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Research and Development for Improved Cassava Varieties in Ghana: Farmers' Adoption and Effects on Livelihoods

Patricia Pinamang Acheampong, Eric Owusu Danquah, Kennedy Agyeman, Kwame Obeng Dankwa and Monica Addison

Abstract

The importance of Cassava in the food systems of Ghanaians cannot be underestimated. As a main staple crop, Cassava contributes about 22% and 30% to the Agricultural Gross Domestic Product (AGDP) and daily calories intake respectively. Per capita consumption of 152 kg makes it the highest among all food crops. Due to Cassava's importance, there have been lots of attention paid to it by the Government and Donor agencies towards its improvement. This has yielded substantial results in terms of the development of cassava varieties and good agronomic practices. This chapter reviewed cassava technologies development in Ghana, adoption of these technologies by smallholder farmers, and livelihood implications. Results generated showed that Research and Development since 1993 has developed, released, and disseminated 25 new cassava varieties to smallholder farmers. Average cassava yields have increased from about 14 t/ha in 2009 to 21 t/ha in 2018. Partial budget analysis showed that smallholder farmers' profitability has increased over the years from GHC644.32 (about US\$ 111) in 2009 to GHC5243.27 (about US\$ 904) in 2018. Again, the crop is gradually gaining attention as an industrial crop for flour, starch, and alcohol production, a drive that would further improve on returns to farmers. It is a food security crop because it is robust, produces more per unit area, and versatile for multiple usages in household foods and derivatives. It is recommended that continuous policy consideration on cassava in national agricultural agenda setting is essential.

Keywords: food system, per capita consumption, productivity, Policy, technologies

1. Introduction

Cassava (*Manihot esculenta* Crantz) is an important food security and income-generating crop cultivated by many smallholder farmers globally, mainly in developing countries [1, 2]. Cassava came to Africa in the 16th century from Brazil through Portuguese traders and was adopted for home consumption as a famine-reserve crop during drought seasons [3]. Cultivation of cassava in Ghana started

around trading ports, castles, and forts as a major food for the Portuguese and their slaves. By mid of the 18th century, its cultivation had spread along the coastlines of Ghana. The serious drought in Ghana in 1982–1983 cropping seasons failed resulting in the failure of many staple food crops accounted for the wild spread of cassava from the coastal area to other areas of the country [4]. Despite the important role of Cassava in Ghanaian food security, productivity is below potential. The continuous efforts by Research and development to increase productivity are necessary to improve the current situation.

The contribution of agricultural technology, such as improved seeds to agricultural productivity and increases in rural incomes, cannot be underestimated. Improved agricultural technology is believed to lead to poverty alleviation through positive effects on consumers' food prices, producers' incomes, and labourers' wage incomes [5, 6]. The impacts of agricultural technologies on poverty alleviation could be direct and indirect; nonetheless, the direct effects are far more significant than the indirect effects, as evident from many countries [7]. The main goal of developing agricultural technologies such as high-yielding crop varieties is to reduce hunger, malnutrition, and poverty in rural and urban areas [5]. [5] opined that a percentage increase in agricultural productivity could decrease the percentage of poor people living on less than \$1 a day by 0.6% and 2%. There had not been any known economic activity that has generated that kind of effect for the poor.

Ghana's agriculture sector, compared to other sectors, is dominated by staple crops and has a greater impact on poverty reduction as it employs the majority of the working force [8, 9]. Cassava is particularly important amongst the Ghanaian staple crops, as it guarantees good yields even in harsh conditions. It also offers flexibility to resource-poor farmers because it could serve as either subsistence or as a cash crop. As a cash crop, cassava generates cash income for the largest number of households with other staples. Due to cassava's importance, a lot of attention has been paid to it. Research and development have released and disseminated 25 new varieties [10] over the years. Many studies [11–13] have reported on their adoption by farming households. The current theme looks at cassava research, cassava varieties developed, improved cassava variety adoption, and their impact on smallholder farmers livelihood.

2. Cassava production, area harvested, and productivity

As a main staple food crop, cassava contributes about 22% and 30% to the Agricultural Gross Domestic Product (AGDP) and daily calories intake of Ghanaians respectively. Ghana since 2005 has ranked 6th globally in terms of value [9, 14]. It is the most widely cultivated and consumed root and tuber crop followed by yam and cocoyam. As presented in **Figures 1–3**, between 2009 and 2018 cassava production, the area planted, and per capita consumption averaged 16,190,210 Mt, 897,230 ha, and 152.9 respectively. Within the same period the production, area planted, and per capita consumption averaged 6,870,810 Mt, 424,080 ha, and 125 respectively for yam and 1,348,230 Mt, 203880 ha, and 40, respectively for cocoyam [9, 14, 15].

The forest-Savannah transition and the forest agro-ecological zones consisting of Eastern, Brong-Ahafo, Ashanti, Central, and Volta regions are the major cassava producing areas contributing about 86% of the total national production. Nation-wide area planted to cassava and production increased by 1.13% and 5% respectively in 2016–2018 [9]. Although productivity increase has been observed,

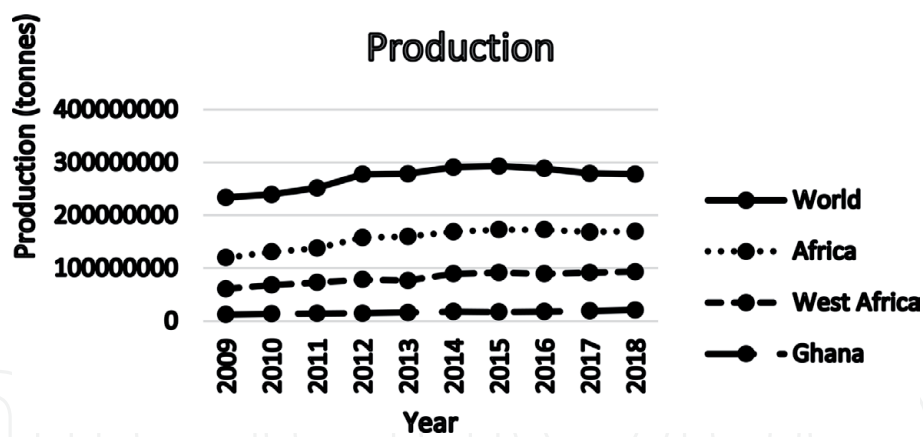


Figure 1.
Production of cassava in Ghana compared with the world, Africa and West Africa. Source: FAOSTAT [15].

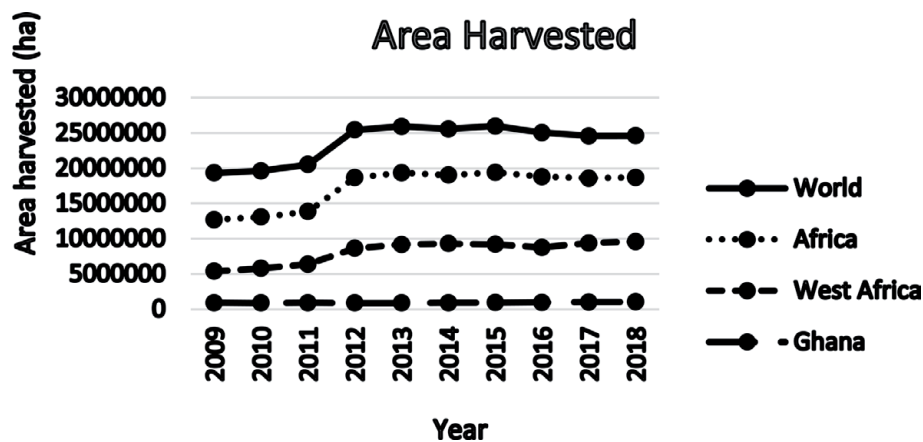


Figure 2.
Cassava area harvested in Ghana and compared with world, Africa and West Africa. Source: FAOSTAT [15].

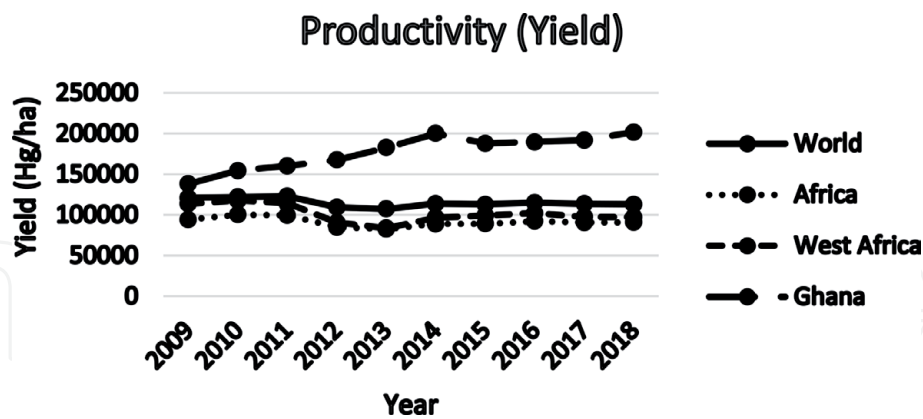


Figure 3.
Cassava yield trend (2009–2018) in the world, Africa and West Africa compared to Ghana. Source: FAOSTAT [15].

production expansion may be due to area expansion as only 47.40% (21.33 Mt/ha) of the potential yield of 45 Mt/ha is achieved currently [9].

3. Cassava improvement in Ghana

Originally, farmers selected or collected cassava stems from previous cultivation to establish new fields with little to no knowledge of disease transfer and trait heritability.

In the '1930's Cassava Mosaic Virus Disease (CMVD) was first reported in Ghana [3]. The disease was highly destructive and severely affected all existing local varieties, especially at the early stages [16]. The government of Ghana's attention was drawn, and the first intervention towards the development of improved cassava varieties began.

The first intervention from the government of Ghana (GoG) toward developing improved cassava varieties was in 1930 when the Cassava Mosaic Virus Disease (CMVD) was first reported in Ghana [3]. The disease was highly destructive enough to merit attention, as all existing local varieties were severely affected significantly at the early stages [17]. This intervention involved introducing superior cassava varieties from other countries in West Africa, East Africa, and the Caribbean. Several crosses were made between these superior varieties and their local counterparts followed by selections for desirable traits resulting in the release of four outstanding cassava varieties namely "Queen", "Gari", "Williams" and "Ankrah" in 1935. These crops were high-yielding (7–10 t/ha), of good taste, highly resistant to CMVD, and were grown extensively across the country [18]. In the late 1950s, the newly released varieties except "Ankrah" became highly vulnerable to CMD, blaming it on either increased virulence of the virus or breakdown in resistance or purity, compelling a second breeding intervention for CMVD resistance [18].

The second breeding intervention involved crosses between the local varieties and four other species closely related to *M. esculenta* since no resistance could be found in any *M. esculenta* varieties. These inter-species crosses were carried out all through the mid-1950s to mid-1960. Out of these crosses four selected progenies K357, K162, K680, and K491 were released to farmers [18]. The best of these varieties, K680, yielded around 19 t/ha, had moderate resistance to CMVD with good palatability and cooking quality. These varieties were cultivated widely and their good characteristics were maintained until the late 1970s and early 1980s. A third intervention had to be sought to obtain varieties resistant to two new pests (cassava green spider mite and cassava mealybug) and a new disease, Cassava Bacterial Blight (CBB), in addition to CMVD [18].

Ghana entered into a bilateral agreement with IFAD, leading to the implementation of the Ghana Smallholder Rehabilitation and Development Programme (SRDP). The National Root and Tuber Crops Improvement Project (NRTCIP), which commenced in 1988, was a component of SRDP [19]. Among the chief aims of the NRTCIP was giving support to root crop adaptive trials, starting a program of biological control of cassava mealybug and cassava green mite, and supporting human resources development for root and tuber crops research and biological control of the pest.

An appreciable number of research works were carried out on Cassava in the late 90s, including; mealybug and green spider mite biological control programme. The SRDP project ended in 1995, but the NRTCIP continued to receive some funding under the succeeding project, the Smallholder Agricultural Development Project (SADEP) born out of SRDP. With the assistance of the World Bank, the Government of Ghana In 1991 launched a National Agricultural Research Project (NARP) as a long-term process to strengthen Ghana's agricultural research system. The project generated improved technologies to contribute to national development objectives and growth in the agricultural sector.

The severe drought and famine experienced during the 1980s in Ghana intensified factors limiting agricultural development, resulting in agricultural production decline [20]. To augment the stumpy growth in the national economy, the government of Ghana (GOG), under the guidance of the World Bank and IMF, established an Economic Recovery Programme (ERP) in 1983 to stabilize the deteriorating economy. Effective policies introduced by the ERP resulted in the decline in

Variety	Year Released	Maturity Period (Months)	Mean Root Yield (T/ha)	Total Dry Matter (%)	Uses	CMV Resistance
Afisiafi	1993	12-15	28-35	32	Starch, flour, gari	Tolerant
Abasafitaa	1993	12-15	29-35	35	Starch, flour, gari	Tolerant
Tekbankye	1997	12-15	30-40	30	fufu, ampesi, gari	Susceptible
Dokuduade	2005	12	35-40	30	Starch, gari	Resistant
Agbelifia	2005	12	40-45	33	Starch, gari	Resistant
Essam bankye	2005	12	40-50	35	Flour, gari	Resistant
Bankyehemaa	2005	9-12	40-50	32	Flour, gari, fufu	Resistant
Capevars bankye	2005	9-12	30-35	30	Flour, gari, fufu, starch	Resistant
Bankyebotan	2005	12-15	25-30	28	Flour, gari, starch	Tolerant
Eskamaye	2005	15-18	16-23	25	Tuo, konkonte	Tolerant
Filindiakong	2005	15-18	16-20	28	Tuo, konkonte	Tolerant
Nyerikobga	2005	15-18	17-29	30	Tuo, konkonte	Tolerant
Nkabom	2005	12-15	28-32	32	Starch, fufu	Tolerant
IFAD	2005	12-15	30-35	30	Starch, fufu	Tolerant
Ampong	2010	12	40-50	36	Flour, Starch, fufu	Resistant
Broni Bankye	2010	12	40-45	33	Flour, bakery products	Resistant
Sika bankye	2010	12	40-45	36	Flour, Starch	Tolerant
Otuhia	2010	12	35-40	39	Flour, Starch	Resistant
CRI-Duade Kpakpa	2015	12-15	60	37	Poundable, Flour, starch	Resistant
CRI-Amansan bankye	2015	12	57	38	Flour and bakery products	Resistant
CRI-AGRA bankye	2015	12	63	32	Starch, flour	Resistant
CRI-Dudzi	2015	12	49	38	Starch, Flour	Resistant
CRI-Abrabopa	2015	12-15	46	40	Hi-starch	Resistant
CRI-Lamesese	2015	12	50	39	Poundable, Beta-Carotene, Flour	Tolerant

Note: CMV is cassava mosaic virus. Source: CSIR - Crops Research Institute's Annual reports (various).

Table 1.
Improved Cassava Varieties Released in Ghana and Their Characteristics.

the production of major food crops, including cassava [21]. Under the ERP, an Agricultural Services Rehabilitation Project (ASRP) was launched in 1987 to expand agricultural production through research, extension services, irrigation, policy planning, monitoring, and coordination [21].

In 2000, the Agricultural Services Sub-sector Investment Programme (AgSSIP) [22, 23] was also introduced, followed by the Root and Tuber Improvement and Marketing Program (RTIMP). In 2008 the West Africa Agricultural Productivity Program (WAAPP) was also initiated to develop improved technologies for roots and tubers in collaboration with the Root and Tuber Improvement and Marketing Program (RTIMP) [23]. Over the years, these programmes and projects have brought about the development and release of 25 new cassava varieties (**Table 1**).

All these varieties have moderate resistance to the cassava mealybug pests and tolerant to the cassava mosaic virus. Without fertilizer application, the new cassava varieties have 40% higher yields than the local varieties on farmers' fields [1]. In terms of various post-harvest attributes and for intercropping these new varieties are as good as the local varieties.

4. Good agronomic practices

The performance of any released improved cassava or crop varieties is significantly influenced by the agronomic package that goes with it. For example, cassava farmers who adopted the Root and Tuber Improvement and Marketing Programme (RTIMP) Technology of improved planting materials and agronomic packages increased productivity [24]. Thus, apart from developing the improved varieties, the research systems have developed improved agronomic technologies that are complementary. They include minimum tillage, spacing, plant density, fertilizer application, use cover and manure of green, weed control, and disease control. The practice of minimum tillage in cassava production is strongly recommended. Farmers are advised to slash but not burn their whole farm but rather practice spot burning when necessary. It is recommended that minimum tillage is practiced in sandy soils to conserve soil moisture and reduce soil erosion. Infertile soils, recommended plant population of 10,000 plants/ha is used. Stem cuttings must be planted at 1.0x1.0 m for sole crop cassava or at wider row spacing (up to 2 m between rows) and closer in-the-row spacing (down to 0.5 m) for intercropping [25–28].

While Cassava can grow better than most other crops in impoverished soils, the crop does respond well to chemical fertilizers or animal manures. A fertilizer application rate of 200 kg of N-P₂O₅-K₂O 15-15-15/ha or 20 g of fertilizer per plant is recommended. Leguminous intercrops and green manures can improve the N status of soil through N fixation. In areas where ploughing is used, farmers are advised to plough leguminous cover crops such as *Mucuna* to improve the soil's physical and chemical properties. They are also advised to add manure such as cow dung or poultry droppings at land preparation [25, 26].

Cassava is a poor competitor and may suffer severe yield losses if weeds are not adequately controlled during the early growth stages. Generally, weeds should be cleared 2-3 times during the first three months or until canopy closure. Weeding is most often done manually by hoe or with herbicides. Weed competition is lessened by adequately applying fertilizer to speed up canopy closure, intercropping, and planting in the early dry season when weed growth is less vigorous. When herbicides are used, it is recommended to apply glyphosate (roundup)/paraquat (gramoxone) as a pre-planting herbicide to kill fallow vegetation. For post-emergence control of weeds, a shield should be used to keep chemicals off the crop [25, 26].

The primary diseases affecting cassava are bacterial blight, mosaic disease, root rot, and anthracnose. The means of controlling the mosaic disease are not yet known. Planting tolerant varieties, planting clean stem cuttings, roguing out disease plants and burn to reduce diseases' spread are some of the recommendations [25].

Ghana's agro-ecological zones have annual rainfall ranging between 800 mm and 2200 mm with a soil pH of 3.5–7.8. The Forest, Forest-Savannah transition and Coastal agro-ecological zones have bimodal rainfall whiles the Guinea and Sudan savannahs have unimodal rainfall. These suitable conditions for cassava production give Ghana a competitive advantage for cassava production in the entire world [9].

5. Adoption of improved varieties

The major reasons for the development of improved technologies and the release of high-yielding varieties are to reduce hunger, malnutrition and poverty. Also, it is expected to result in improved income and livelihood of poor people living in marginal areas [5]. Interestingly, cassava production has been increasing in the past five years since 2007. In 2007, cassava's total production was a little over 10.2 million tons (MT). Currently, cassava production is estimated at 19.2 million tonnes, the highest among all food crops [9].

The increase in production can be associated with the adoption of improved cassava varieties. In Ghana, farmers' preference for the variety they choose for cultivation is based on; yield, in-soil storage (longevity) and disease resistance [29].

Variable	All zones	Forest	Transition	Costal savannah	Guinea Savannah
All improved Cassava	41.22	47.85	48.39	41.03	43.85
Afisiafi	15.69	10.84	18.71	19.23	11.63
Filindiakong	0.25	0.00	0.00	0.00	1.00
Tech bankye	0.34	0.41	1.29	0.00	0.34
IFAD	0.08	0.00	0.65	0.00	0.00
Nkabom	0.34	0.61	0.65	0.00	0.00
Capevarse	0.25	0.61	0.00	0.00	0.00
Bankyehemaa	11.62	13.70	15.48	7.26	9.63
Esambankye	1.36	2.45	1.94	0.00	0.66
Agbelifia	0.34	0.20	1.29	0.00	0.00
Abasafita	0.59	0.41	0.00	0.43	1.33
Ampong	1.53	1.23	2.58	1.14	1.00
Sika	3.73	4.91	0.00	1.28	5.98
Otuhia	0.93	0.00	0.00	4.70	0.00
Bronibankye	0.17	0.00	0.00	0.00	0.33
Agric/MoFA	4.66	7.77	2.58	2.14	6.97
Indigenous	58.86	52.15	49.68	58.97	56.15

Source: Acheampong et al. (2007).

Table 2.
Adoption rates of improved varieties by agro-ecological zones, Ghana.

For example, [30] reported that some farmers in the Brong-Ahafo and the Ashanti Regions have testified that the improved varieties of cassava yield three times more than the local varieties. Poverty alleviation is possible with the use of improved technologies [31]. The adoption of improved cassava varieties in Ghana is essential since the crop is cultivated by about 90% of the farming population in Ghana [32], making it the right target crop for reducing poverty in the country [33]. A recent study by [12] put the overall adoption rate of improved cassava varieties at 40%, indicating the need to do more to encourage adoption. Adoption of improved cassava varieties is very crucial to improving productivity. [34] observed that higher adoptions can be achieved through the availability and distribution of planting materials and farmer participatory demonstrations. **Table 2** presents adoption rates of improved varieties by agro-ecological zones in Ghana.

6. Livelihoods improvements

Ghana's national food security is time and again attached to the availability of root and tuber crops especially cassava. The food security role of Cassava is widely attributed to its availability during times of food shortages. Because cassava can provide multiple opportunities for poverty reduction and nourishment for poor people in Ghana, lots of research efforts have gone into the development and dissemination of it for increased production to meet increasing demand. To increase food production, policy objective and research emphasis have been on increased production and adaptability to diverse production systems and environments [24, 35]. The rapid increase in cassava production will undoubtedly have significant implications on food security, employment creation, living conditions, and economic growth [31, 36, 37]. Food security is attained once the total available physical supplies of food are adequate and households have ample access to those food supplies through either their production, the market, or other sources, and the utilization of those food supplies is appropriate to meet the specific dietary needs of individuals [38].

[39] found many uses of cassava in Ghana and other West African Countries. Cassava tubers can be eaten as a vegetable after boiling or roasting. They can also be boiled and pounded into a paste and then added to soups and stews ("Fufu" in Nigeria and Ghana). The fresh tubers can be preserved as sundried chips ("Kokonte" in West Africa) and consumed after cooking or ground into flour [40]. Cassava can also be eaten as coarse flour form known as "Gari". Apart from fresh consumption of Cassava, the crop can also be processed into chips for animal feed and into starch for either food or non-food industries. Cassava flour is used to prepare bread, biscuits, confectionery, pasta, and couscous-like products and the production of adhesives. It is used in the textile and paper industries and plywood and veneer adhesives manufacture. In pharmaceuticals, it is used in the production of glucose and dextrin syrups. Cassava root extract can be fermented to produce alcohol. As a waste material, it can be processed into biogas.

Cassava is also an income generation crop for many farming households in Ghana. Cassava yields improved from 13 to 16 t/ha to 18–20.1 t/ha between 2009 and 2012 and 2013–2018, respectively [14]. This resulted in an average benefit–cost ratio of 1: 0.59 and 1: 1.54 for 2009–2012 and 2013–2018, respectively. Thus, a profit or returns of about Gh ¢ 0.54 would be accrued in addition to the Gh ¢ 1.00 invested capital for cassava production after the 2012 cropping season. This is compared to early seasons before 2012 when losses would have been incurred (**Table 3**). Improvement in the adoption of improved cassava varieties by farmers might increase productivity (yield) after 2012.

Year	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Average yield (ton/ha)	13.81	15.43	16.01	16.75	18.27	20.02	18.78	18.96	19.19	20.18
Average rural wholesale price (GhC/ton)	171.96	202.88	200.27	305.64	422.55	399.61	478.09	453.40	511.87	449.36
Gross benefit (C/ha)	2374.32	3130.99	3206.84	5119.05	7720.16	8001.75	8978.66	8596.52	9824.72	9068.27
land clearing(C/ha)	400.00	450.00	510.00	600.00	690.00	715.00	780.00	810.00	830.00	860.00
Cost of planting materials(C)	300.00	350.00	380.00	500.00	640.00	650.00	690.00	710.00	740.00	780.00
Labor cost for planting(C/ha)	280.00	330.00	360.00	410.00	430.00	460.00	490.00	615.00	640.00	655.00
Cost of weeding 2 times till harvest (C/ha)	450.00	480.00	510.00	560.00	645.00	690.00	705.00	735.00	760.00	780.00
Harvesting cost(C/ha)	300.00	390.00	450.00	510.00	590.00	640.00	690.00	710.00	740.00	750.00
Total cost of production	1730	2000	2210	2580	2995	3155	3355	3580	3710	3825
Net benefit	644.32	1130.99	996.84	2539.05	4725.16	4846.75	5623.66	5016.52	6114.72	5243.27
Benefit cost/Ratio	0.37	0.57	0.45	0.98	1.58	1.54	1.68	1.40	1.65	1.37

Note: Average rural price of cassava from 2012 to 2018. Source; FAOSTAT [15] & MoFA (2018).

Table 3.
Partial budgeting and profitability of cassava production in Ghana from 2009 to 2018.

A higher adoption rate of improved cassava varieties is associated with increased income, poverty reduction, and household food security. [41] showed that improved cassava varieties had significant poverty-reducing impacts in Zambia and [42] in their impact assessment of the adoption of improved cassava varieties in Ghana, revealing an increase in income of cassava farmers where the impact is more realised in female farmers than male farmers. Their Average treatment effect (ATT) estimates suggested that participation in improved cassava varieties increased total crop incomes of women by ₦3,173 (USD 1,823) whilst that of men was increased by ₦149 (USD 86) per hectare. In stimulating agricultural growth by using improved cassava varieties; household food security is also ensured as most farmers can use food from their production rather than food purchases [43–45]. Cassava provides farmers with additional income-earning opportunities and enhances their ability to contribute to household food security [46, 47]. This is beneficial to alleviating poverty as [48] reiterated that the adoption of agricultural technology by women is significant as it can generate large gains in alleviating poverty. Also, the increase in its production through the adoption of improved cassava varieties of high-yielding and disease-resistant characteristics can improve rural welfare [12]. [49] opined that cassava consumption aids in the nutrition of its consumers due to its nutrient traits. In the study, he stated that cassava produces remarkable energy quantities per day, even compared to cereals.

The rising demand for cassava starch at both the local and international market presents a great opportunity for Ghana to enhance foreign exchange revenue through export and improve farmers' livelihood through improved income. In light of this, the Government of Ghana in 2001 introduced the Presidential Special Initiative (PSI) on cassava, which aimed at industrialising the cassava sector for job creation and livelihood improvement through starch production export. The Ayensu starch company at Bawjiase was established for this purpose [50]. The general expected impact was that Ghana would improve cassava value chain and take advantage of the rising global demand for cassava-starch which stood at about 222 million metric tonnes in 2002 [51]. Cassava starch has a competitive advantage for ethanol production over other materials [44, 45] Gradually, cassava is becoming an urban food as cassava flour is reported to be an excellent supplement to wheat flour up to 20% for the production of bread and other pastries [50, 51].

7. Conclusions and future directions

This chapter has reviewed cassava varieties development, adoption, and livelihood indicators in Ghana. Generally, improved cassava technologies play critical roles in agricultural transformation and livelihood improvements of smallholder farmers and other value chain actors in Ghana. Research and development have generated many new varieties and good agronomic practices. Since 1993, 25 new cassava varieties have been developed, released, and disseminated to smallholder farmers. The average yields of cassava over the years have been encouraging. The average yield of cassava has increased from about 14 t/ha in 2009 to 21 t/ha in 2018. Partial budget analysis showed that smallholder farmers' profitability increased over the years from GH¢644.32 in 2009 to GH¢5243.27 in 2018.

Adoption of improved cassava technologies such as improved varieties and good agronomic practices should, *ceteris paribus*, increase cassava productivity and provide additional income for smallholder farmers. The suggestion is that a demand-driven approach should be adopted to promote and develop cassava-based industries identifying opportunities and constraints of cassava at each stage of

the commodity chain. This is achieved by individuals interested in developing the cassava industry; producers, processors, and consumers of cassava, and associated national and non-governmental organisations. Government and non-governmental organisations could support to establish a cassava seed system. Commercial seed producers could then be encouraged to adopt it through training and demonstrations and setting up sales points across the country.

Cassava serves as a major staple as in calories consumed and as a source of raw material for starch-based industries. It is now regarded as a major food security crop. It can change the livelihood of various actors along the value chain making it essential not only as a food crop but also as a significant source of income for rural households. Research on alternative food forms and breeding to improve the shelf-life of the tubers would be required.

To achieve food security through the production and supply of staple food as cassava, to meet the population's demands, the government and private sector should increase support to the development and dissemination of improved cassava technologies that improve cassava farmers' resilience to climate change. Also, smallholder farmers should be incentivised in terms of credit and other production inputs to adopt improved technologies for increased productivity and improved livelihoods.

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Conflict of interest

The authors declare no conflict of interest.

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