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Past, Present and Future Perspectives of Rice Production in Tanzania

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Abstract

Cultivated rice (*Oryza sativa* L. *and Oryza. glaberrima*) is one of the most important food crops in the world. World rice production has increased three times since the green revolution. However, climate change and global warming effects as well as ever increasing world population will require the world to produce more rice without increasing area under rice production in order to meet those demands. The best option to overcome these challenges includes adoption of climate-smart technologies and sustainable solutions to rice production. Rice was probably introduced in Tanzania over 1000 years ago by Asian traders during trade contacts between Asia and East Africa Coast through Indian Ocean. Rice cultivation had been restricted to coastal area until 19th century when it started spreading to interior areas of Tanzania. During colonial period (1880s-1960s), the emphasis was to produce cash crops as raw materials for industrialized world. After independence production of rice increased significantly. Currently, rice is the second most important food crop in Tanzania after maize and Tanzania is the leading producer of rice in East African countries. It ranks 4th and 22nd in Africa and World respectively in terms of rice production. In this paper, the rice history, ecosystems, challenges and future perspective for sustaining rice production in Tanzania is reviewed.

Keywords

Rice, Production History, Ecosystems, Challenges, Perspectives, Tanzania

1. Introduction

Cultivated rice is divided into two distinct types namely *Oryza sativa* L. *and Oryza glaberrima* which are commonly known as Asia rice and African rice respectively. Between the two subspecies *Oryza sativa* which originated from Asia continent around 8000 BC is the most widely distributed and grown almost globally while *Oryza glaberrima* which originated in West Africa around 3000 BC is restricted only in West Africa [1] [2] [3]. Nevertheless, both of the rice have unique domestication histories and play most important components of human diet that have energized and nourished mankind for thousands of years [4]. Rice is the staple food and principal food crop for more than 50% of the world's population [5] [6]. Because of its potential of feeding more people in the world the Food and Agriculture Organization (FAO) regards it as a strategic crop for food security in the world [7].

Rice is the second most important food crop after maize in Tanzania, It is being grown by 18% of the farming households and is more marketed than maize. The quantity of marketed rice is approximately 42% of the total production while that of maize is 28%, thus being more commercialized than maize [8]. Tanzania is among the top three countries in Africa and it ranks 22nd in the world in terms of rice production [9] [10]. This indicates how important this crop has evolved to be in Tanzania [11]. The rapidly increasing trend in rice production and consumption is partly due to increase of population, urbanization and rice preference [11] [12] [13].

Notwithstanding the evidence that Tanzania is one of the top producers of rice in Africa, the rice productivity is one of the lowest in the world (**Table 1**), it ranges from 0.71 tons/ha to 3.31 tons/ha which is far below the world standard of 4.5 tons/ha. Increasing rice production/productivity and value addition in Tanzania will have paramount effects on resource poor farmers in Tanzania in terms of food security, livelihoods and source of income [14]. Rice value addition will not only introduce new cuisine with rich taste but also spurs small and large scale industries such as wine, vinegar, flour blending, furniture, and animal feedstuff making. This will enable farmers to have alternative sources of income as well as empowerment and poverty eradication [14] [15] [16].

2. History of Rice Introduction in Tanzania

The overall physical environment of the East African coast historically made it an important supplier of spices, jewels, timber, laborers, and other goods to Arabia and the rest of the Asia [17]. It is probable that the Indian Ocean was mostly used for commercial navigation after the discovery of the monsoon winds by Hippalus in the third century B.C.E. The information presented in the Periplus and in Ptolemy's Geography, it seems clear that a basic east-west nexus between the Red Sea and India was already in place by the second century. By the ninth century, and probably earlier, a fully articulated commercial system existed that extended from East Africa and the Red Sea to China [17] [18].

[19] narrated that *Oryza sativa* was first introduced to the Coast of East Africa then known as "*Azania coast*" by Asian traders from Sri Lanka and India over 1000 years ago. Some of these Asian traders settled in Zanzibar, Kilwa, Somalia, Mafia, Mombasa and other East Africa coastal towns. They soon started cultivating

Table 1. Post-independence rice production statistics in Tanzania.

Year	Cultivated area (ha)	Production (tonnes)	Yield per ha (tonnes)
1961	82,000	94,000	1.15
1962	83,000	104,000	1.25
1963	115,000	183,000	1.59
1964	110,000	147,322	1.34
1965	56,000	72,954	1.30
1966	127,000	133,082	1.05
1967	110,000	109,687	1.00
1968	128,000	104,000	0.81
1969	129,000	126,000	0.98
1970	151,000	132,000	0.87
1971	153,000	171,000	1.12
1972	155,000	187,000	1.21
1973	130,824	301,000	2.30
1974	163,000	223,000	1.37
1975	204,000	265,000	1.30
1976	267,000	346,000	1.30
1977	243,000	314,000	1.29
1978	258,000	387,000	1.50
1979	260,000	262,000	1.01
1980	245,000	291,000	1.19
1981	280,000	200,000	0.71
1982	300,000	320,000	1.07
1983	224,110	349,231	1.56
1984	271,210	355,385	1.31
1985	236,540	427,692	1.81
1986	273,760	547,692	2.00
1987	351,190	644,615	1.84
1988	345,000	615,385	1.78
1989	385,310	718,461	1.86
1990	384,500	740,000	1.92
1991	368,700	624,615	1.69
1992	306,570	392,220	1.28
1993	353,700	641,000	1.81

Continued

1994	352,600	614,300	1.74
1995	394,000	622,600	1.58
1996	513,400	806,800	1.57
1997	439,300	549,700	1.25
1998	654,500	849,100	1.30
1999	379,100	728,600	1.92
2000	415,600	781,538	1.88
2001	405,860	867,692	2.14
2002	565,600	984,615	1.74
2003	620,800	1,096,923	1.77
2004	613,130	1,058,462	1.73
2005	701,990	1,167,692	1.66
2006	633,770	1,206,154	1.90
2007	557,981	1,341,846	2.40
2008	887,660	1,420,570	1.60
2009	805,630	1,334,800	1.66
2010	1,136,290	2,650,120	2.33
2011	1,119,324	2,248,320	2.01
2012	799,361	1,800,551	2.25
2013	928,273	2,194,750	2.36
2014	957,218	1,681,000	1.76
2015	1,154,467	1,937,000	1.68
2016	1,039,205	2,229,000	2.14
2017	1,097,283	2,451,707	2.23
2018	1,032,902	3,414,815	3.31
2019	1,052,547	3,474,766	3.30
2020	1,586,952	4,528,000	2.85
2021	955,729	2,688,000	2.81

Source: [10].

rice in lowlands and valleys. Rice cultivation did not spread quickly to East Africa countryside for centuries until during slave trade. Slave trade opened up the East Africa countryside. The spread of rice as well as other crops such as Maize (*Zea mays*), Cassava (*Manihot esculentum*) country side followed along the slave trading routes from Zanzibar, Bagamoyo, Morogoro, Iringa, Dodoma, Singida, Sumbawanga, Tabora, Shinyanga, Mwanza, and Kigoma and beyond Lake Victoria and Lake Tanganyika [18] [20]. At first cultivation of rice was done mostly by Arab traders who settled in these areas. The local farmers were not interested to the new crop because they did not know how to cultivate, cook and its production turned out to be less reliable in comparison their indigenous crops such as pearl millet (*Pennisetum glaucum*), banana (*Musa spp*), finger millet (*Eleusine coracana*) and sorghum (*Sorghum bicolor*) [20] [21].

During colonial period, Colonial government emphasized cash crops as raw materials for their industries in Europe. In Tanganyika (Tanzania) the German introduced cotton in western Tanzania, sisal in Eastern coastal areas, coffee and tea in Northern and Southern highlands of Tanzania [20] [22]. After taking over from German in 1920s there were evidences showing British colonial agricultural officers sighting rice cultivation [20] [22] [23]. The British colonialist emphasized on cash crops rather than food crops as their predecessors, for example, the colonial authorities shifted labour from food production and attempted to create a surplus of a labour-intensive non-food cash crop [24]. During colonial period only cash crops research centres were established such as Ukiriguru Research Centre (established in 1930) for cotton in Western Tanzania, Ilonga Research Institute (established in 1943, Mlingano Agriculture Research Institute (established in 1934) for sisal research and improvement [25]. All these actions and colonial policy resulted into low production and circulation of quantity and quality of food which in turn caused severe food shortage, chroming malnutrition, hunger and even deaths to many local people [24].

3. Rice Production after Independence and Current Status

After independence, farmers became free in choices of what to cultivate. The record of rice cultivation became available (**Table 1**). The Tanzania government focus included research to improve food crops as well as livestock under smallholder farmers. The year after Tanzania got independence (1961) rice production was recorded at 94,000 tonnes from 82,000 (ha) cultivated area. The succeeding year's rice production (tonnes) as well as area under rice cultivation (ha) steadily increased [10]. After green revolution in 1960s in Asia, The Tanzania government introduced many high yielding varieties from India and Philippines. The varieties introduced included IR54, IR56, IR64, IR68, Supa8, Kihogo Red Basmati Pishori, Ran Captain, Calyaman, Supa India [20] [26] [27] [28]. The growing interest for rice by the farmers encouraged the Government to establish rice research centre Katrin at Ifakara in 1975. Since 1975 Katrin has operated as the major institute dealing with rice research in the country. A number of traditional varieties including Faya of the Theresa, Afaa mwanza, Kihogo selection No. 1/159, 0/746, Kihogo selection No.7, 22 and 23, Gamti, Tunduru Dunduli, Salama have been developed through pure-line selection, testing and evaluation at different locations in the country [28]. In 1980s, Sokoine University of Agriculture was established at meantime Uyole and Ukiriguru research center's started doing rice research and improvement as well. International research institute such as West Africa Rice Development Association (WARDA), Africa rice, International Rice Research Institute (IRRI) and International Institute of Tropical Agriculture (IITA) they all opened office in Tanzania by year 2000. New rice varieties, rice production technologies and various good agriculture practices were introduced to farmers by the researchers and extension officers. By 2019 and 2020, Tanzania produced 3,474,766 and 4,528,000 tons of rice respectively (**Table 1**). Rice is a very essential part of the daily Tanzania meal. It is also cooked on festivals and special occasions in different forms using several spices. This has propelled Tanzania to produce more rice and now is the leading producer of rice in East, Central and Southern African countries [9] [10] [29]. Also rice has emerged as a vital crop not only as staple food but also source of income and livelihoods to millions of farmers in Tanzania. Above all, rice has massive potential for powering small industries and development in Tanzania.

4. Rice Production Ecology in Tanzania

In Tanzania, rice is cultivated under three major ecosystems namely rain-fed lowland, upland rice and irrigated ecosystem [30] [31]. The large scale rice farmer's account for small proportion (less than 10%) While the majority of rice farmers in Tanzania are small scale farmers (about 90%). Most large scale rice producers use irrigation because of their economies of scale and large investment. Hence, it is estimated that only 5% of rice is produced under irrigation system. Most of small scale farmers can't afford irrigation system investment therefore it is estimated that 85% of rice is produced under rainfed lowland and around 10% produced under upland ecosystem [14] [32] [33] [34].

4.1. Upland Rice Ecosystem

Upland rice is cultivated under a monocropping system and sometimes under a mixed cropping system with other food crops [31]. The Upland rice ecosystem it represent 20 percent of rice growing ecosystem in Tanzania. Usually it uses little inputs such as machines, inorganic fertilizers and pesticides. Soils are relatively poor and water is inadequate. Landraces commonly Salama, dunduli ya mlimani are commonly grown (**Table 2**). In this ecosystem, NERICA varieties (**Table 2**) are being introduced in order to increase productivity. The productivity in this ecosystem is low and it ranges from 0.8 to 1.2 t/ha [31] [35].

4.2. Lowland Rainfed Rice Ecosystem

In rainfed rice ecosystem, farmers rely on rainfall for water needed to grow the rice. Water is not reliable and problems of flooding and drought or rainfall are persistent since rainfall is unpredictable [27] [31]. The rainfed rice ecosystem represent 71 percent of rice growing ecosystem in Tanzania. Soils are relatively fertile compared to upland soils. It is characterized by the use of hand hoe or ox plough, little use of tractor, transplantation by hand, farmers generally apply little fertilizers, farmers usually use farm saved seeds and minimal use of other

Table 2. Prominent cultivars and their ecosystems grown since Tanzania independence.

S/N	Source	Cultivars	Rice Ecosystems
1	Landrances	Afaa	Rainfed lowland
2		Afaa mwanza	Rainfed lowland
3		Chamota	Rainfed lowland
4		Chaka	Rainfed lowland
5		Cherehani	Rainfed lowland
6		Dunduli ya mlimani	Upland
7		Faya manana	Rainfed lowland
8		Faya mzinga	Rainfed lowland
9		Faya Theresa	Rainfed lowland
10		Gombe	Rainfed lowland
11		Jaribu	Rainfed lowland
12		Kahogo	Rainfed lowland
13		Kalamata	Rainfed lowland
14		Kalubangala	Rainfed lowland
15		Kalundi	Rainfed lowland
16		Katani	Rainfed lowland
17		Kilombero	Irrigated
18		Kisegese	Rainfed lowland
19		Kikweta	Upland
20		Tule na Bwana	Rainfed lowland
21		Kyela	Irrigated
22		Limota	Rainfed lowland
23		Lugata	Rainfed lowland
24		Mabu	Rainfed lowland
25		Malamata	Rainfed lowland
26		Malomogambiki	Rainfed lowland
27		Masantula	Rainfed lowland
28		Mbawa ya njiwa	Rainfed lowland
29		Mbawambili nyekundu	Rainfed lowland
30		Mbega	Rainfed lowland
31		Mwanamwala	Rainfed lowland
32		Mwenda mbio	Rainfed lowland
33		Moshi	Rainfed lowland

Continued

34		Mpaka wa bibi	Rainfed lowland
35		Msongo	Rainfed lowland
36		Nondo	Rainfed lowland
37		Rangi mbili nyekundu	Rainfed lowland
38		Ringa	Rainfed lowland
39		Serena	Rainfed lowland
40		Shingo ya mwali	Rainfed lowland
41		Sindano	Rainfed lowland
42		Sina Bibi	Rainfed lowland
43		Sumbawanga	Rainfed lowland
44		Supa	Rainfed lowland
45		Supa 8	Rainfed lowland
46		Supa Kinyope	Rainfed lowland
47		Supa Kitere	Rainfed lowland
48		Supa kyela	Rainfed lowland
49		Supa Utafiti	Rainfed lowland
50		Tondogoso	Rainfed lowland
51		Tunduru	Rainfed lowland
52		Turiani	Rainfed lowland
53		Usiniguse	Rainfed lowland
54		Wahiwahi	Rainfed lowland
55	TARIa	Dakawa Line 85	Irrigated
56		Dakawa Line 88	Irrigated
57		IR 9101-124-1	Irrigated
58		ITA 283	Rainfed lowland
59		ITA 303	Rainfed lowland
60		KATRIN	Irrigated
61		Komboka	Rainfed lowland
62		SATO1	Irrigated
63		SATO61	Rainfed lowland
64		SATO9	Irrigated
65		TAI(IR 0334262)	Rainfed lowland
66		TARI-RIC1	Rainfed lowland
67		TAR-RIC2	Rainfed lowland

Continued

68		aTXD 306 (SARO5)	Irrigated
69		TXD 307(SARO7)	Irrigated
70		TXD 85	Rainfed lowland
71		TXD 88	Rainfed lowland
72	SUAb	Kalalu	Rainfed lowland
73		Mwangaza	Rainfed lowland
74		Salama M-19	Upland
75		Salama M-57	Upland
76		SSD 1	Rainfed lowland
77	IRRIc	IR8	Upland
78		IR 22	Rainfed lowland
79		IR 56	Rainfed lowland
80		IR 68	Irrigated
81		IR54	Irrigated
82		IR64	Irrigated
83		IR72	Rainfed lowland
84	AfricaRice	IRAT 256	Irrigated
85		NERICA 1	Upland
86		NERICA 2	Upland
87		NERICA 4	Upland
88		NERICA 7	Upland
89		WAB450	Irrigated
90	India	Super india	Rainfed lowland
91		Basmati	Rainfed lowland
92		Pishori	Rainfed lowland
93		Ran Captain	Rainfed lowland
94		Calyaman	Rainfed lowland

Source [18] [20] [21] [23] [25] [27] [30] [31] [34] [35]. a. denotes for Tanzania Agricultural Research Institute; b. denotes for Sokoine University of Agriculture; c. denotes for International Rice Research Institute.

inputs. The productivity in this ecosystem is low and it ranges from 1.4 to 2.1 t/ha and there is only one season for rice cultivation per year. Common cultivars cultivated in this system includes all landraces such as Afaa, Afaa Mwanza, Kalamata, Kilombero, Mabu etc, are prominent on this ecosystem (**Table 2**). Some improved varieties such as Mwangaza, Komboka, TXD85 and TXD 88 are cultivated in the rain fed ecosystem [31] [35].

4.3. Irrigated Rice Ecosystem

Irrigated ecosystem is the system or rice cultivation where by the rice fields have assured water supply throughout the growing season. In Tanzania only few farmers (around 9%) use this rice ecosystem. It is characterized by use of modern mechanization technology such as tractors, rice planters, agrochemicals and good agricultural practices. Rice productivity ranges from 3.2 to 4.5 t/ha with great scope for further yield improvement through improved crop management and further intensification. In this system some farmers in Tanzania they have 2 - 3 season for rice cultivation per year. Improved rice varieties commonly used in this system includes Dakawa line 85, Dakawa line 88, TXD306, TXD 307, SATO 1, SATO9 (**Table 2**) [31] [35].

5. Major Pests and Diseases

Rice production in Tanzania has been loaded by many pests and diseases which have significantly reduced yield. The incidence, severity and distribution of these pests and diseases depend on stage of infestation/infection, rice ecosystem, location, season, variety, farming system, and weather condition [36]. Other important diseases are leaf blast caused by *Magnaporthe oryzae* and Bacterial leaf blight caused by *Xanthomonas Orzae pv oryzae* [6] [36] [37]. Also pests can cause total rice yield loss. Common pests include stem borers (Chillo spp), African rice gall midge (*Orseolia oryzivora*), rodents and birds (**Table 3**). Integrated disease and pest management (IDPM) options are being used includes good agricultural practices, mechanical, botanical, chemical and biological control of pests and disease in the country. Despite the use of IDPM methods in controlling pests still the problem continue to exist. There is a need to renew IDPM by involving all stakeholders such as Researchers, extension officers and farmers with the help of updated technologies ICT tools to disseminate information about different IDPM strategies.

6. Climate Change, Price Fluctuation, Sustainability and Resilience in Rice Production

6.1. Climate Change and Globalization

Global warming and climate changes are anticipated to cause a wide-range effect to world food production systems and food security. The climate change is predicted to impact more developing tropical countries than temperate countries [48] [49]. Rice is among of crops likely to be affected severely due to its photoperiod sensitivity and susceptibility to altered environmental effects such as salinity, drought and new pest and diseases.

Globalization refer to the growing interdependence of the world's economies, cultures, and populations, brought about by cross-border trade in goods and services, technology, and flows of investment, people, and information. While, it has it has helped to raise global trade, economy, human rights and civilization, it

Table 3. Common pests of rice and their effects in Tanzania.

S/N	Type of Pests	Pest name	Causative agent	Effects	Sources
1	Bacterial disease	Bacterial Blight	*Xanthomonas oryzae pv oryzae*	Yield losses 20% - 30%	[36]
2		Bacterial Blast	*Magnaporthe oryzae*	Yield losses 11.9% to 37.8%	[37]
3	Virus disease	Rice yellow mottle disease	*Rice yellow mottle virus*	Yield losses 20% - 80%	[38]
4	Fungus disease	Brown leaf spot	*Helminthosporium spp*	Significance losess	[39]
5		Sheath rot	*Acrocylindrium oryzae*	Yield losses 20% - 80%	[35] [39]
6	Insects	African armyworm	*Spodoptera exempta*	Significance losess	[40]
7		White stem borer	*Maliarpha seperatella*	Significance losess	[40]
8		Stalk-eyed fly	*Diopsis thoracica*	Significance losess	[40]
9		Spotted stem borer	*Chilo partellus*	Significance losess	[40]
10		African pink borer	*Sesamia calamistis*	Significance losess	[40]
11		African Rice Gall Midge	*Orseolia oryzivora*	Significance losess	[41]
12		Flea beetles	*Chaetocnema varicornis*	Significance losess	[41]
13	Rodents	African soft-furred mouse	*Mastomys natalensis*	Pre-harvest loss 10% - 12%	[42] [43]
14		African grass rat	*Arvicanthis niloticus*	Pre-harvest loss 10% - 12%	[42] [43]
15		The house mouse	*Mus musculus*	Stored rice (Significant losess)	[44]
16		The black rat	*Rattus rattus L*	Stored rice (Significant losses)	[44]
17	Birds	Red-billed quelea	*Quelea quelea*	Yield losses 15.2%	[45]
18		African Golden-Weaver	*Ploceus subaureus*	Yield losses 15%	[46]
19		Black-headed weaver	*Ploceus melanocephalus*	Yield losses 15%	[46]
20	Nematode	Root-knot nematodes	*Meloidegyne graminicola*	Significance losess	[14]
21	Weeds	Nutgrass	*Cyperus rotundus*	Yield losses 28% to 89%	[47]
22		Common barnyard grass	*Echinochloa crus-galli*	Yield losses 28% to 89%	[47]
23		Yellow nutsedg	*Cyperus esculentus*	Yield losses 28% to 89%	[47]
24		Red rice	*Oryza longistaminata*	Yield losses 28% to 89%	[47]
25		Chickenspike	*Sphenoclea zeylanica*	Yield losses 28% to 89%	[47]
26		Saramollagrass	*Ischaemum rugosum*	Yield losses 28% to 89%	[47]
27		African wild rice	*Oryza barthii*	Yield losses 28% to 89%	[47]
28		Nees	*Asteracantha longifolia*	Yield losses 28% to 89%	[47]

is blamed for the spread of plant diseases, biosafety issues, invasive species of pests and weeds in the world [48] [49] [50]. Evolutionally plants, Animals and pathogens have coevolved with their host and environment [48]. In a way they balance each other but when barriers are broken as in case of globalization in which exotic pathogenic organisms are introduced into new environments, potentially finding suitable hosts lacking resistance genes and environments favouring pathogenic behaviour; this increases spread and emergence of new disease, pests and epidemics [50] [51]. Countries especially developing countries which less phytosanitary measures and personnel has great chance of being affected. This can be demonstrated by the case of fall army worm (*Spodoptera frugiperda*) *and* Greater grain borer (*Prostephanus truncates*) in Tanzania and East Africa [52] [53].

Among the several strategies to tackle the effect of global warming, climate and globalization effects includes creation of variations in rice using mutation induction. Artificial mutation have been used successful in Europe, America and Asian counties to produce rice varieties which are disease resistant, drought tolerance, early maturing and high yielding [6] [54] [55] [56]. Other technologies include Genetic engineering, interspecific hybridization with wild rice to produce perennial rice, Digital early warning systems, Biotechnologies and the use of Artificial intelligence [35] [57] [58] [59]. Tanzania should take leaf and adopt such technologies, build capabilities and personnel in order to combat global warming, climate and globalization effects for sustaining and increasing rice production as well as other strategic crops in the country.

6.2. Rice Price Fluctuations and Value Chain Additions

Price fluctuation is the irregular up and down movement of price of rice in the market. In Tanzania rice price cultivation is either seasonal or yearly [11]. Generally the dry season (May-October) coincides with harvesting season (supply of rice is high) which result into lowering the price of rice. During the rainy season (November-April) there is high demand of rice while the supply is low. This results into raising the price of rice. Table two indicates the variations in rice production as well the area under rice cultivation. Since, most of rice is produced under rainfed ecosystem rainfall determines whether the farmer produces more rice and vice versa. For instance in 2020 Tanzania had highest rice production as well large area under rice cultivation because it received abundant rainfall in 2019/2020 season whereas in 2021 rice production as well area under rice cultivation decreased because it received very low rain fall in 2020/2021 rain season (**Table 2**).

According to [60] price fluctuation is a serious problem to farmers and often make farmers vulnerable to investment losses and sometimes they lose their investment altogether. Although farmers benefits when the prices rises many farmers prefer stable prices which gives them clear information that can be used it as benchmark in long term investment plans. One way of keeping the price of rice stable even when there is high supply is through value addition of rice [11] [16] [61]. Investing more in rice value addition will not only affect price but also make rice contribute more in people livelihoods, source of income, small scale and large scale industry development [61]. Currently, rice in Tanzania is mainly used for household consumption as staple food which is usually cooking as white rice, spice rice (*pilau*) or fry as fermented rice cake (*vitumbua*) which is a popular snack. Also the husk is used as poultry or piggery feedstuff. The full potential of rice cannot be realized substantially by the current lack of streams of value addition. Table 4 illustrates streams of rice value addition in some countries such as wine, vinegar, animal feedstuffs, films, paper, adhesives, furniture, brown rice and flour blending which have impact in industrial stimulation, rice price stability and increased contribution of rice as food, livelihoods and source of income.

6.3. Resilience and Sustainability of Rice Cultivation in Tanzania

Building or making communities resilient in development arena in the face of climate change and globalization is among of top agenda in UN Sustainable Development Goals [74]. A resilient community is the community which is capable to stand firm, soak up, contain, and recuperate from adverse environment brought up by number of issues such as changing climate, price fluctuation, diseases, and globalization to sustain its livelihoods in a sustainable manner against all adversity [75]. Tanzania rice production and productivity have been increasing steadily year after year. More farmers are entering in rice cultivation hence the area under rice cultivation has increased from 82,000 hectares in 1961 to 1,586,952 hectares in 2020 (Table 1). However, the effects of climate change and global warming are evidently impending attainment more production. For instance in 2021 Tanzania received very little rainfall which resulted into dropping of area under rice cultivation to 955,729 (Table 1). During time of little rain or drought some farmers switch to producing other crops such as sorghum, millet

Table 4. Rice value addition practices around the world.

SN	Product	Uses	Country	Source
1	Brown rice	Healthy food especially to diabetic people	Japan	[62]
2	Rice cake	Food/snack	Korea	[63]
3	Flour Blending	Blending with wheat flour (for baking)	Japan	[64]
4	Biodegradable films	Packaging foods	Brazil	[65]
5	Starch	For medical and industrial use	Japan	[66]
6	Vinegar	For cooking and other purposes	Japan	[67]
7	Wine	Alcholic beverage	Japan	[68]
8	Noodle	Healthy food	China	[69]
9	Particle Board	For ceiling and other uses	Nigeria	[70]
9	Rice bran	Livestock feedstuff	Bangladesh	[71]
10	Rice straw	Livestock feedstuff	Philipines	[72]
11	Paper	For education and industrial use	India	[73]

and cassava which can withstand prolonged drought period. Making the rice farmers resilient and sustaining the upward trajectory for rice production in Tanzania against the effects of climate change, global warming and globalization is the key for rice sub-sector development. The resilient of rice farmers and sustenance of rice productivity will bring about specialization in rice production rather than switching or unpredictability of crops to be grown. Specializations are touted to increase trade off, increase efficiency and lead to development of famer's economies of scale [76].

7. Perspectives

In order to increase rice production and make rice contribute more to food security and farmers livelihoods interventions is needed by Government and Agricultural stakeholders to undertake more researches which will lead into new varieties, new method of farming and crop protections. Furthermore, utilization of modern technologies such as mutation breeding, polyploidy breeding, biotechnologies, production of perennial rice variety and climate smart farming systems will be key in obtaining sustainable solutions to future rice production. This technologies have successful utilize in rice and other crops in many countries so it has potentials to be fully utilized in Tanzania and became effective as well [6] [29] [35] [41].

Moreover, enhancing extension services using ICT, lead farmers and field demonstration centres will help making sure research outputs and solutions are put in use by farmers. Studies shows most of research output or solutions that are published in journals and books are rarely used by farmers in rural areas [77]. Despite having some high yielding varieties such as SARO5, NERICA etc (**Table 2**) most farmers continues using farm saved seeds from landraces which are mostly of low quality [57] [77]. Training rice farmers on community seed production under the umbrella of Agricultural Marketing Cooperative Society (AMCOS) will likely help the diffusion of improved seed. The improved seed they can be introduced to farmers through AMCOS and Quality declared Seed (QDS) can be produces in subsequent years under the supervision of Zonal Tanzania Seed Certification Institute (TOSCI) and agricultural officers in their villages or wards [78]. Similarly, implementation of Good Agricultural Practices (GAP) from land selection and preparation to harvesting is key in sustaining high and increased rice production. The use of system of rice intensification (SRI) and enhancement of irrigation schemes via diversion of rivers, use of lake, underground water and harvesting of rainwater will increase productivity, reduce dependence on rain and increase resilience of farmers [57]. Also, will make it possible to produce rice at least twice or thrice a year in some areas increasing out a, revenue and profit margin to rice farmers. With the rice production of 4,528,000 tonnes in 2020, rice production can jump up to close or more than 10,000,000 tonnes a year which will make Tanzania the leading country in rice production in Africa. Other countries like Egypt and south Asia they produce twice a year so it can be done in Tanzania as well [34] [57].

The increase of rice production will enhance food security and rice surplus. The rice surplus will spur industrialization in rice growing areas. Rice farmers will be able to sell rice and rice by products such as rice husks and rice straws. Small and large industries will be established for rice processing, grading and packaging of white or brown rice. Rice processors can further make rice flour, rice flour blending or manufacture starch for both medical and industrial purposes. Flour can be locally used for making porridge, *ugali* or rice cake (*vitumbua*). Other industries will be established use rice and rice product in the manufacturing of different products such as pasta, noodles, vinegar, rice wine, animal feedstuffs and furniture's.

Markets (both local and international) will be created for rice products. Many people will be able to self-employ or be employed in businesses related to rice. The Value of rice and profit margin will increase hence many farmers will enter and specialize intensively in rice production and the rice cultivation will finally become resilient and sustainable because farmers will be more professional, have good profit margins, assured profits and available markets for their produce.

8. Conclusions

Rice production in Tanzania happened by chance through the Asian early settlers. It passed centuries unnoticed. Slave trade helped its spread. After independence, the production increased dramatically despite many setbacks and challenges. Although production has increased significantly, rice productivity is low in comparison to world rice productivity standards. This is partly due to dependence on rainfall, little use of improved variety and low adoption of good agricultural practices. The consumption and demand of rice are ever increasing because of high preference of rice as a staple food by Tanzanians and people in neighbouring countries in Africa. In order to sustain rice production and make rice farmers resilient against climate change, global warming and globalization effects climate smart technologies, new varieties, irrigated rice ecosystem, research on new varieties and more rice value addition should be adopted. As long as farmers will continue getting good harvests and good profits from rice cultivation despite all other challenges then farmer will continue or perhaps increase rice cultivation. Rice has potential of becoming a main food as well as source of income, livelihood and re-ignite industrialization and economic development in Tanzania.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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