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How has Rice Production in Sub-Saharan Africa Expanded? A Comparison of Growth Rates Before and After CARD Implementation and the Case of Tanzania

Hitoshi Fujiie[*] and Fumihiko Suzuki[†]

Abstract

In sub-Saharan Africa (SSA), the rapid expansion of rice consumption in recent years has led to increased production. It is assumed that the expansion of rice production in SSA is mainly due to an increase in production area, while the total amount of unutilized arable land is decreasing. In this paper, we first analyze the changes in rice production before and after the launch of the Coalition for African Rice Development (CARD) using the compound average growth rate (CAGR). The results show that, recent rice production in many countries has expanded at a higher rate and that this growth has been mainly driven by an increase in production area. We also analyze the factors that brought about productivity improvements based on the example of Tanzania, which achieved production growth through productivity improvements after implementing CARD. In Tanzania, a comprehensive strategy for the promotion of rice cultivation has been developed, and the dissemination of cultivation techniques, expansion of irrigated areas, and promotion of mechanization under this policy have contributed to improved productivity. Based on the findings of this study, many countries need to transition from the phase of expanding production area to that of improving productivity. To achieve this, it will be necessary to address issues directly related to improving productivity, such as irrigation improvement and the dissemination of proper cultivation technology.

Keywords: Rice, CAGR, Sub-Saharan Africa, Tanzania, Coalition for African Rice Development (CARD)

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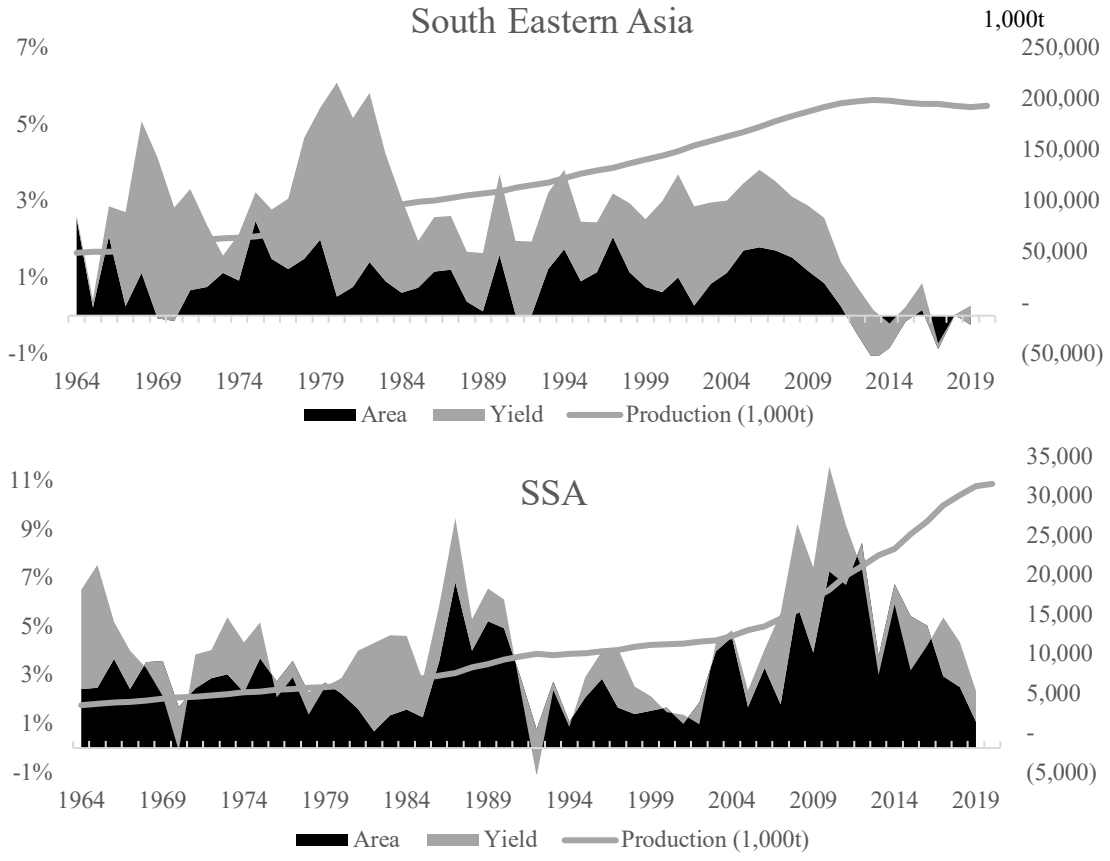
1. Introduction

In sub-Saharan Africa (SSA), rice consumption has increased rapidly since the late 2000s due to rapid economic growth and associated urbanization. In line with this trend, rice production has also increased in many countries in SSA, primarily attributed to the expansion of production areas.

Nevertheless, researchers have noted the diminishing availability of surplus arable land across SSA (Chamberlin et al. 2014), suggesting that the opportunity for area expansion is likely to decrease in the long term—a factor observed in many Asian countries. A shift to increasing production through productivity improvements is therefore essential.

Figure 1 shows the year-on-year growth rate of harvested areas and yields per hectare of rice in Southeast Asia and SSA. The production increase through the expansion of harvested area had already reached its limits in Southeast Asia in the early 1960s, but the introduction of seed-fertilizer technology, known as the Green Revolution, led to increased production from the late 1960s due to higher yields. In SSA, on the other hand, production remained stagnant until the beginning of the 2000s, and although production has increased rapidly since then, this has been consistently achieved by increasing the harvested area.



Source: By the auther from FAOSTAT

Figure1: Year-on-year growth ratio of the rice production area and yield in South Eastern Asia and SSA

In SSA, the Coalition for African Rice Development (CARD) was launched in 2008, with Phase 1 running from 2008 to 2018 and Phase 2 being implemented from 2019 to 2030. In Phase 2, 32 member countries [1] are specifically targeting the advancement of the rice industry.

The objective of CARD Phase 1 was to achieve a doubling of rice production in SSA from 2008 to 2018 (from 14 to 28 million tons (paddy basis)) and for CARD Phase 2 to achieve a further doubling from 2018 to 2030 (from 28 to 56 million tons) (CARD Secretariat 2019a). As noted above, CARD member countries include 32 countries in SSA as of 2023, as well as steering committees formed by the 12 Development Partners and four Regional Economic Communities (RECs).

According to the CARD Secretariat (2019b), the main functions of CARD are to support member countries in formulating their National Rice Development Strategies, provide information to member countries, promote the efficient implementation of rice-related programs through advocacy, mobilize the resources needed to implement the NRDS in each country, and monitor the progress of rice development by member countries. As of 2023, 25 out of 31 countries have officially validated and launched NRDS. During Phase 1 (2008–2018), USD 9 billion was mobilized for rice sector development through CARD by the development partners (World Bank, African Development Bank, JICA, etc.) and member countries. As a result of those efforts, CARD Phase 1 achieved its goal of doubling rice production by 2018.

Several research projects have been undertaken to consider the potential of rice cultivation in SSA as a whole, focusing on the recent increase in rice production in SSA (Balasubramanian et al.

2007; Saito et al. 2023). Based on the cases of Mozambique, Tanzania, Uganda, and Ghana, Otsuka (2015) found that productivity increased dramatically in areas where Asian-type cultivation techniques were introduced, while productivity stagnated in areas where they were not.

Many studies have also focused on the technical aspects of rice cultivation in SSA, especially productivity (Abe 2012; Bola et al. 2013; Kolawole and Olufemi 2019; Mdoe and Mlay 2021; Nakano and Kajisa 2014; Yamane et al. 2019). However, few studies have focused on the CARD initiative and analyzed changes before and after the launch of the project. Arouna et al. 2021 applied the ARIMA model to analyze the contributions of CARD to the growth of rice production

[1] Angola, Benin, Burkina Faso, Burundi, Cameroon, Central African Republic Chad, Congo, Côte d'Ivoire, Democratic Republic of the Congo, Ethiopia, Gabon, Gambia, Ghana, Guinea, Guinea-Bissau, Kenya, Liberia, Madagascar, Malawi, Mali, Mozambique, Niger, Nigeria, Rwanda, Senegal, Sierra Leone, Sudan, Togo, Uganda, Tanzania, and Zambia,

in SSA from 2008 to 2018, when CARD Phase 1 was implemented. However, no study has yet conducted an in-depth analysis of the changes in rice production by country before and after CARD.

In this paper, therefore, we examine how rice production in sub-Saharan Africa changed before and after CARD implementation, using country-specific data introduced in Section 2. We use FAOSTAT data to analyze whether there was a change in the trend of rice production expansion before and after CARD and whether there was a change in the factors contributing to the expansion of production. In addition to changes in production, harvested area, and productivity in each country, the compound average growth rate (CAGR) will be calculated and compared. Differences in CAGR changes in harvested area and productivity among countries will also be analyzed.

In Section 3, the case study of Tanzania is examined, as productivity growth in Tanzania has been the main driver of rice production expansion since the implementation of CARD. Existing research and key informant interviews are used to analyze the drivers of productivity growth. Key informant interviews were conducted in May 2022 with experts working on rice promotion projects in Tanzania for an extended period. After summarizing the main findings, Section 4 considers the implications for rice production expansion in SSA.

2. Rice production before and after CARD

In this section, we review the trends in rice production in 31 of the 32 CARD-member countries.[2] Table 1 compares the average production, average harvested area, and average yield for Period I—the 13 years from 1996 to 2008 before CARD began—followed by Period II for the 13 years from 2009 to 2021 using FAOSTAT country data.

The average production for all 31 countries increased 2.1 times, from 12,533 thousand tons to 26,417 thousand tons, harvested area increased 1.7 times from 7,426 thousand hectares to 12,875 thousand hectares, while yield increased only 1.1 times, from 1.87 t/ha to 2.2 t/ha. However, production, harvested area, and yield increased statistically significantly from Period I to Period II, indicating that rice production has been growing steadily in SSA since the launch of CARD.

Looking at these trends by country, only two countries show a decrease or no statistically significant increase or decrease in production from Period I to Period II. Similarly, only three countries show either a decrease or no statistically significant increase or decrease in harvested

[2] Of the 32 countries, Sudan is excluded from the analysis here because long-term data are not available due to the independence of South Sudan in 2011.

area. On the other hand, there are 12 countries with decreasing or no statistically significant increase or decrease in yield. This data shows that the increase in rice production in SSA was achieved mainly through area expansion.

Table1: Average production, average harvested area, and average yield in 31 African CARD countries

Country	NRDS[a]	Period I (1996-2008) Production (1,000t)	Area (1,000ha)	Yield	Period II (2009-2021) Production (1,000t)	Area (1,000ha)	Yield	Difference Production (1,000t)	Area (1,000ha)	Yield
Ethiopia	2009	11	6	1.78	137	48	2.87	126***	42***	1.09***
Benin	2011	56	23	2.31	298	84	3.50	242***	60***	1.19***
Senegal	2008	223	87	2.52	841	233	3.71	619***	146***	1.19***
Cameroon	2008	56	35	2.12	251	199	1.35	195***	164***	-0.76**
DR Congo	2013	327	434	0.75	1,025	1,185	0.85	697***	751***	0.09**
Burkina Faso	2012	102	50	2.06	336	155	2.17	233***	105***	0.12
Ghana	2008	240	120	2.01	690	250	2.72	449***	130***	0.71***
Mali	2008	876	377	2.29	2,345	746	3.12	1,469***	369***	0.83***
Côte d'Ivoire	2010	650	372	1.77	1,667	644	2.58	1,017***	271***	0.81***
Zambia	2011	14	12	1.23	42	29	1.46	28***	17***	0.23**
Tanzania	2008	989	568	1.76	2,396	1,009	2.37	1,406***	441***	0.61***
Nigeria	2008	3,334	2,244	1.49	7,224	3,369	2.11	3,889***	1,124***	0.62***
Togo	2010	74	35	2.14	149	78	1.96	75***	43***	-0.18
Kenya	2008	47	14	3.53	120	27	4.41	72***	13***	0.88*
Mozambique	2008	131	226	0.72	174	297	0.63	43**	72**	-0.09
Rwanda	2011	33	9	3.39	99	25	4.31	67***	16***	0.91**
Guinea	2008	1,174	670	1.75	2,065	1,613	1.29	891***	943***	-0.46***
Liberia	2012	166	135	1.21	282	246	1.15	115***	110***	-0.06
Gambia	2014	25	16	1.58	53	66	0.80	29***	50***	-0.79***
Uganda	2008	122	86	1.42	231	89	2.60	109***	3	1.18***
Madagascar	2008	2,926	1,222	2.39	4,109	1,328	3.14	1,183***	106*	0.76***
Sierra Leone	2008	489	407	1.19	1,091	712	1.58	602***	305***	0.39***
Central African Republic	2012	29	18	1.60	21	13	1.59	-8*	-5**	-0.01
Angola		8	8	1.11	21	19	1.23	13***	12***	-0.12
Burundi	2014	60	19	3.20	100	40	2.47	40**	21***	-0.73***
Chad		120	93	1.30	246	172	1.41	126***	79***	0.11
Congo		1.2	1.8	0.67	1.2	2.0	0.60	0	0.2***	-0.07***
Gabon		1.0	0.5	2.20	1.6	0.6	2.75	0.6***	0.1***	0.55***
Guinea-Bissau	2015	102	68	1.51	185	110	1.69	83***	43***	0.18**
Malawi	2014	81	49	1.64	122	65	1.87	41***	16***	0.23**
Niger	2009	64	22	3.13	96	24	3.93	32***	2	0.80***
SSA(31 country)		12,533	7,426	1.87	26,417	12,875	2.20	13,883***	5,449***	0.33***

Source: FAOSTAT

Note: *** denotes significant at 1%, ** significant at 5%, and * significant at 10% in t-test comparison between the Priod I and II.

[a] Year of launch the National Rice Development Strategy.

Next, the Compound Average Growth Rates (CAGR) for the respective periods of Period I and Period II are shown in Table 2.[3] In SSA as a whole, production continued to grow by 3.3% per annum during Period I, indicating that rice production increases began in the 1990s. Furthermore, in Period II, the CAGR has risen to 5.0% per annum, accelerating the rising trend in rice production since 2009. Looking at the drivers of this increase, the CAGR of the harvested area is 2.4% per annum in Period I and 1.6% in Period II, while the CAGR of yield is 0.3% and 0.1%, respectively, indicating that the production increase has been driven by the expansion of the harvested area.

By country, only 15 countries have higher CAGR in Period II than in Period I: Ethiopia, Senegal, Cameroon, DRC, Burkina Faso, Ghana, Mali, Cote d'Ivoire, Nigeria, Togo, Kenya, Mozambique, Guinea, Burundi and Chad. The higher CAGR in Period II compared to Period I can be explained by the rapid increase in rice production in these countries. On the other hand, only 22 of the 31 countries in Period II achieved positive CAGR. Of these 22 countries, 21 increased their harvested area, while 14 countries have growth in yield. Tanzania and Kenya are the only two countries where the growth rate of yield is higher than the growth rate of harvested area.

[3] CAGR was calculated by regressing time series data on production, harvested area, and yield exponentially against time using the following equation.

$Y_t = abe^u$

where Yt is the dependent variable (area, production, and yield) for which the growth rate was estimated, a is the intercept. b is b = (1 + r), where r is the annual growth rate. t is the year (period) and u is the error term in year t. This equation was transformed to log-linear and estimated by the ordinary least squares method.

Table2: Compound average growth rate (CAGR) for rice production, harvest area and yield in 31 African CARD countries

	Period I (1996-2008)			Period II (2009-2021)		
	Production	Area	Yield	Production	Area	Yield
Ethiopia	-14.8%	-13.2%	-1.8%	7.0%	5.5%	1.4%
Benin	11.5%	7.1%	4.1%	10.3%	8.5%	1.6%
Senegal	4.3%	2.8%	1.4%	11.2%	12.5%	-1.1%
Cameroon	3.8%	17.5%	-11.6%	9.1%	12.1%	-2.7%
DR Congo	-0.9%	-0.9%	0.0%	10.8%	7.2%	3.3%
Burkina Faso	1.2%	1.4%	-0.2%	5.3%	5.1%	0.2%
Ghana	1.9%	0.6%	1.3%	8.7%	6.9%	1.6%
Mali	6.3%	2.5%	3.7%	6.4%	4.9%	1.4%
Côte d'Ivoire	0.7%	-1.7%	2.5%	5.8%	3.7%	2.0%
Zambia	4.9%	1.7%	3.1%	-1.3%	0.7%	-2.0%
Tanzania	6.5%	4.2%	2.3%	5.1%	0.8%	4.2%
Nigeria	1.6%	2.4%	-0.8%	8.4%	7.1%	1.3%
Togo	-0.4%	-2.4%	2.1%	1.4%	5.5%	-3.9%
Kenya	-1.2%	4.6%	-5.6%	7.1%	1.0%	6.1%
Mozambique	-6.9%	6.3%	-12.5%	-2.6%	2.0%	-4.5%
Rwanda	25.8%	18.9%	5.8%	5.2%	9.2%	-3.6%
Guinea	3.4%	2.8%	0.6%	4.1%	3.2%	0.9%
Liberia	3.0%	2.4%	0.6%	-0.9%	0.1%	-1.0%
Gambia	2.0%	4.0%	-1.9%	-7.3%	-0.6%	-6.8%
Uganda	6.9%	7.0%	-0.1%	1.7%	-0.1%	1.8%
Madagascar	4.0%	0.8%	3.2%	-0.9%	2.6%	-3.4%
Sierra Leone	8.9%	8.2%	0.7%	1.4%	3.4%	-1.9%
Central African Republic	9.1%	7.1%	1.8%	-10.6%	-8.9%	-1.8%
Angola	-4.7%	7.6%	-11.5%	-7.1%	-11.4%	4.8%
Burundi	3.7%	2.7%	1.0%	7.2%	7.6%	-0.4%
Chad	1.9%	3.2%	-1.2%	4.4%	3.4%	0.9%
Congo	0.7%	2.4%	-1.7%	-2.3%	-1.7%	-0.6%
Gabon	2.8%	1.1%	1.7%	1.6%	0.7%	0.9%
Guinea-Bissau	2.0%	1.1%	0.9%	0.3%	2.1%	-1.8%
Malawi	1.9%	3.1%	-1.1%	1.0%	1.5%	-0.4%
Niger	-0.3%	-4.9%	4.8%	-0.7%	0.5%	-1.2%
SSA(31 country)	3.3%	2.4%	0.3%	5.0%	4.6%	0.1%

Source : Authors

Table3: CAGR of harvest area for all cereal crops and rice in 31 African CARD countries

	1961-2020	1961-1970	1971-1980	1981-1990	1991-2000	2001-2010	2011-2020
All cereal crops	2.2%	1.9%	-0.5%	5.8%	2.0%	2.8%	1.6%
Rice	3.0%	2.8%	2.9%	3.3%	1.7%	3.6%	4.2%

Source : By the author from FAOSTAT

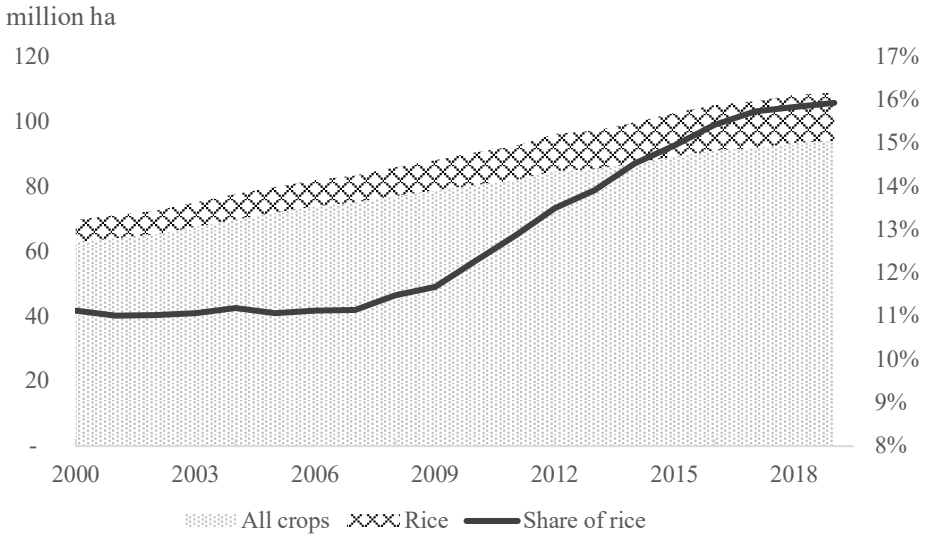
The harvested area of rice has been consistently increasing since 1960, and growth has been accelerating since the 2000s. Beginning in the 2000s, the growth rate of rice was higher than the overall grain growth rate, especially in the 2010s, when the difference was 2.6%. Figure 2 shows the total grain harvested area and the share of rice in that area. The share of rice in the total grain harvested area was about 11% until the early 2000s but began to increase rapidly in the mid-2000s, reaching 16% in the late 2010s. This implies that part of the expansion of rice harvested area has been due to crop conversion rather than newly developed farmland. As mentioned above, however,

with the slowdown in the increase of new farmland development, expansion of rice production area by crop conversion will soon stagnate, and thus, productivity improvement will be vital for a further production increase.

As described above, the expansion of rice production in SSA has been driven by an increase in harvested area, but this trend is not limited to rice alone. Seo (2017) found from FAOSTAT data that, underpinning the long-term trend of grain production in SSA, the expansion of harvested area is the main driver of production growth. Table 3 shows the CAGR of harvested area of all grains and rice from 1961 to 2020. From 1961 to 2021, grain harvested area expanded by 2.2% per annum. While the growth of harvested area stagnated in the 1960s and 1970s, it expanded rapidly in the 1980s, reaching 5.8% per annum. By the 1990s and 2000s, growth had returned to the 2% level. In the 2010s, the rate declined to 1.6%, the second lowest since the 1970s, when there was negative growth. This suggests that the expansion of harvested area, which had been continuing since the 1980s, may have reached a ceiling. In addition, OECD and FAO (2016) projected an annual growth rate of 1.0% for the area of cereal production until 2025, meaning that it will be difficult to increase production through area expansion in SSA.

Consequently, the question arises as to how such productivity improvements might be realized. As mentioned above, a comparison of the CAGR of harvested area and yield since 2009 shows that the growth rate of harvested areas is higher in most countries, with only two countries, Tanzania and Kenya, experiencing a growth rate of yield that is higher than the growth rate of harvested area. The next section focuses on Tanzania as a case study. Despite the fact that the area under rainfed cultivation is still larger than that under irrigation,[4] productivity in Tanzania has steadily increased. We will analyze the factors behind the recent improvements in productivity using existing studies, statistical data, and interviews with JICA experts who have been engaged in rice promotion.

[4] In Kenya, 75% of rice is cultivated under irrigated conditions (Ministry of Agriculture, Livestock, Fisheries and Cooperatives 2020).



Source: by authers from FAOSTAT

***Figure* 2** : Harvested area for all crops and rice

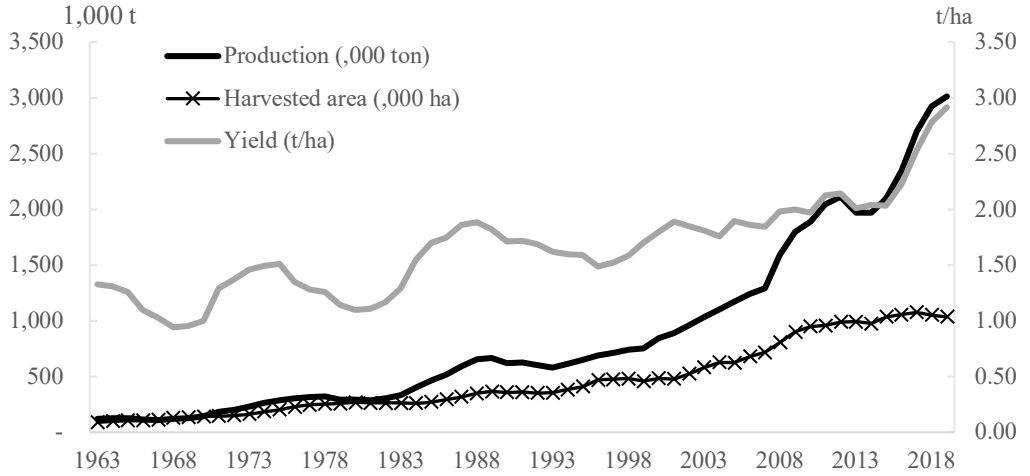
3. Case study: Rice Production in Tanzania

Table 3 shows the long-term trend of rice production, harvested area and yield in Tanzania. Rice production has been gradually increasing over a long period. However, increases in production became more remarkable around 2000 due to growing demand as a result of population growth, urbanization, and higher incomes, with the most rapid increase occurring since 2009 (Lazaro, Sam, and Thompson 2017). Furthermore, the demand for rice within Tanzania is projected to continue to grow, and as a result, the expansion of rice production has become a major policy issue for the Government of Tanzania (Trevor and Lewis 2015).

Looking at the trends of rice production in Tanzania, both production area and yield have been increasing. However, the expansion of production area has remained stagnant since 2010 while yield has been improving rapidly. Consequently, the rapid production increase in recent years can largely be explained by yield improvement. Rice yield is determined by various factors. Multiple studies in Africa have found that yields increase when farmers use improved seeds, irrigation, and basic cultivation techniques, such as leveling, line planting, and proper weeding (Bola et al. 2013; Kolawole and Olufemi 2019; Mdoe and Mlay 2021; Nakano and Kajisa 2014). It has also been reported that there is a difference of yield under rainfed and irrigated conditions (Abe 2012; Yamane, Ichijo, and Asanuma 2019; Nakano and Kajisa 2014).[5]

[5] Abe (2012) states that the creation of suitable paddy fields is a crucial prerequisite for irrigation development. Ofori et al. (2006) also found that improved varieties and chemical fertilizers are ineffective when appropriate paddy fields are not created.

What, then, is the driver of the recent rice production increase in Tanzania, especially yield? We analyze the possible factors that may affect recent yield improvement in the subsectors of the rice sector based on previous studies, statistical data, and interviews with JICA experts who have engaged in Tanzania's rice sector.



Source: by authers from FAOSTAT

Figure 3 Rice production, area and yield in Tanzania (5 years moving average)

3.1 Rice development policy

Tanzania has implemented policies to enhance rice production at the sub-sector level. Programs for input subsidies were introduced in the 1960s, and in 2008, the National Agricultural Inputs Voucher Scheme (NAIVS)—an extensive input subsidy program for maize and rice—was introduced. In 2005, import tariffs were increased from 25% to 75% in order to protect domestic rice. However, those policies are associated with a limited number of farmers being able to access program services and are said to have had negative impacts, such as regional disparities and widening gaps between small and large-scale farmers[6] (Mdoe and Mlay 2021).

In 2009, the Government of Tanzania launched the National Rice Development Strategy (NRDS) with the objective of doubling rice production by 2018.[7] This was followed by a second version of the NRDS in 2019. Unlike previous subsector-specific policies and programs, NRDS takes a more comprehensive view of the entire rice value chain and identifies necessary measures and priorities. As shown in Table 4, the NRDS identifies irrigation, marketing, mechanization, and

[6] According to Mdoe and Mlay (2021), import tariffs did not apply to Zanzibar, so the objective of protecting rice farmers was not achieved, as cheap imported rice continued to flow through Zanzibar. In addition, Tanzania introduced a rice export licensing system in the 1980s, but due to corruption and other factors, priority was given to large farmers with strong lobbying power, resulting in a widening gap with small farmers.

[7] In 2019, NRDS 2 was being formulated as the successor to NRDS.

better access to agricultural inputs such as extension and improved seeds as priority areas (United Republic of Tanzania 2009). Efforts to promote certified seed and improve access to inputs and credit—which were strengthened in the framework of the NRDS—have had the effect of enhancing the productivity of small farmers, who have hitherto not fully benefited from subsector-specific support (Ntengua and Glead 2021).

Another feature of the NRDS is that it has set the goal of doubling on-farm rice productivity from 2 t/ha to 4 t/ha by 2030. The approach includes mechanization and improved access to agricultural inputs, promotion of climate-resilient varieties, increasing the number and capacity of extension officers, promotion of good agriculture practice (GAP), linking research and extension, promoting investment in research, improving farmers' access to information, promoting soil testing, formalizing ownership of farmland, promoting the use of agricultural inputs, and strengthening farmers' groups (United Republic of Tanzania 2009).

Table4: Outline of NRDS 1 (2009)

Seed System	・Producing basic and certified rice seeds ・Strengthening rice seed distribution network in the country ・Supporting on-farm seed production ・Creating awareness of available seeds of rice varieties to farmers ・Strengthening the capacity of public and private seed companies
Genetic resources conservation and use	・Collecting, characterizing and conserving germplasm for future mining of novel genes against biotic and abiotic stresses ・Building capacity in terms of facilities for both the rice research program and the National Plant Genetic Resource Centre ・Developing high-yielding varieties with desirable consumer/market qualities. These qualities include desirable postharvest and production attributes such as milling percentage, resistance to lodging, early maturity, and resistance to major biotic and abiotic factors
Soil health and soil fertility management/ Crop management and protection options	・Ensuring recommendations on fertilizer rates both for organic and inorganic fertilizers are established, particularly in intensive rice-producing areas ・Revising fertilizer recommendations is required in view of the increased prices of fertilizers and new brands of fertilizers being introduced into the market ・Integrating disease and pest management options developed or verified in the country will be disseminated to farmers ・Improving crop management options for irrigated lowlands, rain-fed lowlands and rain-fed upland ecosystems will be disseminated and repackaged
Fertilizer marketing and distribution	・Strengthening the capacity of agro-dealers to access input credits and agribusiness skills ・Ensuring proper use of inputs for increased rice production and productivity ・Producing and distributing agricultural input vouchers
Irrigation and investment in water control technologies	・Rehabilitating selected existing irrigation schemes with worn-out infrastructure and those with infrastructure destroyed by floods ・Rehabilitating traditional irrigation schemes ・Constructing new irrigation schemes ・Constructing rain-water harvesting and storage structures
Access to and maintenance of agricultural equipment	・Promoting the use of medium-size tractors and combine harvesters, power tillers, transplanters, weeders, milling and grading machines.
Post-harvest and marketing	・Promoting agro-processing of paddy and value-addition technologies ・Strengthening capacity of post-harvest and rural-based agro-industries ・Enhancing access to and use of improved post-harvest, rural travel and transport, processing, storage and marketing technologies ・Facilitating private sector investment in medium-scale processing of rice products

Advisory services-extension, NGOs and agri-business	・Improving productivity will require an efficient extension service which would facilitate increased transfer of appropriate technologies as well as application of research results
Access to credit/agricultural finance	・Facilitating the formation of farmers' groups and associations to strengthen their bargaining power and accessibility to credits. ・Establishing contract farming scheme as one way of alleviating the lack of formal farm credit among the smallholder farmers as well as providing access to extension services, farm inputs and product markets ・Scaling up agricultural inputs guarantee pilot scheme arrangement to the rice-producing areas to facilitate timely availability of agro-inputs to farmers ・Strengthening the capacity of agro-dealers to access credit to meet incremental working capital requirements for acquisition and distribution of inputs ・Establishing an agricultural bank

Source: United Republic of Tanzania (2009)

3.2 Technology dissemination

Rice yield improves with the use of basic cultivation techniques such as bund construction, leveling, line planting, proper weeding, improved seeds, pesticides, and fertilizers. Nakano and Kajisa (2014) used household data collected in the Eastern Zone, Southern Highland Zone, and Lake Zone, the major rice-growing regions of Tanzania, to examine the impact of adopting modern rice varieties on rice yield and income. The results showed that while Modern Variety increased rice yields, this outcome appeared only when combined with improved bunds—a basic cultivation technique under irrigated conditions—and that the introduction of chemical fertilizer and the practice of line planting increased rice yields even among farmers who had used non-modern varieties under irrigated conditions.[8] Nakano, Tanaka, and Otsuka (2018) also explored the impact of training in the improved System of Rice Intensification (SRI) on performance among small-scale rice farmers in rainfed rice-growing areas in Tanzania. The results showed that the average yield of those who received the training reached 4.7 t/ha, which was 1.3-1.8 t/ha more than those who did not receive the training.

As mentioned above, technology diffusion has a significant effect on yields, and diffusion of these cultivation technologies is being implemented through government extension efforts, donor projects, private sector advisory services, and NGO/NPOs (Nord et al. 2022). However, along with the high cost of activities and lack of agricultural knowledge, there are still insufficient numbers of government extension agents (Ortiz et al. 2021). In this context, for example, the

[8] Contrary, the effect of MVs was limited in the case of rainfed farmers. This suggests that MVs are effective under conditions of proper water management.

Project for Supporting Rice Industry Development in Tanzania (2012–2019), supported by JICA, developed seven agricultural training centers across the country as focal points for rice cultivation technology and provided direct training to farmers in 90 irrigation schemes. As a result, line planting was adopted by more than 15,000 farmers. In addition, the adoption rates of bunds, leveling, fertilizer application, and improved varieties also increased due to the project. SRI is also being disseminated by donors, and it is assumed that those efforts are enhancing the level of rice farming skills among farmers.

3.3 Irrigation

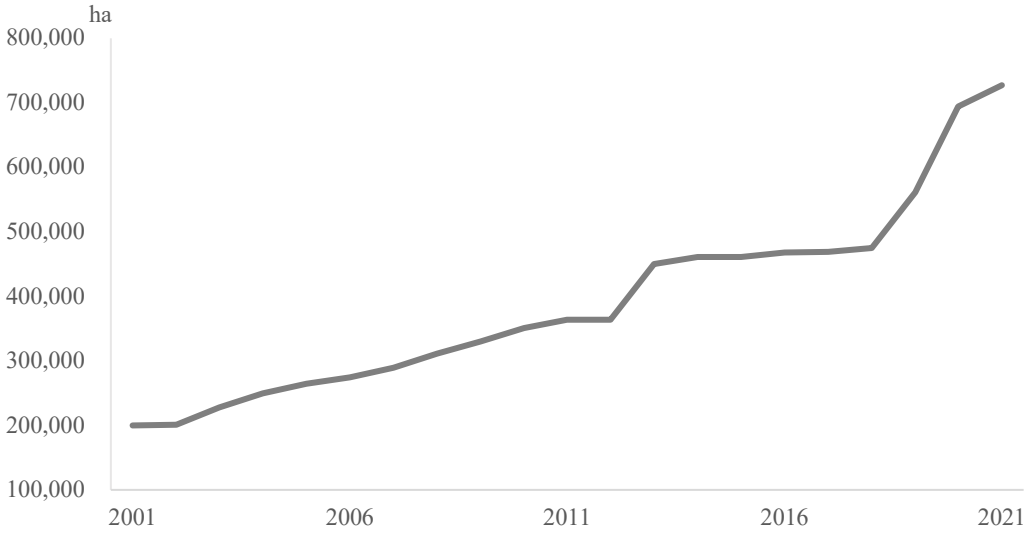
Irrigation development in Tanzania has been a major agenda of the government since independence in 1961, but the pace of development has been slow. In the 1980s, a program for the rehabilitation and modernization of traditional village irrigation schemes was attempted to increase the irrigated area, but this did not lead to substantive improvements. In 1994, the Irrigation Development Plan was formulated, setting a target of constructing or rehabilitating 147 irrigation sites by 2014, but by 2002, only 60 irrigation scheme was constructed or rehabilitated (Ministry of Water and Irrigation 2010). One turning point was the National Irrigation Master Plan (NIMP) of 2002, which identified 29.4 million ha of potential areas for irrigation development throughout Tanzania and prepared an inventory of these areas.[9] Furthermore, based on the NINP, the ruling CCM's 2005 election manifesto included the development of small- and medium-scale irrigation, and the 2006 launch of the Agriculture Sector Development Plan also included the development of 1 million ha of irrigation at the initiative of the president as a major policy issue (Ole 2011). This has led to intensive investment in irrigation development: from approximately 200,000 ha in 2002, the irrigated area increased by 1.5 times to 310,000 ha in 2009 and by 3.6 times to 720,000 ha in 2021.[10]

It is well known that yields are higher under irrigated conditions than under rainfed conditions. Mkanthama et al. (2018) compared irrigated and rainfed farmers in Tanzania and found that their average yields were 3.4 t/ha for irrigated farmers and 1.2 t/ha for rainfed farmers. It also revealed that irrigated farmers have higher rates of fertilizer application and adoption of improved varieties than rainfed farmers. Moreover, all irrigated farmers receive some form of extension services, while only 27% of rainfed farmers receive such services. In other words, the difference of yield

[9] The Master Plan identifies 29.4 million ha as 2.3 million ha of high potential area, 4.8 million ha of medium potential area, and 22.3 million ha of low potential area.

[10] However, Ole (2011) pointed out that irrigation development based on the ASDP was less than originally planned due to lack of funds and human resources, and that the irrigation systems developed were not sustainable because operations and maintenance (O&M) was not taken into account. On the other hand, the National Irrigation Master Plan formulated in 2002 proposed 372,000 ha of irrigation development by 2015 as a "high-case scenario." However, with 461,000 ha now developed, irrigation infrastructure in Tanzania has progressed much faster than the scenario as of 2002 (JICA 2018).

is not simply due to access to water but also to access to technology, which brings about a combined effect that improves the yield. Furthermore, it should not be overlooked that most farmers working in irrigated conditions belong to farmer groups. This likely leads to increased farmer-to-farmer diffusion of cultivation techniques under irrigated conditions.[11]



Source: Data from National Irrigation Commission（NRIC）

Figure 4: Irrigated Area in Tanzania

3.4 Agricultural Mechanization

In Tanzania, the use of four-wheel tractors (4WTs) has long been the norm, but their numbers declined in the 1990s and 2000s as they aged, and the mechanization of agriculture did not progress. In Tanzania, draft animals (cattle and oxen) were used in agriculture instead of tractors.

However, the droughts experienced in 2009 and 2010 killed many draft animals, leading to the rapid introduction of two-wheel tractors (2WTs) as a replacement. In Tanzania, the number of 2WTs has grown by 30 times in 10 years, from 300 units in 2005 to 9,000 units in 2015 (Mrema, Kahan, and Agyei-Holmes 2020). In particular, small farmers have traditionally used draft animal power, but the rising cost of livestock feed and the decrease in the number of livestock have led to a shift to 2WTs.[12]

The study by Magezi, Nakano, and Sakurai (2023), which analyzed the effects of 4WTs, 2WTs, and draft animals using four-year panel data in Tanzania, found the following points (see also

[11] According to Nakano et al. (2015), the average yield of farmers who did not participate in the training also increased from 2.6 to 3.7 tons per hectare due to information dissemination within the irrigation scheme.

[12] However, it is difficult for small-scale farmers to own 2WTs, and they generally rent them for land preparation. Therefore, only those farmers who can afford to pay the rental fee have access to them.

Table 5): (i) Both 4WTs and 2WTs have a positive impact on cropland expansion; (ii) 4WTs and draft animals have no positive impact on land-productivity improvement. However, farmers using 2WTs showed an improvement in land productivity. This is perhaps due to an increase in the adoption rate of basic cultivation techniques that led to higher yields only among farmers using 2WT[13]; (iii) On the other hand, labor productivity has increased with 4WTs but not with 2WTs.[14]

This is likely due to the increased labor input for cultivation management as a result of the adoption of basic cultivation techniques by farmers using 2WTs, as described above.[15]

In Tanzania, therefore, the rapid adoption of 2WTs since 2009 has increased the adoption rate of cultivation techniques that lead to higher yields, thus contributing to higher productivity.

Table5: Effects of Introducing Agricultural Machinery

	4WTs	2WTs	Draft Animals
Expansion of the area	✓	✓	
Adoption of the technology		✓	
Land Productivity		✓	
Labor Productivity	✓		

Source: By the author from Magezi, Nakano, and Sakurai (2023)

Note: Comparison between the farmer using four-wheel tractors (4WTS), two-wheel tractors (2WTs), and draft animals against hand tools.

4. Conclusion

A comparison of rice production in the CARD Initiative member countries for the 13 years before and after the launch of CARD in 2008 shows an average production increase of 2.1 times for the 31 countries, indicating a continued increase of rice production in SSA after the launch of CARD.

Analysis of this factor shows that the growth rate of harvested area was 2.4% before and 4.6% after the CARD launch, while the growth rate of yield was 0.3% and 0.1%, respectively, indicating that the production increase was driven by an increase in area. In SSA, this trend is not limited to rice alone; the long-term trend in grain production is driven by the expansion of harvested area (Seo 2017). However, it seems likely that the expansion of harvested area that has continued since the 1980s may be reaching a ceiling; FAO and OECD (2016) project an annual growth rate of

[13] Magezi et al. indicate that 2WT is used for puddling and 4WT is used for plowing and hallowing, with the factor that puddling is more effective in increasing rice productivity.

[14] Although farmers using draft animals have reduced labor inputs, they have also reduced their productivity and therefore their labor yield has also decreased.

[15] In farmers using 2WTs, family labor input decreased and hired labor input increased.

1.0% for cereal production area until 2025, making it difficult to increase production through area expansion.

In this context, some countries have been able to increase their rice production by increasing yield despite the stagnation of growth in harvested areas in recent years. In this paper, we analyzed Tanzania as a case study to identify the factors contributing to the improvement in yield. A possible factor leading to this increase is the development of comprehensive policies. In 2009, the National Rice Development Strategy (NRDS) was launched by the Tanzanian government. The revised NRDS, introduced in 2019, has further reconfigured and prioritized rice production away from the previous separate sub-sectoral efforts to undertake a comprehensive effort aimed at rice promotion. As a result, the assistance needed by the main beneficiaries, small-scale farmers, was implemented.

In addition, agricultural technology extension, irrigation development, and mechanization have also been significant factors in increasing rice yields. It should be noted here that improvements in agricultural inputs such as improved varieties, fertilizers, irrigation, and mechanization are not effective on their own but induce "farmers' adoption of basic cultivation techniques" in the process. It is not simply a matter of increasing agricultural inputs; the addition of appropriate cultivation techniques to these inputs produces a significant productivity improvement effect. Otsuka, Mano, and Takahashi (2022) argue that "the primary strategy for achieving this goal is to strengthen the rice extension system to promote farming intensification along with the adoption of improved rice management practices," and the discussion in this paper supports that argument.

Over the past two decades, rice production in SSA has steadily expanded, contributing to poverty reduction among farmers. It is assumed that the demand for rice in SSA will continue to increase, and it is clear that there will be a need to expand rice production in SSA countries. However, it remains doubtful whether rice production can continue to expand using the same approaches as those adopted over the past two decades, whereby increased production was achieved by expanding the cultivation area. It is likely, therefore, that countries that succeed in improving their productivity will be able to achieve rice production expansion over the coming decades and that we are now at a turning point in this process.

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Abstract (in Japanese)

要　約

サブサハラアフリカにおいては、近年コメの消費量の急速な拡大に伴い、生産量も拡大している。コメの生産の拡大は主に生産面積の拡大によってなされていると考えられている一方で、可耕地は減少していると言われている。本稿では、まずCARDのメンバー国におけるCARD実施前後のコメ生産の変化についてCAGRを用いて分析した。その結果、多くの国においてコメ生産はCARD後により高い成長率で拡大していること、その成長は主に生産面積の拡大によってなされていることが分かった。他方で、CARD後に生産性の改善によって生産量の拡大を達成しているタンザニアを例に、生産性改善をもたらした要因を分析した。タンザニアでは、稲作振興の総合的な政策が整備され、その政策の下で栽培技術の普及、灌漑面積の拡大、機械化の推進が行われたことが生産性の改善に貢献している。以上から、今後多くの国において生産面積の拡大フェーズから生産性の改善フェーズへの移行が必要となっており、そのためには限られた資源を栽培技術の普及を伴う灌漑整備等の生産性向上に直結する課題へあてるといった対応が必要であると考えられる。

キーワード：稲作、CAGR、サブサハラアフリカ、タンザニア、アフリカ稲作振興のための共同体(CARD)