FOOD REVIEWS INTERNATIONAL
2026, VOL. 42, NO. 1, 278–314
https://doi.org/10.1080/87559129.2025.2481449

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Comparative Analysis of Five African Traditional Multipurpose Crops Using a Food Systems Approach

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ABSTRACT

Diversifying food systems with traditional multi-purpose crops like sorghum, cassava, and amaranth is key to improving food security and nutrition. However, studies focusing on a variety of nutrient-dense crops, addressing research, policy, and practice, are missing. Most research focuses on cereals like sorghum, overlooking other crops such as vegetables, root crops, legumes, and nuts, limiting nutrient diversity in food system. A review of five traditional crops—sorghum, amaranth, cassava, cowpea, and cashew nuts—assessed research, policy, and practice, aiming to enhance food systems. The review found that existing initiatives on traditional crops are mainly production-focused and region-specific, with gaps in processing, value addition, marketing, nutrition, consumption, and transport. Limited policies and stakeholder involvement has hindered commercialization. Key recommendations should be implemented across research, practice, and policy along the food systems. Research actions include improving taxonomic classification, developing modern breeding programs, researching yield gaps, and enhancing understanding of transport and logistics. Practical strategies involve improving field management through training, integrating informal and formal seed systems, and promoting commercial use. Policies should address all food system aspects including processing, consumption, marketing, and transportation. Increased stakeholder engagement across the value chain is essential for unlocking the potential of traditional crops.

KEYWORDS
Food systems; policy; practice; research; traditional crops

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Background

Globally, the number of people who faced food insecurity and poor nutrition due to fragile food systems increased from 7.9% in 2019 to 9.2% in 2022, representing an additional 122 million people in the hunger category.[1] Occurrences such as the COVID-19 pandemic, Russian–Ukraine war, the actions by Russia to withdraw from the Black Sea grain initiative, and actions by India to impose a non-Basmati rice export ban have further disrupted the global food supply chains leading to an increase in agricultural and food commodity prices.[2–4] The changing climate has had an effect on yields of major food crops such as maize, wheat, and rice. The current statistics show yield decreases of −22% for wheat, −5% for maize, and −2% for rice,[5] leading to price increase of these crops. The prices of agricultural, export, and cereal commodities have risen by 6%, 4%, and 10%, respectively.[1] This has further increased the vulnerability of global food systems. Food insecurity globally is projected to rise further in 2030 with an additional 600 million people in the hunger bracket.[4] The effect of the food insecurity situation is exacerbated in the African continent, which heavily relies on food imports (grains and cereals). At the moment, approximately 282 million people are undernourished with the number expected to rise.[6]

The effect of the fragile food systems is evident in the health, economic growth, and wellbeing of people globally. For instance, in many countries, food consumption is characterized by either a situation of limited diets comprising staples (maize, wheat, rice) and a few selected foods such as meat, dairy as well as the overconsumption of processed meat, red meat, sugar, and salt.[7] There is under consumption of foods that have been shown to protect (vegetables, fruits, nuts, whole grains, and omega-3 diets) against adverse health outcomes.[7,8] The consumption of less nutritious foods can be attributed to the monocropping type of farming, which currently characterizes most agricultural production systems. This has led to poor health manifesting as malnutrition (stunting and wasting) in children and non-communicable diseases (diabetes, cancer, and hypertension) in adults.[7] In Africa alone, current statistics show that the burden of non-communicable diseases increased by 67% between 1990 and 2017.[9] More than 43% and 22% of children experienced stunting and wasting in Africa in 2022.[10] Subsequently, high economic losses resulting from non-communicable diseases (USD 1 trillion-37%) and malnutrition (16% of GDP-Gross Domestic loss) have been recorded.[11] Climate change, sporadic wars, and emerging pandemics will further expose vulnerabilities within food systems increasing the burden of malnutrition and non-communicable diseases on economic growth.[12,13] This is because the current status of food systems is characterized by the production of a few high energy crops with disparities along the value chain as attention is given to the production activity.[14] Also, the involvement of institutions such as policy is low and mostly limited to a few crops such as maize, cassava, and on the production activity.[14] Measures to enhance sustainable food systems are needed to reduce the burden of malnutrition and non-communicable diseases and enhance economic growth.

Diversifying agricultural systems to include traditional multipurpose crops (cereals, roots and tubers, vegetables, pulses, and nuts) in different geographic regions has been commended as one avenue to make food systems sustainable.[15] Traditional crops such as cereals (sorghum), African Leafy Vegetables (amaranth), root and tubers (cassava), legumes (cowpea), nuts (peanut) are multi-purpose crops.[14] These crops are loaded with micro- and macro-nutrient content including minerals such as calcium, phosphorus, potassium, magnesium, iron, manganese, and zinc.[14,16,17] Nutritionally, *Sorghum bicolor*-sorghum contains proteins, carbohydrates, amino acids, phenolics, and minerals in amounts higher than other cereals like maize and wheat.[18,19] Vegetables of the *Amaranth* spp contain high levels of minerals and vitamins A and C compared to other leafy vegetables.[20,21] While seeds of amaranth have high levels of protein, amino acids, lysine, fat albumins, and globulins compared to maize, wheat, rice, and teff.[22–24] *Manihot esculenta*- Cassava has abundant levels of calories, and essential amino acids such as arginine, glutamic acid, and aspartic acid compared to maize, rice, sorghum, and wheat.[25] *Vigna unguiculata*-cowpea contains twice as much protein compared to cereals and root and tuber crops, 50–60% carbohydrates and 1% fats.[26] *Anacardium* *occidentale*-Cashew nuts have a good amount of unsaturated fatty acids (linoleic, oleic, palmitic, stearic acid), fibre, sterols, vitamins, and amino acids.[27] Additionally, these crops contain medicinal properties (antidiabetic, diuretic, antipyretic, antileprotic antivenom, anticarcinogenic, anti-inflammatory, antiallergic, antimicrobial, and antihaemorrhoid properties) that when consumed can help prevent occurrence of non-communicable diseases and enhance health.[22,28–30]

The other multidimensional benefits of these crops include; economic and social development.[31–34] These crops have also been shown to be resilient to climate change adaptation to harsh environments, and low-input agriculture.[35–39] The contribution of traditional crops to biodiversity conservation, cultural diversity, and heritage has also been reported.[40–43] The numerous values of traditional crops such as sorghum, amaranth, cassava, cowpea and cashew nuts, are yet to be fully explored to enhance human health and economic well-being of people. These crops are also facing threats of extinction due to fewer research priorities and development initiatives that have been directed to improve genetic diversity, agronomic management, seed systems, marketing, processing, and consumption and enhance their contribution to sustainable food systems and livelihoods of traditional crops.[14,44] The African continent is increasingly relying on a few food crops such as maize, wheat, rice, and beans. The continuity reliance on a few crops could have implication on biodiversity loss, low genetic diversity, and low benefits from agricultural systems in the coming years.[45] According to the International Union for Conservation of Nature (IUCN), approximately 3900 plant species are currently facing extinction.[46] Furthermore, climate change manifested as drought has impacted the socio-economic conditions of approximately 88.9 million people within the African continent.[46] This calls for concerted efforts to refocus research and practices around these crops in order to reduce the loss of agrobiodiversity and mitigate the effects of climate change.[45]

Understanding research trends, policy, and practice on traditional crops to identify intervention points has been proposed to promote their potential.[14,47] A number of review studies have emerged, exploring aspects such as production, markets, processing, value, branding, and consumption of traditional crops like amaranth,[22,48] sorghum,[49–51] cassava,[52–55] cowpea,[56–58] within Africa. The studies have focused on one aspect within the food systems components; single crop, e.g. amaranth, and or one value chain activity, e.g. production. Comparative studies looking at multiple crops to explore similarities, differences, gaps, and opportunities are largely missing.

Our analysis compares research, policy, and practice by applying a food systems lens to five traditional crops from different categories: cereals (sorghum), African leafy vegetables (amaranth), root, and tubers (cassava), legumes (cowpea), and nuts (cashew). The unique inclusion of diverse crops aims to provide a comprehensive analysis that supports the development of inclusive policies and interventions to enhance the multipurpose role of traditional crops in food systems. The review identifies similarities, gaps, and opportunities, offering recommendations to boost their contribution to sustainable food systems.

Methodology

A comprehensive analysis using a food systems lens was applied to research, policy, and practice on five crops: sorghum, amaranth, cassava, cowpea, and cashew nuts. Research and development (R&D) has largely focused on cereals, leading to energy-dense foods, low dietary diversity, and negative health impacts.[45] This focus has limited the broader benefits of traditional crops. As suggested by Manners and Etten[44], research and investment (R&D) should focus on strategic investment across food crops. The five selected crops represent different food categories – cereals, vegetables, roots, tubers, legumes, and nuts – and provide a comparative review to identify R&D opportunities for nutrient-dense food systems. These crops were chosen for their high production capacity,[44] making them strong candidates for R&D investment.[59–63] They were also chosen because of their multipurpose benefits including high nutritional value, and resistance to marginal conditions (high temperatures, low fertile soils) compared to other traditional crops.[45] Except for cashew nuts, the selected crops also have the highest research outputs and provide a good basis to understand the type and extent of research on traditional crops. This can be important for improving agricultural practices, understanding genetic diversity, or developing more sustainable farming methods.[45]

An integrative review approach was chosen over the commonly used systematic approach. This was aimed at describing and synthesizing the findings from published articles to address the current dearth in knowledge and provide actionable recommendations in research, policy, and practice in traditional and neglected crops. The benefits of integrative review include identifying issues and gaps in the current research and assessing future research needs.[64] The method can also be used to identify successful theoretical or conceptual frameworks to apply in a certain area of research.[64] The method allows for a wider scope resulting in inclusion of documents from different search engines such as Scopus, PubMed, Web of Science, Science Direct, and Google scholar as well as Grey literature from institutional repositories and other editorial pieces.

A food systems analysis was used to provide in-depth and inclusive analysis focusing on all the food systems activities. This was guided by the FSNet framework shown in Fig. 1. The FSNet framework comprises many components among them the drivers, actors, institutions, food systems components, outcomes, and activities; input and output markets, logistics and production, innovation and branding, production and processing, consuming food, and obtaining nutrients. The actors and the institutions involved in research on Africa's crops were also identified.

Research questions

The review sought to answer the following research questions

(1) Which are the major production areas of the selected traditional crops?
(2) Which are the current consumption and export trends of traditional crops in the relation to their production capacity?
(3) What research is being conducted on traditional crops considering the food systems activities?
(4) What practices are being carried out on traditional crops considering the food systems activities?
(5) Which policies have been enacted to support the production of traditional crops considering the food systems activities?

Inclusion and exclusion criteria

The study included articles focusing on sorghum, amaranth, cassava, cowpea, and cashew nuts, limited to research within the African continent. Also, only articles in English were included, while those in other languages or outside Africa were excluded.

Sources of information

The articles were identified from a wide range of search engines which included; Scopus, PubMed, Web of Science, Science Direct, and Google Scholar as well as Grey literature from institutional repositories and other editorial pieces. This was done for a comprehensive search of information and analysis. Information was identified from diverse sources, both scientific and non-scientific. This included journal articles, technical reports from the National Research Institution, the Consortium of International Agricultural Research Centres (CGIAR), books and book chapters and thesis articles, web pages among others. Information was also collected from different countries across Sub-Saharan Africa. Collection of information of diversified sources and different countries was done to minimize bias according to Mayo-Wilson et al.[66]

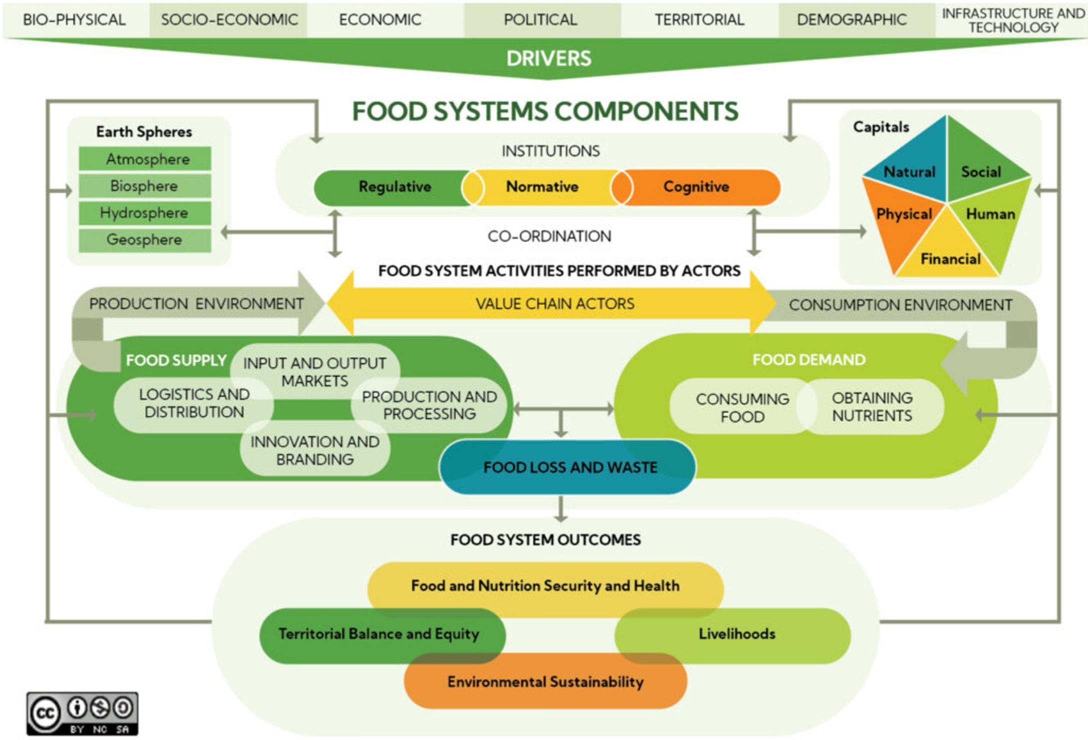

Figure 1. The conceptual framework guiding formulation of research questions. Adopted from.[65]

Screening of articles

Data was extracted from online articles focused on traditional crops, and information along the food systems activities was synthesized along the following themes as shown in Table 1. The data extraction adopted the abductive extraction method according to Conaty.[67] Data was entered into an excel sheet, coded and analyzed to respond to the study objectives. Analysis methods adopted included; comparative and descriptive analyses.

Overview of traditional crops investigated in the review

Amaranth

Amaranth originated in Central and South America and belongs to the family Amaranthaceae. In Africa, the vegetable amaranth was first introduced and domesticated in Eastern African countries in the 16th century. The crop was then naturalized and is one of the traditional crops consumed in many communities in Africa. Amaranthus species that have been described and taxonomically classified include; (1) vegetable Amaranthus such as *Amaranthus* tricolo and *Amaranthus hypochondriacus*, (2) grain Amaranthus, which includes *Amaranthus hypochondriacus, Amaranthus caudatus, Amaranthus cruentus*; and (3) weed Amaranthus with members such as *Amaranthus spinosus, Amaranthus viridis, Amaranthus retroflexus, Amaranthus graecizans, Amaranthus dubius*, and *Amaranthus hybridus*.[68] Amaranth is grown in range of agro-ecological locations and has been shown to be adapted in areas with marginal soils, high temperatures, drought and is tolerant to pest and disease infestation. In this review, both grain and vegetable amaranth are considered.[69] Fig. 2a,b shows the vegetable and grain amaranth.

Table 1. Food systems activities and information collected.

Food system activity	Information synthesized
Overview of traditional crops	Origin, morphological and structural characteristics, production environment.
Production regions	Geographical distribution of the traditional crops.
Production	Production trends, taxonomic classification, genetic conservation, breeding, field/agronomic management, seed environment
Agro-processing and value addition	Value addition, product development, commercial and industrial use
Marketing	Marketing systems, export trends, marketing organization, challenges in marketing
Nutrition, consumption and medicinal use	Nutritional properties, medicinal properties, consumption patterns
Transport, logistics and distribution	Methods and transport arrangements, Types of logistical arrangements.
Stakeholder involvement	Types of stakeholders, geographic reach, involvement along the food system activities
Policy and strategy papers	Existing policy and strategy papers, geographic reach, availability along the food systems activities
Data	Production, consumption, exportation data, geographic reach, availability along the food systems activities

Sorghum

Sorghum originated in South Sudan around 4000–6000 BC and belongs to the grass family Poaceae. It is the fifth most commonly consumed staple food crop after maize, wheat, rice, and barley. There are several sorghum varieties namely; grain, forage, sweet, and fibre sorghum.[71] Sorghum has been shown to grow in areas with minimal rainfall, has excellent nitrogen usage efficiency, water lodging tolerance, salinity, and drought resistance.[72] Only a few sorghum varieties; (mainly the grain type and scarcely the sweet variety) are cultivated in the African continent, despite the fact that the crop is uniquely adapted to the African climate.[73] Sorghum is characterized by white, red, or brown coloured grains; straight, curved, or semi-curved head; compact, semi-compact, and loose head compactness.[74] Fig. 3a,b show different sorghum varieties.

Cassava

Cassava originated from South America and was first domesticated in Africa in 1600–1700 century in Benin, Burkina Faso, Sao Tome, and Principe, Congo, Nigeria.[77] Cassava perennial woody shrub with an edible root and has been shown to be drought-tolerant, capable of growing on less fertile soils. Two varieties of cassava exist; the sweet and bitter. The sweet variety has less cyanide compounds >40 parts per million and requires less processing before it is consumed.[78] The bitter variety contains large quantities as high as 490 parts per million of cyanide compounds and requires more processing before it is consumed. Cyanide levels <50 parts per million are considered harmful to health and should be processed through drying, roasting, soaking to leach out the compounds, and boiling in multiple change waters before it is consumed.[78] Fig. 4a,b shows the leaves and roots of cassava, respectively.

Cowpea

Cowpea is prostrate, sub-erect, or erect herbaceous annual summer legume with origin in Africa.[80] Cowpea belongs to the family Fabaceae and in some cases Leguminosae is used as the family name with Papilionoideae as the subfamily.[81] There are three types of legumes; forage, grain, and dual-purpose cowpea.[82] Cowpea is mainly cultivated for grain. In a few incidences, it is used as a vegetable or fodder crop. Fig. 5a shows cowpea leaves 5b and cowpea grain.

Figure 2. a) Amaranth vegetable. b) Amaranth grain. Source: a) Authors (Credit: Sussy Munialo) b) (Credit: Lavin M[70]).

Figure 3. a) Red sorghum variety. b) White sorghum variety. Source: a) (Credit: Cyanocorax[75]) b) (Credit: Culos R[76]).

Cashew nut

Cashew nut (Fig. 6a,b) originated in Brazil and South America and was introduced in Africa during the 16th century. The cashew nut tree is a tropical low spreading evergreen tree with alternative simple leaves (Fig. 6a), which belongs to the Anacardiaceae family.[86]

The production regions of the selected traditional crops

Although, traditional crops in Africa are adapted and tolerant to harsh climatic conditions and marginal soils which characterize the vast geographic regions in Africa, it is evident from these findings that only a few regions are major producers of the selected traditional crops in Africa as shown in Table 2. These include: Nigeria, Ethiopia, Nigeria, Côte d'Ivoire, which are the largest producers of cassava, sorghum, cowpeas, and cashew nuts accounting for 30%, 22.8%, 61%, and 50% of the production in Africa. The other producing countries for traditional crops are shown in Table 2. For amaranth, production occurs in Tanzania and Kenya as shown in Table 2. The limited geographic production of traditional crops can be attributed to the erosion of these crops due to socio-economic,[94,95] political,[96] cultural,[97] and changing global consumption trends[98] among others. Adebayo W[88] has also shown limited geographic study of traditional crops and attributed them to climate changes such as increasing temperature, marginal soils, and rainfall variability. Eliminating these barriers is needed to increase the geographic coverage in the production of traditional crops and contribute to food security.

Figure 4. a) Cassava plant (left) and cassava root (right). Source: (Credit: Maari T[79]).

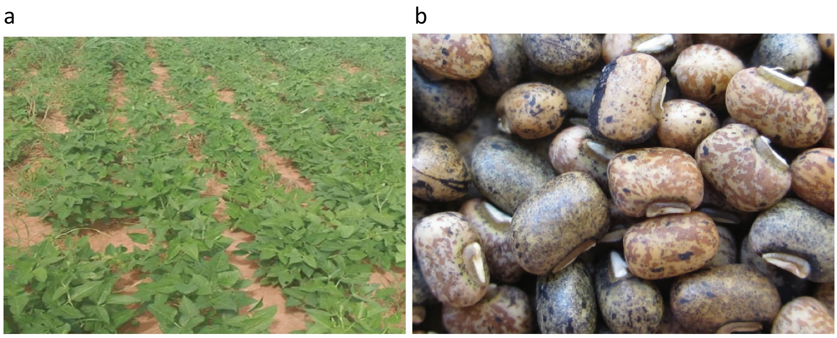

Figure 5. a) Cowpea leaves. b) Cowpea grains. Source: a) Authors (Credit: Sussy Munialo). b) (Credit: Ruken T[83]).

Production, consumption, and export trends for traditional food crops

The uneven demographic expansion in coming decades requires a forecast of the yields to inform decision-makers on strategies to adopt to ensure sustainable supply of nutritious foods in future.[99] Understanding the current production trends in indigenous crops to forecast yields is therefore needed. The production, consumption, and export trends of the traditional crops are shown in Table 3 and Fig. 7. Cassava had the highest quantities produced, consumed, and exported compared to sorghum, cowpea, cashew nut, amaranth grain, and leafy.[63,87,89,93,103] Sorghum was the second most produced and consumed, followed by amaranth leafy and cowpea grain. Cashew nut was second most exported food crop, followed by grain amaranth. Cassava had the highest percentage of the unaccounted quantities, followed by sorghum, cowpea and cashew nut. The high unaccounted quantities in agricultural production can be attributed to several factors, including post-harvest losses, underreporting due to a lack of proper data collection, and the presence of unregulated markets. These unaccounted quantities can negatively contribute to food security issues, such as inflated prices and an increase in imports, which in turn raises related costs for consumers and governments.[104] Additionally, unaccounted production can lead to inefficiencies in resource allocation, particularly for inputs like fertilizers, labor, and water, ultimately causing waste or shortages in essential resources.[105] Accurate data on production is crucial for effective policy and planning, as decisions are often based on the quantities reported. When production figures are inaccurate, they can influence policy and planning processes in ways that have significant consequences for food security.[104] Moreover, unaccounted production may contribute to losses and wastage, which in turn affects environmental sustainability through unsustainable farming practices and increased pressure on natural resources.[106]

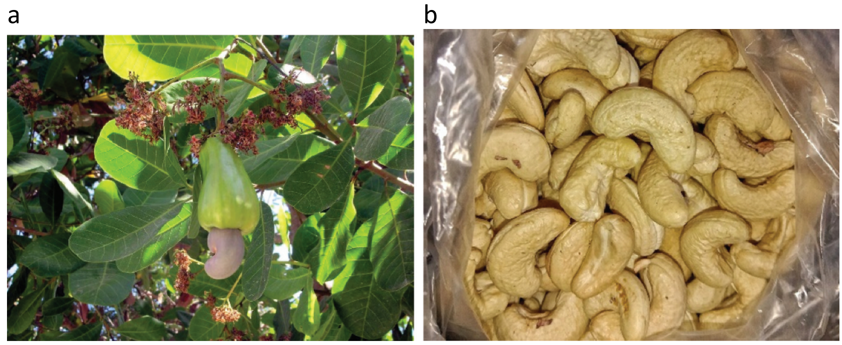

Figure 6. a) Cashew nut tree and fruits. b) Cashew nut. Source: a) (Credit: D-Stanley[84]) b) (Credit: Biljones94[85]).

Table 2. The top producing regions for traditional crops within Africa.

Amaranth gain and leafy	Cassava	Sorghum	Cowpea grain	Cashew nut
Tanzania	Nigeria	Ethiopia	Nigeria	Nigeria
Kenya	Angola	Nigeria	Ghana	Côte d'Ivoire
South Africa	Ghana	Sudan	Niger	Mozambique
Benin	DR Congo	Burkina Faso	Burkina Faso	Tanzania
Zimbabwe	Mozambique	Mali	Mali	Ghana
Côte d'Ivoire		Niger	Cameroon	Kenya
Nigeria			Senegal	
Zambia				

Source of data; Cassava,[87] amaranth,[63] cowpea[87–91] and Cashew nut.[92,93]

Although the data presented in this study is an indicator of the production, consumption, export, and unaccounted quantities, there is a need to carry out a further data investigation on these crops. Most data on agricultural production and yield are largely insufficiency even on data sites such as FAOSTAT, for example data on amaranth grain. This can be attributed to lack of data keeping and management among producers and is likely to have implications on decision making at different levels; global, regional, national, and local.[107] Encouraging the establishment of more robust agricultural databases at national and regional levels could facilitate the collection of comprehensive, reliable data. Implementing digitization efforts, training farmers in record-keeping, and using satellite technology to monitor crop health and yields are all potential solutions.

Characterization and conservation of genetic diversity

Species extinction is affecting genetic diversity and could undermine efforts to achieve sustainable food systems. Most of indigenous crops that could contribute genetic diversity and enhance sustainable food systems are facing extinction.[108] Increased characterization of genetic diversity of the traditional crops is needed. However, the current findings show that characterization and conservation of genetic diversity of traditional crops within Africa has been done for a few species to sub-genus

Table 3. Production, consumption, export, and unaccounted quantities in tonnes for traditional crops in Africa.

	Production	Consumption	Export	Unaccounted
Cassava	192,102,224	153,681,779	2,600,000	35,820,445
Cowpea grain	7,107,000	5,117,040	175,906	1,814,054
Amaranth leafy	6,960,000	6,055,200	25000	929,800
Amaranth grain	451,626	131,323	320,302	0
Sorghum	27,200,000	21,216,000	133,183	5,850,817
Cashew nut	1,200,000	120,000	730,000	350,000

Source data: Amaranth leaf and grain,[63] Cassava,[100] Sorghum,[89,90] Cowpea,[101,102] Cashew nut.[93]

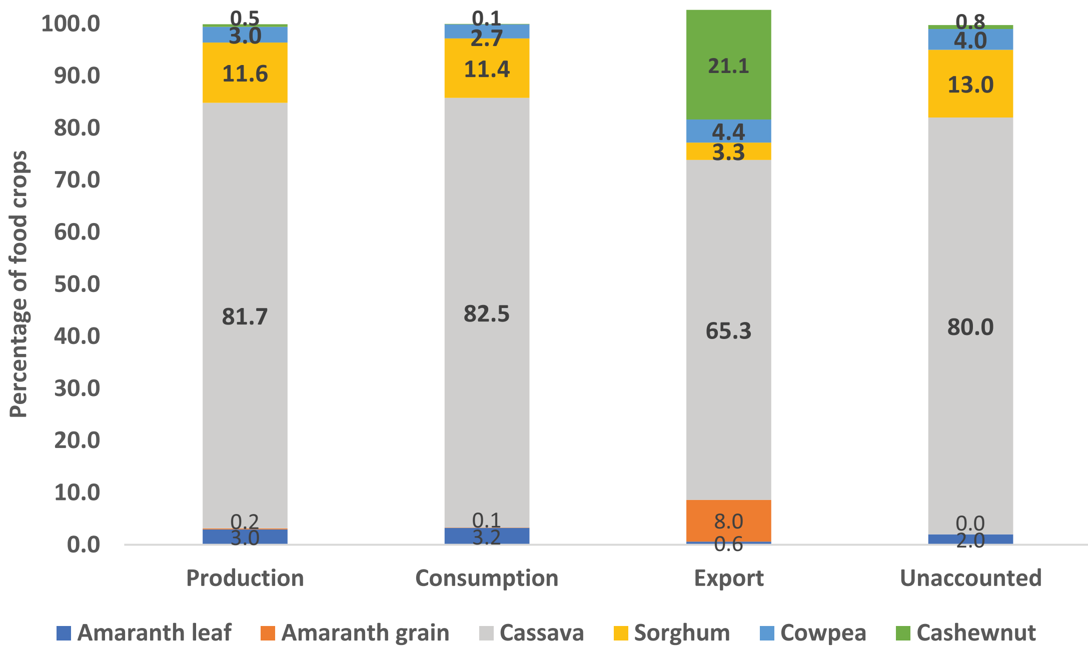

Figure 7. Percentage of production, consumption, export and unaccounted for traditional food crops. Data source: Amaranth leaf and grain,[63] Cassava,[100] Sorghum,[89,90] Cowpea,[101,102] Cashew nut.[93]

level. Fig. 8 shows the percentage of species that have been taxonomically described and found in Africa. Amaranth has the largest percentage of species described followed by cowpea grain, sorghum, and cashew nut. Cassava has the least number of species that are found in Africa. For amaranth spp, out of the 70 species, 13 species in Eastern Africa and 32 species in South Africa have been taxonomically described.[63,109] Amaranthus species that have been taxonomically classified include: 1. vegetable Amaranthus such as Amaranthus tricolor, *Amaranthus hypochondriacus* (2) grain Amaranthus which includes *Amaranthus hypochondriacus*, *Amaranthus caudatus*, *Amaranthus cruentus*; and (3) weed Amaranthus with members such as *Amaranthus spinosus*, *Amaranthus viridis*, *Amaranthus retroflexus*, *Amaranthus graecizans*, *Amaranthus dubius*, and *Amaranthus hybridus*.[68] Of the 100-cowpea species identified, 45 have been taxonomically classified and are found in Africa.[110,112,113] They include: three species; *Vigna unguiculata, Vigna subterranea, and Vigna vexillata* successfully domesticated and 42 wild species. For sorghum, out of the 24 species only 3 have been taxonomically classified and characterized.[112] More than 100 cassava species exist, only 3 have been described and are found in Africa and include: *Manihot esculenta*, *Manihot glaziovii, and Manhoti flabellifoli*. The cashew nut species; *Anacardium occidentale L* is found in Africa has not been classified as sub-genus level.[92]

It is evident that many traditional species have not been described and taxonomically classified. Classifying traditional crops beyond the species level will be needed to identify varieties with the biological ability to survive changing weather patterns for sustainable yields. Efforts to increase taxonomic classification and description together with digital sequencing will increase characterization, conservation of the genetic diversity and utilization of traditional crops. Creating genebanks within different agro-ecological regions will enhance conservation and biodiversity of amaranthus. This will underpin the identification of species that can be utilized economically to promote food security and livelihoods. Identification of wild land races is also needed to improve the genetic makeup of crops to meet human needs.[114]

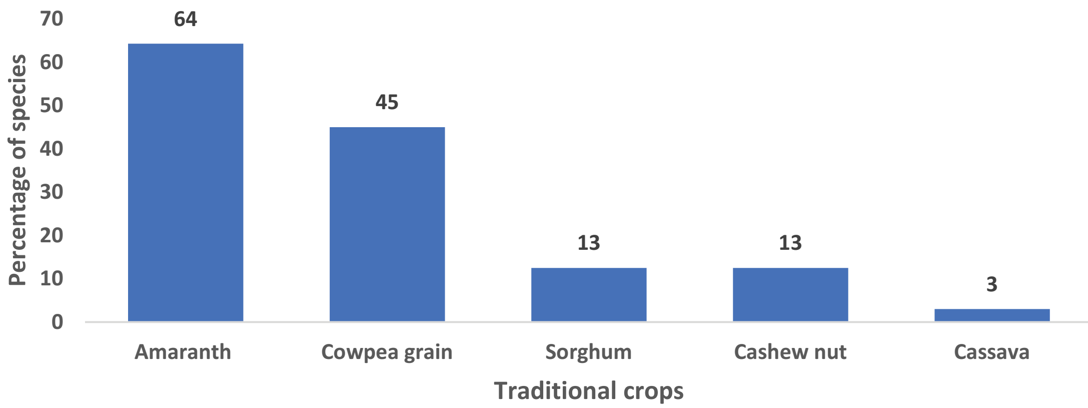

Figure 8. The percentage of traditional crop species that have been taxonomically described and found in Africa. Data source; Amaranth,[63,109] cowpea,[110,111] sorghum,[112] and cashew nuts.[92]

Breeding of traditional crops

Breeding is one of the pillars of food security as it promotes crop improvement, genetic diversity, health and nutrition, adaptability to climate change and marginal soils.[115] The findings of the review show that breeding efforts continue to focus on agronomic and crop improvement aspects. Compared to other traditional crops, breeding in sorghum has been extensively done. Breeding has primarily focused on agronomic aspects such as resistance to disease (downy mildew, striga, anthracnose, and smuts), insects (aphids, midges, worms, shoot-fly, and others), stressful conditions (drought, heat, soil acidity, and salinity), resistance to weathering (seeds that do not soften), higher yield (more grains of good size in each seed head).[51,116–118] Breeding for morphological characteristics has also been donefor example, for strong stalks, non-senescence, twinning in-seed formation, easy threshing, erect leaves for increased light interception, greater root development, faster grain filling to reduce susceptibility to drought and insect infestation. Breeding for varieties with light colours to increase protein content, superior amino-acid balance, improved flavour, and greater digestibility, have also been conducted to enhance sensory and taste ability of sorghum.[50,119–122]

Similar to sorghum, cassava varieties resistant to diseases such as cassava brown streak disease and high yielding have been developed in Nigeria.[123,124] These varieties which were released by IITA include 'Game-Changer', 'Hope, Obasanjo-2', 'Baba-70', and 'Poundable'. In Uganda, drought tolerant cassava varieties; 'NASE 19', 'NASE 14', 'AKENA exist'. In Ghana, 25 varieties resistant to Cassava Mosaic Virus such as CRI- 'Lamesese', 'Abrabopa, Dudzi', 'AGRA bankye', 'Amansan bankye', 'Duade Kpakpa' are available for farmers to use.[125] In DRC, the varieties include 'Obama', 'Disanka', 'Butamu', 'Nsansi', 'Zizila', 'Mvuazi' among others. Other breeding programs in cassava have focused on increasing the starch content,[126–128] high yield and dry matter,[129] nutrient level (carotenoid content, iron, and zinc),[129,130] early bulking,[52,131,132] and reducing carcinogenic content,[133] improving nutrition through biofortification.[134] Less research has been done on post-harvest physiological deterioration.[53,135]

In amaranth, varieties resistance to diseases (white rust, leaf spot), lodging, heat tolerance, better leaf qualities, vigor, and growth are available.[63] Amaranth varieties with long shelf life, calcium, iron, and fibre content, better leaf quality, taste, and cooking quality are available to enhance post-harvest handling, nutritional quality, taste and sensory ability.[63] The varieties are available in Kenya and include *Dubius, Hybridus, Triclor, Cruentus, Blitum, AM-UG-40, Madiira1, Madiira 2, Lividus, Retroflexus, Hyprochondriacus, and Palmeris. In Tanzania, developed varieties include: golden giant, mchicha Nafaka, black grain amaranth, Ex Zanzibar, Madiira1, and Madiira2.*[63]

For cowpea, there exist many review articles on breeding. Mekonnen et al.[136] has shown the need and importance of breeding for biotic and abiotic stresses, protein quality and quantity, minerals, vitamins, fatty acids, carbohydrates, climate resilience, and strategies for breeding. Ana Maria et al.[137]

identified key areas to enhance the performance of cowpea elite varieties which include biotic and abiotic resistance. Gerrano et al.[138] have discussed breeding methods and genetic variability strategies in cowpea production such as pure line selection, pedigree breeding, bulk population breeding, and mutation breeding. However, few breeding studies have focused on evaluating genetic variability with regard to agronomic performance in cowpea,[139] improved agronomic performance using gamma radiation in South Africa,[140] drought tolerance in Mozambique.[141]

In cashew nut a few studies on breeding have focused on agronomic management and crop improvement. These studies have focused mostly in other regions and include: India,[142] Brazil,[143,144] and China.[145] There is a scarcity of literature in breeding in Africa as only one study on cashew nut breeding has been conducted in Ghana was found.[146]

The findings demonstrate that most breeding for traditional crops has focused mostly on production activity (production, agronomic management, and crop improvement) along the value chain. Some research on breeding to enhance nutrition also existsfor instance, for sorghum, cassava, and amaranth. Development of varieties to enhance consumer preference, taste, and sensory, processing, value addition, and product development is needed as well as varieties that are resistant to climate change.

Field management practices

The transition to sustainable farming in the wake of climate change requires research into innovative and site-specific field management practices such as land preparation, planting, control of pest and diseases, weeding, and harvesting for improved yield and nutrition.[147] The findings of this review show that field management research has been done on certain traditional crops while others remain under researched. Compared to other traditional crops, extensive research has been done to evaluate field management practices in cassava and cowpea production. In cassava, field management studies have focused on the effect of practices such as timely planting and harvesting on dry matter content[148] classification of agricultural practices on environmental outcome,[149] yield gap assessment,[54] disease management and control,[150] cassava production processes,[151] production trends,[152] land management practices; planting on the surface, ridge, and the mound land management system on yield.[153]

In cowpea production studies on agronomic practices have focused on seed production, (intercropping and crop rotation),[154] planting and zinc application,[155] production practices, post-harvest handling, and quality cow pea,[58] improving cultivation practices,[156] growth and yield responses of cowpea to inoculation and phosphorus fertilization,[156] cowpea cropping systems, traits preferences and production constraints,[56] and performance of cowpea varieties under different moisture levels.[157]

Field management practices involved in amaranth production have been evaluated and described and include: seed bed preparation, use of certified seeds, plant density, methods of planting, fertilizer application, water requirements and irrigation, pest and disease infestation and control measures, quantity, and harvesting methods.[158–160]

In sorghum practices including land preparation, planting, weed management, pest and disease control, harvesting, and post-harvest practices such as drying, threshing, and storage have been documented in manuals to guide production.[161–164] Less research has been done on the production and agronomic management of cashew nut production. Ojotule and Mustapha[165] evaluated the adoption of agronomic practices such as seed selection, manual weeding, and pruning in cashew nut production.

It is also evident that research carried out is conventional. With the changing climatic conditions research into a combination of conventional and modern agronomic practices on traditional crops specific to given geographic environments is needed. Such practices would include a combination of crop diversification and plant density, crop diversification and fertilizer application, fertilizer application and irrigation, organic farming and cover cropping among others. The utilization of technology such as artificial intelligence, remote sensing, satellite imagery, modelling will also be significant in providing real time information to monitor crop development and provide alleviatory measures in the case of anomalies.

Training manuals on agronomic management practices

Advancement in agricultural research has led to new crop varieties, fertilizers, and agronomic management.[166] Documenting these practices in a training manual for farmers to use is needed. Although the findings of this review show that field management practices have been documented and exist for traditional crops in different geographic regions, the manuals are available in a few countries as shown in Table 4. Some of the manuals are old and need constant updating.

These have led to slow adoption of the released technologies and practices. For instance, in amaranth production, the use of quality and certified seeds is still low at 12%, use of line sowing at 40%, less than 40% of farmers use mineral fertilizers, 31% of farmers practice transplanting.[63] For cassava, the adoption of improved varieties is averagely at 45% as per statistics from Nigeria, Cameroon, Congo, and Zambia.[170–173] There is a relatively high adoption rate of 60% and 63% in some countries such as Nigeria and Cameroon and low 28% and 30% for Congo and Cameroon, respectively. The adoption rate for cowpea varieties in Senegal and Nigeria is at 33% and 38%, respectively.[174,175] Subsequently, high yield gaps (high compared to low yields) in traditional crops exist as shown in Fig. 9. In some incidences in amaranth production, studies show overuse of nitrogenous fertilizers, which leads to concentration of nitrates in the leaves posing a threat to human health.[48] The low adoption rate of technologies and practices to increase the production of these crops could be attributed to the "volunteer" nature of the crops where more often they grow on their own especially amaranth.[178] Increasing awareness on the value of these crops regarding nutrition and marketability and on agronomic practices could enhance productivity and utilization. Increased production and utilization of training manuals within different geographic regions in Africa is needed to improve agronomic management of traditional crops and reduce yield gaps.

The seed systems

The seed system for amaranth, sorghum, cassava, cowpea and cashew nuts comprises both informal, formal, public and private sector.[63,175,179] The seed system is dominated by informal sector where farmers have control over seeds where mostly the recycled seed is used resulting in timely availability and relatively cheaper seeds.[179] However, there is no standards to test for quality leading to low germination.[179] Farmers must also use large quantities of seeds to compensate for poor germination. The formal seed system comprises government extension, non-governmental organizations (NGO's), private companies, and Agro-dealers.[179]

In addition to formal and informal sector, the sorghum seed system is segmented by breeding technology (Hybrids, Open Pollinated Varieties & Hybrid Derivatives).[180] The main sorghum seed-producing countries for hybrid, open pollinated and hybrid derivatives include by Country (Egypt, Ethiopia, Ghana, Kenya, Nigeria, South Africa, Tanzania).[181]

The use of certified seeds varies across different traditional crops as shown in Fig. 10. Less than 50% of farmers use certified seeds. Cowpea has the highest number of farmers using certified seeds, followed by cassava, sorghum, and lastly amaranth.

Linkages between different stakeholders and institutions involved in the seed sectors have also been created to enable farmers acquire quality seeds. In the amaranth production, linkages between farmers and private seed companies also exist to help farmers acquire certified seeds. In East Africa, institutions such as CABI have created initiatives to link farmers to private companies to access certified seeds. Farmers with no formal agreements with private companies have acquired certified seeds resulting in high yields and income of more than 70%.[188] In Tanzania and Nigeria, companies such as Agrilinks have created innovative models to increase the involvement of farmers in cassava seed production.[189] In cowpea production, the Tropical Legume III (TL III) project in Ghana facilitated the access of smallholder farmers to improved cowpea seeds through the establishment of innovation platforms. During the four years of the project (2015–2018), a total of seven multi-stakeholder platforms (MSPs), which comprised six seed companies, 46 farmer groups, five public

Table 4. Training manuals on field management practices for traditional crops in different countries and year of development.

Cassava		Cowpea		Amaranth (gain and leafy)		Sorghum		Cashew nut	
Region	Year	Region	Year	Region	Year	Region	Year	Region	Year
Zambia	2016	Zimbabwe	2017	Kenya		Zimbabwe	2017	Côte d'Ivoire	2021
Nigeria	2021	South Africa	2012	Uganda	2017	Nigeria	2020	Benin	2020
West & Central	2014	Nigeria	2020	South Africa	2014	Ethiopia	2015	Sierra Leone	2017
		South Sudan	2015			Africa	2017		
		Africa	2012						

Data source; Cassava.[167–169]

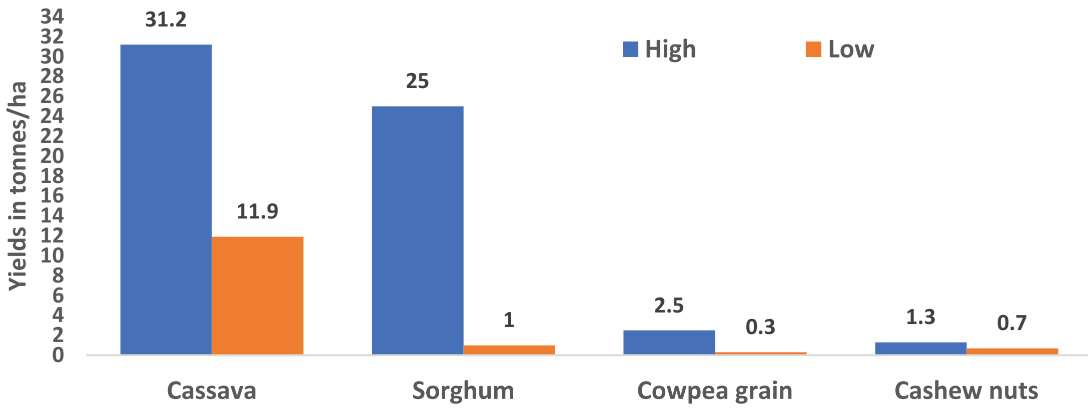

Figure 9. Yield gaps (high versus low yields) for selected traditional crops. Estimates adopted from; cassava,[54] sorghum,[176] cashew nut[177] and- cowpea.[58,155] The estimate for amaranth was not possible because of data limitation.

seed enterprises, two NGOs, and 718 individual seed entrepreneurs and other stakeholders, were established/strengthened to link actors in the cowpea value chain.[190] There has been establishment of manuals and frameworks to guide seed production. In cassava production, there exist manuals and frameworks for seed production in certain countries such as Uganda,[191] together with a manual for the Standard Operating Procedures (SOPs) which provides guidance for the safe conduct of CFTs for GM cassava species in Uganda.[192]

The processing and value addition activity

Research has shown that traditional crops can be developed into many products as shown in Table 5. Many value-added products have been developed from cassava, sorghum, cashew nut, and amaranth as shown in Table 5. Cowpea contains a few products.

Commercial and industrial application

Although numerous products have been developed from the traditional crops as shown in Table 5, a few of these products have been developed into industrial and commercial products as shown in Table 6. Most of industrial and commercial use has been done in other parts away from Africa such as the USA, India, Trinidad Tobago, Europe, and Mexico as shown in Table 6.

Globally, amaranth is used for the production of functional drinks from vegan protein powder in North America.[202] In Mexico, amaranth is mixed with chocolate and puffed rice and also popped amaranth is mixed with honey to make a type of snack bars called Alegria in Mexico.[203] In Europe amaranth oil is used in making of cosmetic products. In India, seeds are mostly used to make laddoos

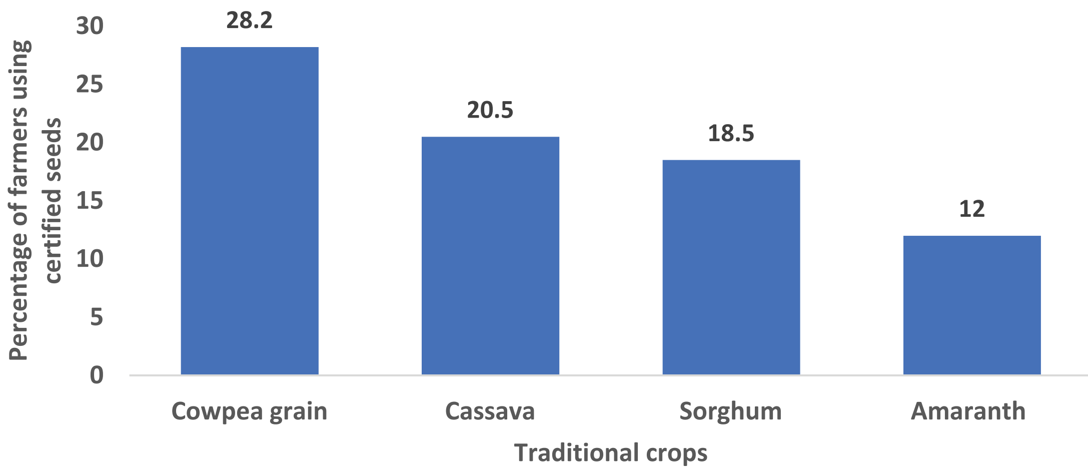

Figure 10. Percentage of farmers using certified seeds in production of traditional crops. Estimates based on data from: Namibia, Senegal, Ethiopia, Nigeria, Burkina Faso, Mali, Niger (cowpea),[175,179,182,183] Nigeria, Ghana, Kenya (cassava),[184–186] Ethiopia, Kenya, Nigeria, Burkina Faso, Mali, Niger (sorghum),[73,117,180,187] Kenya and Tanzania (Amaranth).[63]

and mixed in rice dishes.[195] Amaranth seeds are used to make crackers, cookies, cereal, and porridge in the United States. A mixture of wheat and amaranth flour is combined to make Chapati in the Himalayan region.[22] The African continent continues to lag in scaling up utilization of amaranth both grain and leafy for industrial and commercial use.

Globally, commercial and industrial production of sorghum include: production of sorghum syrup by small plants in Tennessee, and northern Mississippi and Alabama.[208] Production of ethanol is utilized to power motor-vehicles.[209] Industrial production in foundry-mold sands, charcoal briquets, and oil-well-drilling mud exist. Other industrial uses include: manufacture of plywood and gypsum to build houses as well as in the refining process of potash and aluminium.[210] In Brazil, sweet sorghum biomass is fermented into alcohol.[211] In India, sorghum syrup is used as a sweetener due to its higher nutraceutical benefits (vitamins, minerals, and antioxidants) compared to sugarcane syrup. However, its adoption is limited by low crop yields and processing capacity (labour intensive).[212,213] Other factors include: limited demand and awareness, lack of infrastructure, economic competitiveness, as well as policy and research gaps.[213] In Africa (South Africa, Nigeria, Kenya) sorghum is malted into alcoholic and non-alcoholic drinks by small industries.[204] In Botswana sorghum meal that is similarly prepared as rice is already commercially available in hotels and industries.[205] In East Africa, the Diageo-owned industry makes beer from sorghum. In China, a distilled alcoholic beverage with unique flavour and aroma from “kaoliang” (sorghum) is produced and exported.[206] Sorghum is wet-milled to produce starch in Sudan and India.[207] In many communities around Africa, sorghum is used to process local brew.

In Nigeria, cassava is innovatively developed into “fufu”, and “gari” through packaging to attract consumers in formal markets such as supermarkets and accounts for 70% of human consumption.[198] In some cases, cassava peels are used for animal feed as a substitute for maize. High Quality Cassava Flour (HQCF) is used in biscuits and confectioneries, dextrin pre-gelled starch for adhesives, starch and hydrolysates for pharmaceutical products and as seasonings.[198] Starch production from cassava is utilized in food, alcohol, textile, pharmaceutical, cosmetic, adhesive, paper, and plywood industries. In Trinidad and Tobago, cassava is produced into different products such as cassava bread (40% cassava), cassava chips, cassava fries, cassava snack (*krupuk*), frozen cassava mash, cassava cake (*bojo*), cassava sweets (*dokoe* or *lemet*), frozen cassava chunks.[199]

Cowpea in Senegal, has been developed into products such as cowpea flour, “akara” which is prepared from cowpea flour, cowpea stew or “ndambe” prepared (cowpea grains, meat, cassava or sweet potato, tomato).[200] In Ethiopia, biscuits are usually prepared from blended flour of wheat and cowpea.[201] Cashew nut has been developed into cashew apple juice, wine, fenny, vinegar, and apple cider in India.[196]

Table 5. Value-added products of traditional crops.

Cassava	Cowpea	Amaranth grain	Sorghum	Cashew nut
"Fufu"	Soups and sauces	Porridge	"Enjera"	cashew jam
"Gari"	Flour and baked food	Malted for beer	Porridge	cashew jelly
High Quality Cassava Flour (HQCF)	Candies and desserts	Bread	"Nefro"	Cashew Shell Liquid (CNSL)
HQCF used in biscuits and confectioneries	Snacks	Biscuits	"Tella"	Cardanol (Purified CNSL) for chemical industry
HQCF Dextrin pre-gelled starch for adhesives	Biscuits	Pasta	"Arekie"	cashew butter
HQCF starch and hydrolysates	Sun dried frozen vegetables	Crackers	lager beer	Cashew shell cake
Starch used in Alcohol,	couscous	Pancakes	stout	Broken nuts
Starch used in textile,	Dumplings	Muffins	non-alcoholic malt-based beer	Cashew apple squash
Starch used in pharmaceutical,	Cooked dough (beignet)	Paste and cereal breakfast	snack bar	Cashew apple syrup
Starch used in cosmetic,	Cowpea flour	Weaning foods	ethanol and biofuel	Fenny
Starch used in adhesive,		Functional beverages	biscuits	Cashew apple wine
Starch used in paper,		Source of fuel	pasta	Cashew apple vinegar
Starch used in plywood			baby foods	Cash Lime
Cassava bread			bakery products	Cashew Apple Cider
Cassava chips			noodles and pasta	Testa
Cassava fries, meat pie, doughnuts, cakes			extruded products, syrup	Gum
Cassava snack			sweet juice	
Frozen cassava mash				

Source of data: cassava,[168,169,193] cowpea,[194] amaranth,[23,195] sorghum,[71,181] cashew nut.[196,197]

Table 6. Commercial and industrial application of value-added products from traditional crops.

Cassava		Cowpea		Amaranth grain		Sorghum		Cashew nut	
Product	Region	Product	Region	Product	Region	Product	Region	Product	Region
"fufu"	Nigeria	biscuits	Ethiopia	Fortified instant noodles	South Africa	sorghum syrup	USA	Cashew apple juice	India
"gari"	Nigeria	cowpea flour	Senegal	Amaranth juice	East Africa	ethanol	USA	Cashew apple wine	India
Cassava bread	Trinidad and Tobago	Cowpea cake "Akara"	Senegal	Blended with other flours e.g maize,	East Africa	foundry-mold sands	USA	Cashew lime	India
Cassava chips,	Trinidad and Tobago	"Ndambe"	Senegal	"Kita" Unleavened bread	Ethiopia	charcoal briquets	USA	Fenny	India
Cassava fries,	Trinidad and Tobago			"Borde" Alcoholic drink	Ethiopia	oil-well-drilling mud	USA	Cashew vinegar	India
Cassava snack (Krupuk),	Trinidad and Tobago			Light porridge "Atmit"	Ethiopia	alcohol	Brazil	Cashew apple cider	India
Frozen cassava mash,	Trinidad and Tobago			functional drinks	North America	Alcoholic drink	South Africa	Cashew apple cider	India
Cassava cake (bojo),	Trinidad and Tobago			"Alegria" snack bars	Mexico	Alcoholic and non-alcoholic drinks	Nigeria Kenya South Africa		
Cassava sweets	Trinidad and Tobago			Cosmetic products	Europe	sorghum meal like rice	Bostwana		
Frozen cassava chunks	Trinidad and Tobago			"Laddoos"	India	Beer	East Africa		
				crackers	USA	Starch	Sudan		
				cookies	USA	Starch	India		
				cereal	USA				
				Porridge	USA				

Source of data: Cassava,[198,199] Cowpea,[200,201] Amaranth,[22,195,202,203] Sorghum,[204–207] and Cashew nut.[196]

One of the challenges of traditional crops is the lack of value addition and processing which contributes to low commercialization. As a result, farmers are disincentivized to engage in production.

The marketing activity

The marketing systems for traditional crops comprise both export/import and domestic markets. Domestic markets are unique for the specific crops in the different countries. In Zimbabwe, a study by[214] shows that marketing of amaranth is mostly between supermarkets with registered companies. Cross border trade also takes place in amaranth. Marketing of amaranth in Kenya is organized under producer groups. Middlemen form part of the market chain; they connect farmers and retail markets.

The sorghum domestic markets include small scale farmers for human consumption and commercial firms where the product is malted into beer and processed into animal feeds.[215] The marketing arrangement in cowpea is the least developed and comprises rural assemblers, rural consumption markets, urban mixed wholesale-consumption markets, and urban consumption markets. Most farmers sell their produce directly to consumers referred as consumer channels, because most farmers produce for subsistence use while few farmers use industrial channels.[216] The cassava domestic market comprises farmers, wholesalers, retailers, processors, and consumers.

The export market is segmented by either form (seeds, leaves, oil, and flour), or category (organic and conventional), application (bakery, confectionery, snacks, condiments, and beverage), pharmaceuticals, cosmetics, and personal use and geography (North America, Europe, Asia Pacific, South America, the Middle East, and Africa).[217] Amaranth vegetables sold in hotels in Zimbabwe are imported from South Africa.[214] The Middle East and Africa Amaranth Oil Market comprises South Africa, Ghana, Kenya, Ethiopia, Saudi Arabia, the U.A.E., Israel, and the rest of the Middle East and Africa https://www.databridgemarketresearch.com/reports/middle-east-and-africa-amaranth-oil-market. The major sorghum export regions include: Africa (Botswana, Lesotho, Swaziland, and Namibia), America, Asia, Europe, and Oceani.[215] The export market systems in cowpea are less developed as different markets exist in cowpea marketing.

Marketing of traditional food crops is hampered by lack of volumes, exploitation of smallholder farmers by middlemen, poorly organized market structures, and lack of storage facilities. This has contributed to low industrial and commercial use as well as consumption. Measures that improve marketing and commercialization of traditional crops could include: training and empowerment on marketing, infrastructural development, organizing farmers into groups to enhance bulk buying, processing and product development of traditional products, among others.

Nutritional value and consumption patterns of traditional crops

The nutritional content of traditional crops is shown in Table 7. Amaranth contains mineral concentrations exceeding 1% of plant dry weight, which are much higher than typical mineral concentrations in conventional edible leafy vegetables.[20] The protein score in amaranth leaves has been shown to be high that is 74 compared to maize 35, wheat 47, and soyabean 68 and rice 69 as per WHO nutritional standards.[22] The protein content in amaranth has high amino acid lysine, which is a key component that is inadequate in maize, wheat, rice, and other cereals, and the sulphur-containing amino acids, which are normally limited in legumes.[22] Similarly, the protein content in amaranth has been shown to have high levels of albumins and globulins compared to maize, rice, and wheat.[23] The fat content of amaranth also exceeds amounts contained in maize, sorghum, wheat, and teff.[24,231] Dried leaves of amaranth have been shown to contain high levels of protein, minerals, and antioxidant capacity.[232] High values of zinc, magnesium, manganese, potassium, calcium, and iron have also been reported in amaranth compared to maize, sorghum, millet, rice, and wheat.[29]

Sorghum contains proteins, carbohydrates, amino acids, phenolics, and minerals in amounts higher than other cereals. Sorghum contains a high nutrient content; calcium and iron compared to maize.[18] Sorghum also contains slightly higher amounts of protein and fibre than maize.[19] It also has high amount of copper, iron, potassium, magnesium, sodium, phosphorus, and zinc compared to wheat and maize.[19] Sorghum is a gluten-free cereal, and its consumption can prevent the occurrence of Celiac Disease (CD), an immunological response to gluten intolerance.[233] Sorghum has also been shown to contain high phenolic levels compared to other cereals, demonstrating anticancer and anti-inflammatory properties.

Cowpea contains high amounts of proteins, carbohydrates, dietary fibre, phytochemicals, minerals, and vitamins.[26] Cowpea contains 2 times more proteins than cereals and root and tuber crops, 50–60% carbohydrates, and 1% fats. Cowpea also has a low glycemic index, which when consumed in adequate amounts can reduce the occurrence of diseases such as diseases such as obesity, diabetes, cardio-vascular sickness, and cancer.[26]

The nutritional content of cassava roots comprises macro and micro-nutrients, amino acids, minerals, and vitamins. The root has been shown to have comparable levels of calcium, iron, potassium, magnesium, copper, zinc, and manganese to legumes as well as carbohydrates to cereals.

Cashew nut contains high levels of protein, sodium, ash, fat (oleic, linoleic, palmitic, stearic, arachidic, palmitoleic, vaccenic, gadoleic, lignoceric, linolenic, behenic, margaric, elaidic, lauric). Cashew nuts are also rich in high levels of amino acids; alanine, aspartic acid, arginine, cysteine, cystine, glutamic acid, glycine, histidine, isoleucine, leucine, lysine, methionine, phenylalanine, proline, serine, tryptophan, tyrosine, valine, and threonine. The nuts have also been shown to contain vitamins; vitamin B1, B12, B2, B3, B5, B6, B8, B9, C, E, and K1; minerals; iron, zinc, sodium, magnesium, calcium, Phosphorus, and selenium.[27]

Despite the numerous nutritional benefits of these crops, studies have shown low consumption. It is estimated that 40%, 24%, and 16% of the population have access and consume cassava, sorghum, and cowpea respectively.[103,234,235] In some cases, the consumption of these crops is seasonal. The low consumption of traditional crops could be attributed to low availability of the crops due of the limited land for production.[236] Although traditional foods play a crucial role in the cultural identity of communities, there are certain people that do not identify with the foods and thus contribute to low consumption.[236] Other factors that have led to low consumption of traditional foods include: lack of awareness of their nutritional and commercial aspects.[237]

In addition to nutritional properties, traditional crops; cassava, amaranth, cowpea, sorghum, and cashew nuts are loaded with phytochemicals such as phenolics, flavonoids, and tannins, which have been investigated to have preventive and curative properties against diseases.[22,29,30,238] These attributes have not been investigated to advance the contribution of traditional crops on health. Creating awareness on the medicinal properties and integrating both scientific and herbal knowledge is needed to advance the health benefits of these crops.

Distribution and logistics activity

Distribution and logistics play a major role in moving agricultural produce from the farm to the different channels of distribution. However, less research has been done on investigating the effect of logistics and distribution activities on production, commercialization, and utilization of traditional crops. Transportation costs and distance have been studied as barriers in cassava value chain.[239] In some cases, actors involved in moving of traditional crops referred to as transporters have been considered as forming the value chain in some papers.[240]

In most African countries, transportation by road forms a large part of the logistics and distribution channel. Most of roads within the African continent have low access index of less than 60% causing challenges in the distribution and logistics traditional crops from farm to market.[241] This greatly contributes to high post-harvest losses, which more often occur during movement of the produce. Poor road networks have been shown to lead to vehicular vibrations causing damage to the amaranthus.[242] The distance from local production to markets covered in transportation of traditional crops within African countries is long. Most cases, smallholder farmers rely on middlemen to deliver produce to the market, resulting in high transaction costs. This disincentivizes farmers from engaging in production and commercialization of traditional produce.

Logistics and distribution channels form an important part of the value chain and therefore initiatives that support the activity are needed. Due to poor road network, innovation that improve

Table 7. Nutritional properties of the five selected tradition crops.

Nutrients	Cassava	Cowpea	Amaranth grain	Amaranth Vegetable	Sorghum	Cashew nut
Minerals (mg/100 g)						
Zinc	0.84–41	0.17–0.19	2.8–4.8	0.6–5.0	1.6–2.8	3.6–4.45
Magnesium	0.03–52	3.2–4.9	6.2–220	34–43	113–1445	213–419
Manganese	0.3–1	n/a	6.9–23	6.64–10.31	1.30–2.40	4.5–5.9
Potassium	0.3–672	1071–1469	324–601	4521–4892	275–476	254–351
Sodium	7.6–35	0.13–223	8–29.5	32.1–176	2–23	407–540
Calcium	19–176	1.9–106	160–370	131–1851	10–586	10.81–24.49
Iron	0.3–14	0.8–1.23	6.5–13	10.0–53.5	0.9–20	15.47–17.49
Phosphorus	6–152	0.9–566	323–395	396–426	167–751	19.60–45.17
Copper	0.2–0.6	0.9–566	0.6	n/a	0.19–0.5	n/a
Macro-nutrients (g/100 g)						
Moisture	40–85	87	3.0	79–90	4.9–6.3	93.8–94.3
Proteins	0.3–3.4	23–29	13–17	2.7–31	4.4–8.1	23–28
Fat	0.03–0.24	0.13–1.93	3.53–7	0.23–2.63	2.7–3.7	43–45
Carbohydrates	25.3–94.4	n/a	n/a		n/a	n/a
Fibre	0.1–4.4	1.4–4.5	3.1	0.7–3.0	1.0–3.4	5.9–6.4
Ash	0.4–1.7	3.0–3.9	0.9–3.3	2.6	1.3–3.7	3.2–3.4
Vitamins (g/100 g)						
Vitamin A	n/a	n/a	n/a	n/a	0.17–0.57	n/a
Ascorbic acid	14.9–50	n/a	0.6–71	0.8–7.8	n/a	n/a
Pyrdoxine	n/a	n/a	0.4	n/a	n/a	n/a
Niacin	0.6–1.8	n/a	0.9–10	0.05–0.1	n/a	n/a
Thiamin	0.03–1.78	n/a	0.2–2.4	0.003–0.006	n/a	n/a
Riboflavin	0.03–0.84	n/a	0.5–2.7	0.008–0.018	n/a	n/a
Tocopherol	n/a	n/a	44.4	n/a	n/a	n/a
Amino-acids (g/100 g)						
Alanine	0.15	n/a	0.6	n/a	0.5–0.7	4.04–4.4
Aspartic acid	0.13	n/a	1.6	n/a	0.42–0.50	10.2–10.4
Arginine	0.29	n/a	0.5–1.60	n/a	0.24–0.30	9.8–10.2
Cysteine	0.01	n/a	0.8	n/a	0.01–0.02	0.97–1.02
Cystine	n/a	n/a	n/a	n/a	n/a	n/a
Glutamic acid	0.15	n/a	1.22–5.8	n/a	1.2–1.7	21.4–22.5
Glycine	n/a	n/a	n/a	n/a	n/a	n/a
Histidine	0.07	n/a	0.41–0.7	n/a	0.13–0.16	2.7–4.5
Isoleucine	0.03	n/a	0.6–2.18	n/a	0.29–0.3	4.1–4.2
Leucine	0.31–4	n/a	0.7–1.00	n/a	0.77–0.97	11.3–11.5
Lysine	0.07–4.14	n/a	0.5–1.22	n/a	0.13–0.17	4.18–4.46
Methionine	0.03	n/a	0.21–0.5	n/a	0.08–0.1	2.21–2.28
Threonine	0.03–2.6	n/a	0.71–1.4	n/a	0.22–0.26	3.16–3.46
Valine	0.04–3.3	n/a	0.7–2.18	n/a	0.32–4.1	5.24–5.58
Phenylalanine	0.03	n/a	0.4–1.00	n/a	0.27–0.38	4.5–4.5
Proline	0.03	n/a	0.21–0.26	n/a	n/a	n/a
Serine	0.04	n/a	0.42	n/a	n/a	n/a
Tryptophan	n/a	n/a	n/a	n/a	n/a	n/a
Tyrosine	0.01	n/a	0.46–0.56	n/a	n/a	n/a

Source: Cassava,[25,218] Cowpea,[219,220] Amaranth,[21,221–223] Sorghum,[224–228] Cashew nut.[27,229,230] The n/a indicate data not available.

efficiency in logistics and distribution of traditional produce to maintain the quality is required. Improved post-harvest handling practices, transport, and market infrastructure including cold chains, the establishment of simple packing houses where fresh produce is prepared for the market, developing regulations for the informal food sector, applications of innovations such smart sensors are needed to improve efficiency and reduce losses caused by road transportation.

Environmental impacts and potential resilience of the crops

The impacts of climate change on food security are becoming increasingly evident, manifesting as shortages, disrupted supply chains, and, in some cases, nutritionally deficient crops. These challenges are expected to escalate in the coming decades, threatening both global food availability and the nutritional quality of the food supply. To mitigate these effects, the diversification of farming systems, particularly by incorporating traditional crops, has been proposed as a strategy to reduce the negative impacts of climate change on food security. The resilient capacity of these has been largely documented in literature.

Cassava has been shown to have traits resilience to environmental stressors such as pests and diseases, dry spells, survival in waterlogged conditions, and thriving in low nutrient soils.[243] The adaptability of Cowpea to challenging conditions such as low annual precipitation, high temperatures, moderate humidity, and soils with low organic matter content makes it an ideal companion for intercropping with maize.[244] This practice has been shown to enhance maize yields, as cowpea contributes to improved soil fertility through nitrogen fixation and helps increase overall resilience to environmental stressors, promoting sustainable and efficient agricultural systems in regions affected by climate challenges.[244]

Amaranth crop has morphological characteristics such as limited osmotic alteration, stomatal closure, adjustment of the root/shoot ratio helps the plant utilize limited amount of water and survive in dry conditions.[245]

Sorghum is highly resilient, with the ability to withstand flood conditions, drought, diseases, and pests, making it an ideal crop for arid and semi-arid regions.[246] Its adaptability to these harsh environments makes it a crucial crop for food security, providing a reliable source of nutrition and livelihood in areas prone to climate variability and extreme weather events.[246] This hardiness allows sorghum to thrive where other crops may fail, supporting sustainable agricultural practices and enhancing food resilience in vulnerable regions.

The high bioclimatic suitability of cashew nut makes it an excellent crop for promoting biodiversity. Its ability to thrive in a variety of environmental conditions allows it to be integrated into diverse agroecosystems, where it can help enhance soil health, provide habitats for various species, and contribute to ecological balance.[247] By planting cashew trees alongside other crops or in mixed farming systems, farmers can create more resilient agricultural landscapes that support biodiversity while also benefiting from the economic value of cashew production.[247]

This approach not only helps to ensure a more resilient food supply but also promotes sustainable agricultural practices, supports biodiversity, and contributes to economic growth.

Involvement of actors in traditional crops

Institutions involved in traditional crops along the value chain include; universities, national research centres, international institutions, and local institutions as shown in Table 8. The institutions are distributed within a few countries in the African countries and operate mainly along the production activity. For cashew nut, there are institutions that are also involved in processing and marketing. Increased involvement of institutions in traditional crops along the value chain is needed to increase production, commercialization, and utilization and unleash the potential of these crops. These institutions will include: research centres from both public and private sectors, development institutions, community-based organizations, and the industry.

Policy environment in traditional crops

Policy papers and strategy documents have been developed to promote the production, commercialization, and utilization of traditional crops within specific countries in Sub-Saharan Africa as shown in Table 9. Continental papers also exist. The Strategy for Agricultural Transformation in Africa 2016–2025 describes production, marketing, processing, and value addition for including cassava, sorghum, and cowpea.[248] The Enhancement of Cassava Productivity in sub-Saharan Africa together with Policy document upgrading amaranth value chain for cassava and amaranth crops also exist. Additionally, there have been initiatives to support certain traditional crops and include: the 2002 Presidential Initiative on Cassava (PIC) and the creation of the Agricultural Transformation Agenda (ATA) in 2011 and its Cassava Transformation Agenda, Collaborative Study of Cassava in Africa (COSCA).[193,249,250]

It is evident that just a few countries have policy papers, strategy instruments, and initiatives to support traditional crops. Also, the papers describe strategies for transforming a few traditional crops and in most cases, promoting the production value-chain activity, especially for cowpea and sorghum as shown in Table 9. There are a few instruments to support marketing as well processing and value addition for cassava. None of the instruments have outlined strategies to support consumption and nutritional aspects of traditional crops as well as the transport and logistics activities. The few policies, initiatives, and strategies to support traditional crops are contributing to low production, commercialization, and utilization of these crops. Efforts to increase the availability of these instruments from a wide range of stakeholders such as researchers, government and community among others are needed.

Key actionable recommendation to increase the contribution of traditional crops to sustainable food systems

The review reveals systemic gaps in research, policy, and practice along the value chain of traditional crops. Gaps exist in the production, processing and value addition, marketing, nutrition and consumption as well transport and logistics activities. Furthermore, there are widening gaps in stakeholder, institutions, and policies in traditional crops. These have led to low production, commercialization, consumption, and utilization of the crops. The review identifies key actionable recommendations that should be implemented simultaneously in research, practice, and policy.

Research

Characterization and conservation of traditional crops

Large number of traditional crops including wild landraces have not been described and taxonomically classified. Efforts to increase taxonomic classification and description together with digital sequencing are needed to increase characterization, conservation of the genetic diversity and utilization of crops. Creating genebanks within different agro-ecological regions is also needed to enhance conservation and biodiversity. This will support the identification of different species that can be utilized economically to meet human needs. Identification of crop wild landraces is also needed to improve the genetic makeup of the crops.

Breeding

The findings demonstrate that breeding for improved varieties for traditional crops has focused mostly at the production activity (production agronomic management and crop improvement) along the value chain. There exists some research on breeding for varieties with high nutritional content of iron, zinc and proteins for sorghum, cassava and amaranth to enhance nutrition of the crops through biofortification. Less efforts are put in increasing the practical utilization of developed traits to enhance nutrition. Development of varieties to enhance consumer preference, taste and sensory, processing, value addition, and product development is needed. These properties will include better taste, less cooking time, storage quality, palatability, and fast growing.

More often, current breeding programs utilize conventional methods; mass selection, pure line selection, pedigree, bulk population, single seed descent, and backcrossing, among others. There is a need to run breeding programs with modern breeding strategies which may include modern genomics and molecular marker-assisted selection, coupled with digital imaging in high-throughput phenotyping, historical data, and model-assisted selection.

Table 8. Institutions and stakeholder's involvement along the value chain for traditional crops.

Cassava			Cowpea			Amaranth (grain and leafy)			Sorghum			Cashew nut		
Institution	Region/ Country	Value chain activity	Institution	Region/ Country	Value chain activity	Institution	Region/ Country	Value chain activity	Institution	Region/ Country	Value chain activity	Institution	Region/ Country	Value chain activity
National Agricultural Research Institutes (NARIs),	Nigeria	Production	Tropical Legume III (TL III) project	Ghana	Production	Promotion of Neglected Indigenous Vegetable Crops (IV) for Nutritional and Health	Eastern and Southern Africa	Production	African Seed company limited	Zambia	Production	African Cashew Alliance (ACA)	Africa	Processing/ Marketing
International Agricultural Research Centers (IARCs)	Nigeria	Production	International Institute of Tropical Agriculture (IITA),	Senegal	Production	Kenya Plant Health Inspectorate Service (KEPHIS)	Kenya	Production	Zambia Seed Company Limited (Zamseed)	Zambia	Production	Com-Cashew	Benin, Burkina Faso, Côte d'Ivoire, Ghana Mozambique;	Processing/ Marketing
National Agricultural Seed Council (NASC),	Nigeria	Production	Agricultural Research Institute of Senegal (ISRA)	Senegal	Production	Centre for Agriculture and Bioscience International (CABI)	Kenya	Production	FICA Seeds, Capstone Seeds	Zambia	Production	Cracking the Nut	Benin Burkina Faso	Processing/ Marketing
National Agricultural Quarantine Service (NAQS)	Nigeria	Production	Tropical Soil Biology and Fertility Institute of the International Centre for Tropical Agriculture (CIAT-TSBF)	Kenya	Production	World Vegetable genebank	East and West Africa	Germplasm Conservation and production	Heineken Group and Brasseries et Glacières Internationales	Ethiopia	Processing/ Product development Marketing	World Bank cashew Programme	Côte d'Ivoire	Processing/ Marketing
National Centre for Genetic Resources and Biotechnology (NACGRAB).	Nigeria	Germplasm Conservation and production	Agricultural Research Institute (ZARI), Universities,	Zambia	Production	Jomo Kenyatta University of Agriculture and Technology (JKUAT)	Kenya	Germplasm Conservation and production	Institute of biodiversity	Kenya	Germplasm Conservation and production	SOTIC	Côte d'Ivoire	Processing/ Marketing
National Roots Crops Association	Nigeria		Food and Agricultural Organisations (FAO),	Zambia	Production	Kenya Agricultural & Livestock Research Organization (KALRO)	Kenya	Germplasm Conservation and production	National Genebank of Kenya,	Kenya	Germplasm Conservation and production	Centre for Technology Demonstration and Promotion (CDT)	Côte d'Ivoire	Processing/ Marketing
African root crops research network (EARRNET)	Africa		United States Agency for International Development (USAID),	Zambia	Production	Horticultural Research and Training Institute (Horti-Tengeru),	Tanzania	Germplasm Conservation and production	SADC Plant Genetic Resources Centre (SRGB).	Kenya	Germplasm Conservation and production	National Federation of Cashew Producers (FENAPACI)	Côte d'Ivoire	Production/ Processing/ Marketing
			Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH (GIZ)),	Zambia	Production	Mikocheni Agricultural Research Institute	Tanzania	Germplasm Conservation and production	International Crops Research Institute for the Semi-Arid Tropics (ICRISAT)	Kenya	Germplasm Conservation and production	FENACAJOU-CI (Fédération nationale des cajouculteurs de Côte d'Ivoire),	Côte d'Ivoire	Production/ Processing/ Marketing
			World Food Program (WFP)	Zambia	Production	Sokoine University of Agriculture in Tanzania	Tanzania	Germplasm Conservation and production	Diageo industry	East Africa	Processing/ Product development Marketing	Cotton and Cashew Board (CCA)	Côte d'Ivoire	Production/ Processing/ Marketing
			IITA	Sierra Leone	Production	University of Nairobi, Eldoret in Kenya	Kenya	Germplasm Conservation and production						
			Sierra Leone Agricultural Research Institute (SLARI)	Sierra Leone	Production	Uganda Christian University	Uganda	Germplasm Conservation and production						
			Ministry of Agriculture, Forest and Fisheries (MAFF)	Sierra Leone	Production									

Table 9. Policies and strategies instruments in traditional crops.

Cassava			Cowpea			Amaranth			Sorghum			Cashew nut		
Strategy/ Policy	Region/ Country	Value chain activity	Strategy/ Policy	Region/ Country	Value chain activity	Strategy/ Policy	Region/ Country	Value chain activity	Strategy/ Policy	Region/ Country	Value chain activity	Strategy/ Policy	Region/ Country	Value chain activity
The 2002 Presidential Initiative on Cassava (PIC)	Nigeria	Production, Marketing, Processing	Farmer Input Support Programme (FISP)	Zambia	Production	National Plan for promotion of amaranth in Kenya 2015	Kenya	Production	Kenya Agricultural Sector Transformation and Growth Strategy (ASTGS)	Kenya	Production	Formalization of the export tax		Marketing Production
Agricultural Transformation Agenda (ATA)	Nigeria	Production and processing	Programme national d'investissement agricole (PNIA) 2013–2020	DR Congo	Production	Policy document upgrading amaranth value chain	Africa	Production	Exercise duty waiver from 80–60%	Kenya	Production			
Collaborative Study of Cassava in Africa (COSCA).	Nigeria, Tanzania, Uganda	Production and processing	Food and Agriculture Sector Development Policy (FASDEP II)	Ghana	Production	The National food and Nutrition security policy 2011	Kenya	Production	Kenya National Food and Nutrition Security Policy 2011	Kenya	Production			
Enhancement of Cassava Productivity in Sub-Saharan Africa	Africa	Production and processing	Medium Term Agricultural Sector Investment Plan 2011–2015 (METASIP)	Ghana	Production				Agricultural Development Led Industrialization (ADLI)	Ethiopia	Production			
Strategy for agricultural transformation in Africa 2016–2025 Africa	Africa	Production, Processing	Agricultural Sector Development Strategy (ASDS) 2010–2020	Kenya	Production				Development and Poverty Reduction Program (SDPRP) (2000–05)	Ethiopia	Production			
South African root crops research network (SARRNET) (1994–1998 and 1999–2003)	South Africa	Production, Processing	Agriculture Sector Wide Approach (ASWAp)	Malawi	Production				Plan for Accelerated and Sustained Development to End Poverty (PASDEP) (2005–10)	Ethiopia	Production			
High-Quality Cassava Flour (HQCF) initiative	Ghana, Tanzania Uganda Nigeria Malawi	Processing	Sustainable Agriculture Production Programme (SAPP)	Malawi	Production				Growth and Transformation Program I (GTP I) (2010–15)	Ethiopia	Production			
The 2006 Nigerian Cassava Master Plan	Nigeria	Production Processing Marketing	Agriculture Promotion Policy (APP) 2016–2020	Nigeria	Marketing				Growth and Transformation Program I (GTP I) (2010–15)	Nigeria	Production			
Ghana Cassava Industrialization Partnership Project (GCIPP)	Ghana	Processing							(Federal Ministry of Agriculture	Nigeria	Production			
Bilateral Trade agreement	Nigeria	Processing and value addition Marketing							zero-rating VAT	South Africa	Production			
Defined contract farming agreement	Ghana	Marketing and production							Agricultural Transformation Agenda (ATA)	Nigeria	Production and processing			

Agronomy and field management

Agronomy and field management research has focused on land preparation, use of certified seeds, planting density, methods of planting, fertilizer application, water requirements and irrigation, pest and disease infestation and control measures. Less has been done in assessing yields of crops and the corresponding yield gaps. Yield gap studies coupled with modelling for future scenarios in production are needed to reveal and understand the biophysical opportunities to enhance yield and meet projected future food demands.

Processing and product development

Most of the traditional foods are prepared using traditional cooking methods such as boiling and roasting among others. In most communities within the African continent, cowpea, cassava, and sorghum are prepared by boiling which results in foods that may not be appealing with regard to taste and preference especially among young population. This contributes to low consumption of traditional foods. Opportunities in research exist in creating products that can be used in dishes, recipes, bakery products, noodles, and pasta. Preservation methods such as natural drying, use of convection solar tent dryer, evaporative cooling, and fermentation have been shown to have high nutrient retention capacity, improves palatability, and digestibility. However, these methods remain under-exploited. Efforts to step up the use of these methods are needed.

Nutrition, medicinal use, and consumption of traditional crops

The low consumption of traditional crops can be attributed to low production that does not meet demand, preparation, and development of products from traditional crops that appeal to a small population of people regarding taste and preference. Increasing the consumption of traditional crops can contribute to a healthy diet and reduce the risk of Non-Communicable Diseases. Strategies to increase yields such as proper application of agronomic practices, adoption of urban and peri-urban farming are needed. Increased research and advocacy on the nutritional and medicinal properties, integration of both scientific and traditional knowledge is also needed. Development of products that retain nutrients and appeal to everyone at all times can enhance consumption.

More often, sensory analysis to enhance taste and consumption of traditional foods has been limited to a few places, mostly involving just a few people, trained panel on sensory analysis, sometimes representatives from food science and nutrition department. Widening scope in sensory analysis to include different categories; age (young, old), school going children, nutritional needs of people (women of reproductive age, old women, old men) are required to inform the development of products that appeal to a wide range of people.

Marketing

The marketing systems of traditional crops/products remain undeveloped and are hampered by lack of volumes, exploitation of smallholder farmers by middlemen, poorly organized market structures, lack of storage facilities, inefficient extension services, unreliable product markets, inefficient finance delivery, and labour shortages, availability of few processed products. Measures that improve marketing and commercialization could include: training and empowerment on marketing, infrastructural development, organizing farmers into groups to enhance bulk buying, processing, and product development, and development of integrated markets to help farmers to engage in short supply chains. Increasing volumes of production and product development can also be an opportunity to tap into emerging import markets such as the Middle East and Africa Amaranth Oil Market, Nigeria–China Cassava trade market. Development and adoption of frameworks and market protection policies has been successful in strengthening markets in cashew nut production, hence the need to leveraging on such measures for other traditional crops.

Transport and logistics

Transport plays a major role in moving the agricultural produce from the farm to the different marketing channels. However, less consideration is put on investigating the effect of transport, logistics, and distribution activities. More research is needed to enhance post-harvest handling practices, transport, and market infrastructure including cold chains, and the establishment of simple packinghouses where fresh produce is prepared for the market. Development of regulations for the informal food sector, applications of innovations such smart sensors is needed to improve efficiency and reduce losses caused by road transportation.

Data

Scarcity of data on production, consumption, and export trends characterize traditional crops in Africa. As shown from this review, there was scarcity of production information (yield and yield gaps) in amaranth, use of certified seeds in cashew nut, export data for amaranth and cowpea. Measures that increase production and acquisition of data are needed to enhance data driven policies and decisions. Such measures will include: creation of open data platforms, use of big data and artificial intelligence to generate and make available large data sets.

Practice

Seed systems

The current seed system is heavily informal with less formal sector participation. This has led to the distribution of seeds with low germination, pest and disease resistance, poor vigour and low yields. There is a need to develop sustainable seed distribution systems by integrating the informal and formal seed systems. Measure to enhance the participation of rural agro-dealers. e.g by registering, training, and accrediting and reducing the seed accreditation process are needed. Other measures will include: creating regulatory reforms in the seed system, developing sustainable seed markets that account for the uniqueness in traditional crops; that is use seeds for sorghum, cowpea, amaranth and cashew nut and stem cuttings in the case of cassava. Development of seed frameworks that guide the involvement of the formal and informal system in seed development and production.

Adoption

Adoption and utilization of agronomic practices such as timely planting, pest and disease management, certified seeds, organic and inorganic fertilizer use among others to increase production of traditional crops is low. A greater understanding of agronomic management is needed to increase the production of traditional crops and reduce yield gaps. Priority areas to improve utilization of best agronomic practices will include: conducting field demonstration plots with optimal agronomic practices. Technics that promote production of traditional crops in urban and peri-urban areas such as vertical farming should also be promoted. Efforts to develop manuals in agronomic practices that are country specific that can be translated to local languages are needed.

Industrial and commercial use

Although numerous products have been developed from traditional crops, a few of these products have been adopted for industrial and commercial use. This has resulted in low quantity of products exported or exportation of unprocessed products with low market value. For instance, although Nigeria is the world largest cassava producing region, it is not among the top exporting countries. This can be attributed to less processing of cassava into export-oriented products. Most of the cassava exported products such as cassava floor, starch/chips and pellets are obtained from Thailand, Viet nam, and Cambodia. Industrial and commercial application is needed to increase production of processed products with high market value that can be exported to improve the contribution of traditional crops to income and livelihoods. Measures such as investment in agro-processing facilities to scale up production of high-value products, increased research in product development, and development of training manuals in agro-processing are needed.

Stakeholder engagement

There are few institutions and stakeholders involved in traditional crops mostly at the production stage. Increasing stakeholder engagement is needed along the food systems chain taking into consideration all the activities. Development an integrative framework is also needed to guide stakeholder engagement.

Policies and strategy papers

Policies and strategy papers to promote production and utilization of traditional crops are few and available in a few countries. The instrument focus mostly in promoting the production activity especially for cowpea and sorghum, policies that address consumption and nutrition of traditional crops are scarce. Continental papers also exist. However, the papers describe strategies for transforming a few traditional crops. The Strategy for Agricultural Transformation in Africa 2016–2025 describes production, marketing, processing, and value addition for including cassava, sorghum, and cowpea.

Policy action along the traditional crops value chain is needed to improve production, commercialization, and utilization of the crop and different areas of interventions have been investigated. Multifaceted and chain-level interventions that improve supply- and demand-side conditions are needed.[251] Regional and national policies that support consistency of supply, productivity, and inclusivity, including improving the seed system are needed.

Leveraging on existing policies and initiatives in other traditional crops is neededfor example, cassava has most policy documents and strategy papers to support production, marketing as well processing and value addition activities. While cashew nuts new policies enacted in 2016 were expanded to include formalization of the export tax, setting of reference prices by farmers, contractual agreement between the processing industry and farmers. These inclusions have promoted export marketing in cashew nut value chain.

The strength and limitation of the manuscript

Despite the strengths of this study in exploring the status of research, policy and practice of traditional crops, several limitations are pointed. The focus is on English-language documents, and the inability to conduct a meta-analysis. The review was limited to English-language documents, which dominate databases like Web of Science and Scopus. Given the distribution of traditional crops, relevant studies may exist in other languages, such as French, Portuguese, or Swahili. This language bias could affect the generalizability of the findings.

The small amount of available literature prevented the conduction of a meta-analysis to better analyze and describe the findings and publication biases. Although the study aimed to include a variety of sources, including grey literature, reports, theses, and conference papers, some literature; particularly government reports may have been overlooked due to limited online availability. The study should be seen as an attempt to describe and summarize research, practice and policy trends and actionable recommendations which can be adopted to enhance production of these crops. However, further analytical reviews are needed to explore other traditional crops.

Conclusion

The review compared research, policy, and practice on five multipurpose crops drawn from each of the five food categories, namely; cereals (sorghum- *Sorghum bicolor*), African Leafy Vegetables (amaranth- *Amaranth* spp), root and tubers (cassava- *Manihot esculenta*), legumes (cowpea- *Vigna unguiculata*), nuts (cashew nuts- *Anacardium occidentale*) using a food systems approach. The findings show there is work that has been done in research, practice, and policy on Indigenous crops. There has been an attempt to taxonomically characterize the traditional germplasm. However, a large number of the species remain unclassified. This hampers the conservation efforts and the potential use of the crops. Breeding is mainly conducted on the production food systems activity to enhance agronomic and crop improvement aspects (resistance to abiotic and biotic stresses). These aspects are yet to translate into crop performance as the uptake and use is still low and has contributed to low yields and large yield gaps. There is also some breeding to enhance nutrients (iron, zinc) through biofortification and improve the value of the crops through processing. Less research focus has been done on consumption as well as logistics and distribution activities. Policies, strategies, and initiatives to promote investments into these crops have been formulated mainly on the production activity. Similarly, the involvement of institutions and stakeholders such as research institutions, industry, and community is mostly on the production activity. Although there are interventions in research, policy, and practice on the selected traditional crops, the scope of the work is limited to specific crops, the production food system activity and few geographic regions within the African continent. Traditional crops hold the potential of transforming African food systems due to high nutritional value and resilience to climate change effects. There is a need to expand the scope of the current work on research, policy, and practice to cover more traditional crops, food systems activities, and different geographies to enhance the contribution of these crops to sustainable food systems, health, and livelihoods.

Disclosure statement

No potential conflict of interest was reported by the author(s).

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