecurity. From Table 4.3, prevalence of food insecurity at severe level in all the regions, and at the global level increased between 2015 and 2024. In Asia, it increased from 6.6% in 2015 to 8.7 in 2024. In Africa, prevalence of food insecurity at severe level which was 16.6% in 2015, the highest among the regions of the world, increased to 22.2% in 2024, again, the highest. (see Table 4.3).

Table 4.3: Prevalence of Food Insecurity at severe Level in Regions of the World (%), 2015 -2024

Region	2015	2019	2020	2021	2022	2023	2024
Africa	16.6	19.0	20.7	21.3	21.2	21.3	22.2
Asia	6.6	8.2	9.8	10.1	9.4	9.4	8.7
Latin America and the Caribbean	6.0	8.1	10.5	11.5	10.2	8.1	7.8
Oceania	8.5	9.5	8.6	10.1	9.3	10.4	9.6
Northern America and Europe	1.3	0.9	1.1	1.4	1.5	1.6	1.5
WORLD	7.4	9.0	10.5	11.0	10.5	10.4	10.1

Source: Food and Agriculture Organization (2025) *The State of Food Security and Nutrition in the World*, p. 16.

The number of people experiencing food insecurity at severe level reduced only in Asia from 2955 million in 2015 to 417.5 in 2024 (Table 4.3). In Oceania, it increased from 3.4 million people in 2015 to 4.4 million in 2024.

Table 4.4: Number of People Experiencing Food Insecurity at Severe Level in Regions of the World (Millions), 2015 - 2024

Region	2015	2019	2020	2021	2022	2023	2024
Africa	202.4	256.1	285.3	301.7	306.2	315.6	336.9
Asia	2955	383.3	457.9	475.5	445.8	449.4	417.5
Latin America and the Caribbean	37.4	51.9	68.0	74.9	66.9	53.1	51.8
Oceania	3.4	4.1	3.8	4.5	4.2	4.8	4.4
Northern America and Europe	14.6	9.8	12.7	15.3	16.9	18.6	17.4
WORLD	553.2	705.3	827.6	872.6	840.0	841.4	8280

Source: Food and Agriculture Organization (2025), *The State of Food Security and Nutrition in the World*, p. 17.

In Africa, the number of people experiencing food insecurity at severe level increased from 202.4 in 2015 to 336.9 in 2024. The world also experienced increase in the number of people experiencing food insecurity at severe level from 553.2 million in 2015 to 8280 in 2024. Of the four regions that experienced increase in the number of people experiencing food insecurity at severe level, increase in Africa is also notable.

Recommendations

Africa needs modern agricultural technologies in its agricultural transformation matrix. From our findings, the following technologies are recommended for inclusion in Africa's Agricultural Transformation Matrix:

1. Clustered Regularly Interspaced Short Palindromic Repeats (CRISPR) & Advanced Biotechnology- Gene editing. This technology is used to build resilience directly into seeds. Crop scientists, use CRISPR technology to develop crops that are resistant to specific regional pests or extreme drought conditions. This stabilizes food supplies in areas hit hardest by climate change. This technology reduces the use of pesticides.
2. Adaptive laser- weeding
This involves the use of machines with sensors capable to identify plant species in real-time. The machines use thermal lasers to kill weeds instantly. The use of Adaptive Laser-Weeding Machines reduces use of herbicides by approximately 50 percent and prevents the chemical runoff that changes soil health.
3. IoT – Driven precision irrigation
IoT – Driven precision irrigation is a smart agricultural method which uses networked sensors, cloud computing, and automated controls to deliver exact amount of water to crops. Low water sensors embedded in the soil measure moisture and nutrient levels. When levels drop, the system automatically triggers localized irrigation, boosting water efficiency by up to 60 percent.

Conclusion

Africa officially declared its knowledge of technology in economic transformation in 1963 following the formation of Organization of African Unity in 1963, and member states agreed to apply technology to transform their agricultural sector to achieve food security. Africa, again, reaffirmed its commitment to adopt technology to develop agriculture and other sectors of its

economy following the formation of African Union in 2002. From the three dimensions for assessment of technology-driven (sustainable) agriculture in an economy, considered in this article, (i) economic; (ii) sustainability and environmental; (iii) production, trade and prices of commodities, it is observed that agriculture in Africa is less-technology-driven relative to other regions of the world. Also, from the assessment of the four measures of food security considered in this study, (i) Prevalence of Undernourishment, (ii) Number of Undernourished People (iii) Prevalence of Food Insecurity at severe Level, and (iv) Number of People Experiencing Food Insecurity at severe Level, it is obvious agriculture in Africa is not technology – driven, thus, it could not produce more food to reduce food insecurity. So, agriculture in Africa needs some state-of-the-art agricultural technologies for effective transformation.

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