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Cassava for Food Security, Poverty Reduction and Climate Resilience: A Review

Sheela Immanuel, D. Jaganathan, P. Prakash and P. Sethuraman Sivakumar

Extension and Social Sciences, ICAR-Central Tuber Crops Research Institute, Thiruvananthapuram-695 017, India
E-mail: sheela.immanuel@icar.gov.in

***Abstract*:** Cassava plays a significant role in the food security of the rural poor and marginal farmers and is also recognized as an important industrial crop. Among the crops, cassava is the third largest source of carbohydrates in the tropical region after rice and maize. It is a major staple food in the developing world, which has the capacity to provide a basic diet for over half a billion people. The worldwide production of cassava amounted to 315 million metric tons in 2021, out of which Africa's share was about 65%. According to FAO projections, by 2025, about 62% of global cassava production will come from sub-Saharan Africa. Cassava is a crop that can be considered a poverty reduction crop as it is climate resilient and can be grown in marginal, less fertile soil with less-inputs. Its tuberous root contains 30-40% dry matter and 25-30% starch. Nutritionally, cassava contains potassium, iron, calcium, vitamin A, folic acid, sodium, vitamin C, vitamin B-6, and protein. It is a climate resilient and insurance crop that helps rural people tide over the famine caused by natural calamities and other disasters. Cassava is a crop that is considered as a poor man's saviour crop which helps them to sustain their livelihood in times of natural disturbances. Cassava is a best crop which contributes for rural development, poverty reduction, economic growth and food security. The present review gives comprehensive information about the cassava crop and its role in food security, poverty reduction and income generation for farmers.

***Keywords*:** Cassava, Food security, Poverty, Climate resilience

Cassava is an important staple food crop for more than 500 million people worldwide due to its high carbohydrate content (Blagbrough et al 2010) and is an essential crop in developing countries. Cassava is considered as the third most important crop in India with high productivity. Cassava originated in South America and was distributed to tropical and subtropical regions of Africa and Asia (Blagbrough et al 2010). A recent report from the Consultative Group on International Agricultural Research (CGIAR) noted that 'root crops will be many things to many people by 2020' (Scott et al 2000). The worldwide production of cassava amounted to 315 million metric tons in 2021, out of which Africa's share was about 65%. According to FAO projections, by 2025, about 62% of global cassava production will come from sub-Saharan Africa (FAOSTAT 2020). Cassava is mainly cultivated in the southern parts, particularly in Kerala and Tamil Nadu, which contribute over 92 per cent of the total cassava production in India (GoI 2018). Cassava is a tropical root crop that needs at least 8 months of warm temperature to establish and grow. Cassava does not tolerate freezing conditions. It tolerates a wide range of soil pH from 4.0 to 8.0 and is most productive in full sun and is a hardy crop that produces tuber under marginal conditions, e.g., drought or depleted soils (Iyer et al 2010). Its tuberous root contains 30-40% dry matter and 25-30% starch. Nutritionally, cassava contains potassium, iron, calcium, vitamin A, folic acid, sodium, vitamin C, vitamin B-6, and protein (Montagnac et al 2009a). Cassava roots and leaves are good sources of carbohydrates, protein, vitamins, and minerals (Bayatagna 2019). The cassava tubers are also used as raw materials in the garment, bakery, food, and pharmaceutical industries. Cassava is a crop that is considered as a poor man's saviour crop which helps them to sustain their livelihood in times of natural disturbances. Among the crops, cassava is the third largest source of carbohydrates in the tropical region after rice and maize. It is a major staple food in the developing world, which has the capacity to provide a basic diet for over half a billion people. Cassava is a crop that can be considered a poverty reduction crop as it is climate resilient and can be grown in marginal, less fertile soil with less-inputs. Owing to the role of cassava in the African feeding pattern, it is often referred to as the “hunger crop” (Wigg 1993). Though relatively new in African agriculture, it has become very popular because of its ease of cultivation and adaptability to a wide variety of soils even the marginal ones (Hahn 1994).

Status of cassava cultivation globally: Globally cassava is grown in an area of 29.65 million ha producing 314.80 million tons with an average yield of 10.62 tons/ha. It is grown in 94 countries and these countries are in Africa, America, Asia and Oceania continents. Among the continents, African continent occupied the first position in terms of area (80.34%) and production (64.67%) of cassava with a yield of 8.55 t/ha

followed by Asian continent contributing 12.79% of the cassava area with production share of 26.76%. The Americas continent occupied third position accounted 6.80% of the cassava area with a production share of 8.49% of the world production. Among the countries, Nigeria had the largest area under cassava (30.64%) with an annual output of 20.02% followed by Democratic Republic of the Congo (18.90% area and 14.51% production) and Thailand (4.94 % area and 9.56% production). Thailand, Indonesia, Vietnam, China mainland, Cambodia, Philippines and India are the major cassava producing countries in Asia continent (Table 1).

Status of cassava cultivation in India: During 2017-2018, area (51.85%) and production (57.83%) of cassava was highest in Tamil Nadu followed by Kerala (31.67% and 34.87%) and Andhra Pradesh (7.34% and 3.88%). Approximately 97% of the nation's total cassava production was produced in these three states. Tamil Nadu alone contributed about 58 percent of the total cassava production. In addition to the South Indian states, the North-Eastern states of Nagaland (1.60%), Assam (0.58%), and Meghalaya (0.73%) also contributed significantly to the total production of cassava (Table 2).

Cassava as a food security and poverty reduction crop: Cassava crop is known for its wide ecological adaptability and always perform relatively well where other crops fail to

Table 1. World cassava producing regions and countries, 2021

Continent	Country	Area (Million ha)	% to total	Production (Million tons)	% to total	Yield (Tons/ha)
World	Total world	29.652	100	314.807	100	10.62
Africa	Total	23.822	80.34	203.573	64.67	8.55
	Angola	1.017	3.43	9.867	3.13	9.70
	Benin	0.362	1.22	4.219	1.34	11.65
	Burundi	0.321	1.08	2.528	0.80	7.88
	Cameroon	0.395	1.33	4.994	1.59	12.63
	CÃ´te d'Ivoire	1.093	3.69	6.962	2.21	6.37
	DR of the Congo	5.605	18.90	45.673	14.51	8.15
	Ghana	1.010	3.41	22.682	7.20	22.46
	Guinea	0.301	1.02	2.743	0.87	9.10
	Madagascar	0.306	1.03	2.440	0.77	7.97
	Mozambique	0.569	1.92	5.598	1.78	9.84
	Nigeria	9.086	30.64	63.031	20.02	6.94
	Togo	0.322	1.09	1.178	0.37	3.66
	Uganda	0.878	2.96	2.679	0.85	3.05
	UR of Tanzania	0.987	3.33	6.126	1.95	6.21
Americas	Total	2.015	6.80	26.715	8.49	13.26
	Brazil	1.206	4.07	18.098	5.75	15.01
	Paraguay	0.188	0.63	3.384	1.07	18.00
Asia	Total	3.793	12.79	84.252	26.76	22.21
	Cambodia	0.282	0.95	7.722	2.45	27.41
	China, mainland	0.303	1.02	4.954	1.57	16.36
	India	0.183	0.62	6.941	2.20	37.93
	Indonesia	0.666	2.25	17.749	5.64	26.64
	Philippines	0.216	0.73	2.560	0.81	11.84
	Thailand	1.466	4.94	30.108	9.56	20.54
	Viet Nam	0.525	1.77	10.566	3.36	20.14
Oceania	Total	0.022	0.07	0.266	0.08	12.00
	Papua New Guinea	0.016	0.05	0.156	0.05	9.81
	Fiji	0.004	0.01	0.086	0.03	20.00

Source: Authors computation from FAOSTAT, 2021

produce reasonable yield (Otekunrin and Sawicka 2019). This attribute confers on cassava a reliable food security for farming households in the tropics (Ikuemonisan et al 2020) in addition to providing dietary energy for close to a billion people and livelihood for millions of farmers/processors and traders worldwide (FAO, 2018; Ikuemonisan et al 2020). Cassava is recognized as a subsistence crop to overcome food insecurity for the fast-growing population in areas prone to important climatic changes (Chavez et al 2005, Lobell et al 2008, Burns et al 2010). Cassava is a choice crop for rural development, poverty alleviation, economic growth and ultimately, food security (FAO 2018) and is tolerant to drought and its roots can maintain their nutritional value for a longer time without water and thus, it may represent the future of food security in some developing countries (Elsharwey et al 2003). Few cassava varieties are promoted in food insecure northern areas of Ethiopia. Sheela Immanuel et al (2019) reported that cassava is highly suitable for intercropping/farming systems in Kerala and Tamil Nadu for ensuring livelihood and food security of the farmers.

Cassava is by far the most important root crop grown in the tropics and it forms a dietary staple in many African countries. In the early 1970s the cassava mealybug, *Phenacoccus manihoti,* thrived as it had no enemies in nature and by the late 1970s the pest started damaging as much as 80% of the cassava crop in some areas and it was dispersing rapidly leading to extensive famine and economic and environmental calamity. The 1995 World Food Prize was awarded to Dr. Hans R. Herren, a Swiss-born entomologist made a dramatic and highly successful effort to rescue one of Africa's most important food crops the cassava plant which is a key source of the food consumed by 200 million people from a pest that threatened its total destruction, and in the process averted extensive famine otherwise which would have cost 200 million of Africans lives. (Food and nutrition bulletin, 1996). In the Southern Ethiopia, particularly in Amaro-Kello area, cassava is used as a staple food. In Wolayta and Sidama Zone, cassava roots are widely consumed after boiling or in the form of bread or “injera” (Ethiopia staple food) after mixing its flour with that of some cereal crops such as maize, wheat, sorghum, or teff. Preliminary reports from the southern region of the country suggest that cassava is consumed more frequently in low-income households, and fills the food shortage periods of the year, when supplies of cereal crops such as maize and teff are short (Haile 2015, Balta et al 2015, Legesse and Geta 2015). Cassava is a crop which does not fail and whose food quality is generally improved through processing (Falade and Akingbala 2010). In developing countries, cassava root is a valuable food and energy source and optimum post-harvest handling, processing and storage techniques alleviate some concerns of food insecurity (Uchechukwa-Agua et al 2015). Roots and leaves, which constitute 50 to 60% of the mature cassava plant, respectively, are the nutritionally valuable parts of cassava (Tewe and Lutaladio 2004). The edible green leaves of cassava are a good source of protein, vitamins and minerals and are often used to augment the rural diet (Bradbury and Holloway 1988). The root is a physiological energy reserve with high carbohydrate which ranges from 32 to 35% on a fresh weight (FW) basis, and from 80 to 90% on a dry matter (DM) basis (Julie et al 2009). Cassava (*Manihot esculenta* Crantz.) is considered as the future food security crop because of its biological efficiency coupled with ability to sustain climate change. The calcium content is relatively high compared to that of other staple crops and ranges between 15 and 35 mg/100 g edible portion. The vitamin C (ascorbic acid) content is also high and between 15 to 45 mg/100 g edible portions (Charles et al 2004). Raw cassava root has more carbohydrate than potatoes and less carbohydrate than wheat, rice, yellow corn,

Table 2. State-wise area, production and productivity of cassava in India during 2017-18

States/UTs	Area ('000 ha)	Production ('000 t)	Productivity (t/ha)	% share of area	% share of production
Tamil Nadu	89.61	2862.14	31.94	51.85	57.83
Kerala	54.73	1725.98	31.54	31.67	34.87
Andhra Pradesh	12.68	192.15	15.15	7.34	3.88
Nagaland	5.47	79.32	14.50	3.17	1.60
Assam	3.12	28.87	9.25	1.81	0.58
Meghalaya	5.49	36.24	6.60	3.18	0.73
Karnataka	1.08	13.99	12.95	0.62	0.28
Madhya Pradesh	0.28	4.29	15.32	0.16	0.09
Other states	0.37	6.65	13.13	0.21	0.13
India	172.82	4949.62	28.64	100	100

Source: Prakash et al 2020

and sorghum on a 100 g basis (Montagnac et al 2009b). Cassava root is an energy dense food and it produces about 250,000 calories/hectare/day, which ranks it before maize, rice, sorghum, and wheat (Okigbo 1980). Roots contain small quantities of sucrose, glucose, fructose, and maltose (Tewe and Lutaladio 2004).

In the tropical regions, cassava is the most important root crop and, as a source of energy, the calorific value of cassava is high, compared to most starchy crops. The starch content of fresh cassava root is about 30% and gives the highest yield of starch per unit area. The protein content ranges between 1-3% but contains significant amounts of iron, phosphorus and calcium and is relatively rich in vitamin C (Enidiok et al 2008). Cassava flour is highly recommended in the diet of celiac patients who require strictly gluten free food products (Briani et al 2008). Cassava is the fourth most important source of calories in Africa (FAO, 2020). For some countries of Africa, approximately 25 % of the daily calorie intake is provided by cassava (De Souza et al 2016). However, cassava has been less well studied compared to other crops despite its importance as a food in many of the developing countries (Leal et al 2014, Varshney et al 2010).

Cassava produces more food energy per unit of cultivated land than any other staple crop in sub-Saharan Africa (De Bruijn and Fresco, 1989; Plucknett et al 2000). Cassava has remained a vital crop for food security and income generation in the country contributing about 25% of cash income in many households (COSCA Tanzania 1996). Cassava is widely used for staple foods, livestock feeds, processed foods, and starch production, mainly in tropical Asia and Africa (FAO 2013). Cassava has achieved considerable agricultural importance as a staple food for more than 500 million people, especially in the tropics (Egan et al 1998). Cassava withstands difficult growing conditions and long storability underground makes it a resilient crop, contributing to food security (Amelework et al 2021). Low input requirements, tolerance to drought, the capacity to grow in marginal soils and long-term storability of the roots in the ground make cassava a resilient crop for food and nutritional security (Jarvis et al 2012). Cassava production and the demand are expected to grow largely because of the crop's ability to withstand drought and provide yields on marginal and low-fertility soil conditions. Many countries in the world have realized the economic potential of the crop as a food, feed, and industrial crop. In Africa, the demand for cassava production has been mostly driven by its food applications, but in Asia the demand was mainly for industrial applications for starch, livestock feed and biofuel production. (Amelework et al 2021).

Presently, Nigeria grows more cassava more than any other country in the world. Production is driven primarily by the demand for food for its nearly 130 million inhabitants and the rest very little is used for feed and industry. Cassava is the most widely cultivated crop in the country and it has a major role in the food security of the rural economy because of its ability to yield under marginal soil conditions and its tolerance to drought. Agro-processing and value addition are the platform for employment and wealth creation in the cassava sub-sector. The conversion of cassava into various forms for food, feed, and industrial raw material has the potential to help Nigeria to improve its food security situation, diversify its manufacturing base, generate income and employment and achieve a favourable balance of trade (Ezedinma et al 2007). Cassava provides livelihood security to about 10 lakh farm families in India (Ana Raj et al. 2022).

The relative importance of these crops is evident in their annual global production, which is approximately 836 million tonnes (FAO 2013). Tubers are known as functional foods and possess nutraceutical ingredients that have a major role in disease reduction and wellness (Chandrasekara and Kumar 2016). The contribution of roots and tubers to the energy supply in different populations varies with the country. Cassava is a low-cost source of calories accessible to humans and animals (Tolukari 2004). In Africa, nearly 88 % of cassava produced is used for human consumption, and the remaining 12 % is used as feed for animals and starch-based products (Henry et al 1998). Cassava serves as a source of income for rural people. The inherent characteristics of cassava make it attractive to small farmers. As cassava is a carbohydrate-rich crop, it provides dietary energy to humans. The tubers are processed into various granules, pastes, and flours, consumed in boiled forms or raw (Nweke et al 1998). Tropical tuber crops supply food of 28.5 kg/head/year and 75 kcal energy/head/day (Nayar 2014). The energy content and nutritional values reveal the importance of cassava to readdress the issues like 'food insecurity' and 'malnutrition', especially with climate change (Nedunchezhian et al 2016). Cassava production has significantly increased in the Sub Saharan Africa agri-food systems as a rural food staple, source of cash income, famine reserve crop, and urban food staple, and with increased interest in its potential for animal feed in processed form, industrial uses, and a source of foreign exchange (Spencer and Ezedinma 2017). Once the cassava roots attain maturity, they can be stored in underground conditions for two years and harvested as per the food need of the households (Sanchez et al 2013).

In Nigeria, over 70% of the cassava yield is processed into Gari (Sanni and Olubamiwa 2004). Gari is a creamy white, starchy, pre-cooked grit produced by fermenting the peeled, washed, and mashed cassava roots dehydrated,

sieved, and roasted (Onyekwere 1989). Gari is the most commercial and useful product of cassava processing. It is creamy white, pregelatinized, granular and calorie rich food with bit sour taste (Falade and Akingbala 2010). As cassava is an important food and source of energy, better postharvest handling, processing, and storage methods can reduce food insecurity to a certain extent (Uchechukwa-Agua et al 2015). Cassava also addresses the issue of poverty by providing food security to the marginal people who are devoid of fertile land for cultivation. The cost of production may be reduced if family labour is deployed and little attention is given in the initial stages of crop growth.

Biofortification has the potential to improve the nutritional status and health of poor populations in rural and urban areas in developing countries (Saltzman 2013). Katz et al (2013) stated that cassava holds great potential for pro vitamin A bio fortification. Randomised control trial conducted in Kenya with children aged 5-13 years old revealed that a small improvement in the vitamin A status of children fed provitamin A-biofortified cassava (test group), was significant compared to children who were fed non-biofortified cassava (control group) as reported by Talsma et al 2014. Developing biofortified cassava varieties may address the hidden hunger problem in developing countries and it helps in improving the food and nutritional status of the targeted poor population. Nutritional education combined with health programmes will improve the consumption of the biofortified crops.

Cassava as an income and employment generation crop: The roots are rich in energy, starch and soluble carbohydrates, but poor in protein. It is important not only as a food crop, but also as a source of income for rural households (Awotona and Oladimeji 2020). Intercropping of root and tuber crops with plantation crops is common in Andaman and Nicobar islands, especially in small and medium-sized land holdings, to augment the net income and employment opportunities. In such farms, the produce from the perennials generates cash income, while the starchy root and tubers partially meet the farm family's food requirements and farm animals' feed needs (Sankaran et al 2014). Using cassava would break the vicious cyclic effect associated with its production, increase stakeholders' income, create more jobs, solve some health problems, and reduce dependence on wheat as a staple crop (Kaur and Ahluwalia 2017). Cassava also has the potential to increase farm income, reduce rural and urban poverty and help close the food gap (Nwakor and Nwakor 2012). Although cassava plays an important role as a food security crop in sub-Saharan Africa, it is also used as a cash crop in various cassava-growing regions (Spencer and Ezedinma 2017, Munganyinka et al 2018). Cassava is important, not as a food crop alone but even as a major source of income for rural households. Due to its inherent characteristics, it is more attractive, especially to the smaller farmers. It is rich in carbohydrates and provides a basic daily source of dietary energy. Roots are processed into a wide variety of granules, pastes, flours, or consumed freshly boiled or raw (COSCA Tanzania 1996). Cassava roots serve as an efficient source of carbohydrate food energy, cultivated widely for its ability to withstand harsh environmental and agronomic conditions as well as to its utilization as raw material for many uses and food products (Akoroda 1995).

Cassava is now one of the priority crops to be used as a means to wriggle out of the menace of unemployment in the country (Olukunle 2013). Legesse (2013) concluded that in one of the districts (Amaro), in the southern region, the households that were involved in cassava production were better off regarding calorie intake and income than the households which did not cultivate cassava. Cassava is an important food and cash crop for many rural households in Imo State. As a cash crop, cassava generates cash income for a greater number of households when compared to other staples (Adeniji et al 2000). Cassava is a source of income for farmers with small holdings and is also used as raw materials for industrial purposes (Onabola and Bokanga 1998, Sanni et al 1998).

Cassava processing was a profitable business and could be a source of livelihood for most rural dwellers, particularly women (Ojo et al 2015). Among all the cash crops in Nigeria, cassava production plays a significant role in securing the livelihood of the rural poor and providing a sustainable avenue for value chain actors to create advantage (Ho et al 2019). Women play a central role in Nigerian cassava production, processing and marketing (Enete et al 2002), and provide much of the labour associated with cassava production. In particular women perform the majority of cassava processing in Nigeria (Curran et al 2009, Walker et al 2014). Even women's participation is more in cassava cultivation in states like Kerala and Tamil Nadu in India which supports women to earn their income and maintain their families. Cassava products namely gari, cassava flour (lafun), fufu and starch were the major products from cassava processing and that it provided full employment for 81% of the cassava processors. Cassava processing was a source of employment for majority of the processors and also had ability of alleviating poverty among the rural folks (Ojo et al 2015) and are often considered as an entry point for targeting market interventions to the rural poor, particularly women (Forsythe et al 2015). The vast majority of cassava roots are processed at the village by small-scale methods into many different products that cater for local preferences.

Small-scale processing machines namely graters, mills and press are available in the cassava producing zones of Nigeria (Nweke 1994, Ezedinma and Oti 2001).

Value-added traits for developing new products and new markets could offer a huge potential for promoting cassava production of amylose-free (waxy) cassava which has multiple food and industrial applications; varieties with small granule starch which is used in rapid hydrolysis for the ethanol industry; varieties with high beta-carotene content to aid vitamin-A deficit areas; and forage varieties which could provide a strategic animal component into small-holder systems (American Conference 2014). Cassava production in Kogi State, Southern Guinea Savannah Region of Nigeria was subsistent about two decades ago, but now it has become a cash crop, providing food, employment and income in a sustainable manner to millions of people in the State. The cassava value chain has been able to meet the challenges of the nation through job creation, wealth generation and industrialization. Gari processing factory was the highest employer of labour, while cassava production employed the least number (Alhassan 2020). Cassava cultivation also serves as an important source of employment and income in rural, and often marginal areas, and especially for women (Muimba-Kangolongo 2018). Women play a major role in most processing operations (peeling, sieving, toasting, fermenting, cooking, pounding and wrapping of pounded cassava), while men dominate in grating and dewatering because they work with the machineries (Amadi and Ezeh 2018). Polthanee et al (2016b) reported that roots yielded 24 t/ha by crops sampled in the 4th year of intercropping cassava with rubber in the farmer field, and providing cash income about 763 US$/ha/year. Cassava is widely cultivated in tropical regions by small-scale resource-limited farmers, who cannot afford to buy agro-chemicals or install irrigation systems (Costa and Delgado 2019).

Cassava contributes to household food and nutritional security and also ensures the economic security of the farmers with an array of value-added products and plays an inevitable role in fulfilling numerous needs of the people, and thereby significantly contributing to attaining the Sustainable Development Goals (SDGs). Cassava is an established commercial crop as its roots are utilized in an array of products for human food as fresh or processed roots, starch and flour for food and industry, and animal feed. In China, cassava meets the basic needs of food security and income generation, while animal feed in Vietnam. Root and tuber crops are preferential crops over cereals by the farming community and the end consumers, and it forms a major part of programmes, policies, and strategies that are devised to enhance the economic upliftment of the rural population (NRC 2006).

Laode Geo (2020) showed that the average amount of cassava farm production is 1.14 kg per farmer. The average income received by each farmer is Rp. 6,115,969. The efficiency level of 6.10 means that cassava farming is efficient and feasible to be developed. The prospects of cassava for cash were further enhanced with the development and diffusion of improved, small-scale processing equipment (Oppong-Apane 2013, Spencer and Ezedinma 2017). Utilization of about 30 to 40% of leaves from castor and tapioca plantations for Eri culture without affecting the seed/tuber production can fetch the farmers' substantial additional income apart from the regular earnings to the poor dry land cultivators besides providing gainful employment to the women. It is established that about 25% of leaf plucking in tapioca would not affect the average tuber yield (Bhat et al 1991).

Cassava as famine saviour and insurance crop: Cassava has been called “the drought, war, and famine crop” because it can be grown in challenging conditions and it can be harvested when needed providing a reserve of food in times of war and famine (Burns et al 2010) and has a role as a famine-reserve crop since it has the ability to withstand infertile soils, drought, and uncertain rainfall, and it can have delayed harvest of tubers until needed (James and David 2021). Ambayeba (2018) also stated that it is cultivated as a famine reserve crop, it is flexible for cultivation under a mixed-farming system, contributing to food diversification over a long period of time and providing food at the critical moment of the hungriest seasons, thus mitigating the effect of shortfall of other crop cereals. In areas where cassava is a main staple, people process them into storable products such as tapioca starch, dough and gari. It plays a major role in efforts to alleviate the African food crisis because of its efficient production of food, year-round availability and tolerance to extreme stress conditions. Cassava roots can be stored underground for nearly 24 months after maturity, and it can be harvested at any time when a household needs food (Sanchez et *a*l 2013).

The cassava crop saved the people of the erstwhile Travancore province from famine during World War II (1939-45). During this period, the import of rice from Burma (Myanmar) came to a halt, and cassava also saved the people during subsequent times whenever food was scarce and was primarily used as a substitute for rice (staple) by the people of low-income strata (Edison et al 2006). Due to its inherent tolerance to stressful environments, where other food crops fail, it is often considered a food-security source against famine, requiring minimal care (Kamaljit and Preethi

2017). Many developing countries referred tuber crops as the 'drought, war, and famine crop' due to their versatile nature (Pearce 2007). Tuberous roots can be made to remain in the soil for up to three years during agricultural and social instability periods (Lebot 2009). This provides 'insurance' against social disruption, prolonged droughts, or other periods of stress and unrest. Tuber crops are 'famine-secure, drought-tolerant, grows well on poor soil, relative insect and pest resistance, produces high carbohydrate per hectare compared to other crops, remain in the ground for a more extended period before harvesting'. These characteristics are the major factors that make these crops acceptable to small farmers (Nweke et al 2002, Roza 2011). The cassava transformation encompasses four stages that indicate specific importance: famine-reserve, a rural food staple, livestock and industrial materials, and urban food staple (Umeh 2013).

In African, Caribbean and Pacific (ACP) countries, root and tuber crops contribute to the income and nutrition of a large majority of the population, especially the resource-poor rural farmers and village processors. Root and tuber crops act as insurance crops and provide safety shields for hunger and natural disaster. For instance, in Sierra Leone, when it was safe to return to the villages during the devastating war, Sierra Leoneans did not find cereals but found cassava waiting for them. Such stories are repeated everywhere in ACP, especially by countries seeking economic drivers. The Caribbean found the best utilization of RTCs in the diversification programmes as an option for food and nutrition security (Chandra 2010). Burns et al (2010) stated that cassava is essential for small and big-scale plantations as it needs low nutrients and can tolerate dry conditions with less cost involved in its propagation. It is sometimes referred to as the 'drought, war, and famine crop of the developing world' and reliance upon this crop is expected to increase in the coming years as the global climate change.

Cassava as a climate-resilient crop for livelihood security of farmers: Climate change poses many challenges to humanity in the present scenario. The IPCC (2007) defines climate change as 'a change in the state of the climate that can be identified (e.g., by using statistical tests) by changes in the mean and the variability of its properties, and that persists for an extended period, typically decades or longer'. Adaptation is expecting the undesirable effects of climate change and taking proper steps to prevent or mitigate the damage caused or encashing the opportunities it may cause (IPCC 2007). Farmers always decide what they should produce and how to maximize their economic returns. Cassava is a drought tolerant crop and has a great ability to survive under uncertain rainfall patterns (El-sharkawy 1993). In addition, cassava is tolerant to acidic soil conditions and it can grow on poor soils (De Tafur et al 1997, FAO 2010, FAO, 2013). Cassava can withstand significant periods of drought stress. Mechanisms of drought tolerance in cassava is due to the partial stomatal closure to reduce transpiration (El-sharkawy and Cock 1984, Alves and Setter 2000), reduction in leaf canopy (Connor and Cock 1981, Ike and Thurtell 1981, Polthanee et al 2016a) and extensive root systems (El-sharkawy 2007). Cassava is resistant to adverse environments (El-Sharkawy 2003). It has also been suggested that cassava could be more resilient to climate change than other staple crops (Jarvis et al 2012). Cassava, the crop itself, has few mechanisms to tolerate stress. To adapt to climate change, farmers can cultivate cassava in their fields to reduce crop loss and get returns for their livelihood.

Chitiyo and Kasele (2004) stated that the climate-resilient approach can be implemented not only through crop diversification but also by growing low-input crops like cassava (*Manihot esculenta* Crantz), known to tolerate drought, acidity, and low soil fertility (Asher et al 1980, Challinor et al 2007). Cassava is the best alternative crop to combat climate change. Jarvis et al (2012) reported that compared to African staples such as maize, sorghum, and millets, the cassava crop is not affected by the nature of soil and changes in weather conditions. The adaptation strategies of small farmers are conservation agriculture and the production of drought-tolerant crops that thrive in all soils (Herrera Campo et al 2011). Studies indicated that cassava cultivation has the least impact on environmental parameters compared to the other major food crops, such as rice, maize, and sorghum (Reynolds et al 2015). Studies highly recommend the adaptability of cassava in regions with higher temperatures, and it can tolerate up to 40 °C (El-Sharkawy et al 1984). Cassava can be grown even in low fertile soil without many inputs, and it can be harvested after the growth period so that the farmers can harvest it as per their requirements. Thus, the cassava crop support the farmers to cope with the climate vagaries and provide them with livelihood security.

CONCLUSION

Cassava is an important crop to reduce poverty throughout the world because of its climate-resilient nature; and also, it grows in marginal soil, and it is less capital intensive. It forms a staple food in many countries, and it forms the primary source of carbohydrates for people. The tubers can be termed insurance crops as they can be stored in the soil by using appropriate methods to be used when there is a need. In Tamil Nadu and Kerala, many farmers earn

their livelihood through cassava farming. These crops should be propagated in non-traditional areas to increase the area and production. Cassava can be grown as intercrops, which suits the integrated farming system well and fetches additional revenue for the farmers, and the field can be used efficiently. There is ample scope of tuber crops-based cropping/farming system to serve as a livelihood activity. It may be adopted on a larger scale as it contributes to livelihood. Sequential cassava cropping with paddy and pulses may be adopted to maintain soil fertility, which will help food and nutritional security. Moreover, the crop has good potential for value addition in food products, which is an added advantage where it can support the establishment of small village-based production units with the support of the Government and other funding agencies. Under ICAR-CTCRI NEH programme, it was observed that even modest postharvest value addition interventions such as cassava slicers, chipping machines, and graters could bring desirable changes among farmers in their postharvest management. When coupled with adopting new cassava varieties, appropriate value chain interventions can play a significant role in the livelihood enhancement of farmers.

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