

A review of some aspects of Uganda's crop agriculture:

Challenges and opportunities for diversified sector output and food security

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Cover photo: preparing the ground for kitchen gardens, Uganda (photo: Janny Vos, CABI).

Abstract

Despite Uganda being largely agricultural, with the climate and soils suitable for the production of a wide range of crops, average total factor productivity growth in agriculture has been negative for the last two decades. National agricultural output has grown at only 2% per annum over the last five years, compared to 3.3% per annum growth in Uganda's population over the same period. As such, food insecurity and poverty remain widespread and the prevalence of national food imports has increased in the last decade. Many crops have in the past been introduced into the country, evaluated for their performance and suitability to local production zones, and many reached a stage of adoption by Uganda's farming households. However, due to several intrinsic and extrinsic factors, including policy changes, planting of some previously highly regarded crops has either declined or been forgotten altogether. In certain instances, some other crops have remained in isolated spots on farmers' fields or parklands lacking organized production and marketing. We review some aspects of Uganda's crop sector and the nature of past and present government agricultural policies, highlighting issues pertaining to some of the would-be important and yet seemingly neglected crops with the aim of bringing them into the limelight for further consideration by research and policymakers. We also make recommendations for the revitalization of reviewed crops in order to contribute to sustainable food security, diversified agriculture sector output and expansion of the national export base. Further, amidst global climatic changes, increased crop diversification and selection of crops most suited for different zones has been fronted as a rational and cost-effective method for building resilience into agricultural systems. Lessons and recommendations are scalable to other countries, with similar farming systems.

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Acronyms and Abbreviations

APEP	Agricultural Productivity Enhancement Program
ASSP	Agriculture Sector Strategic Plan
CDO	Cotton Development Organization
CFC	Common Fund for Commodities
CMB	Coffee Marketing Board
COVOL	Cooperative Office for Voluntary Organisations
DFI	District Farm Institute
DSIP	Agricultural Sector Development Strategy and Investment Plan
ERP	Economic Recovery Program
GDP	Gross domestic product
LMB	Lint Marketing Board
MAAIF	Ministry of Agriculture, Animal Industry and Fisheries
NAADS	National Agricultural Advisory Services
NaCRRI	National Crops Resources Research Institute
NaFORRI	National Forestry Resources Research Institute
NARO	National Agricultural Research Organization
NARS	National Agricultural Research Systems
NDP	National Development Plan
NERICA	New Rice for Africa
NGO	Non-governmental organization
PEAP	Poverty Eradication Action Plan
PFA	Prosperity For All
PMA	Plan for Modernization of Agriculture
PMB	Produce Marketing Board
RDS	Rural Development Strategy
SSA	Sub-Saharan Africa
TFP	Total Factor Productivity
UBOS	Uganda Bureau of Statistics
UCDA	Uganda Coffee Development Authority

1 Introduction

1.1 Background

The path to prosperity is clearly marked by the 2030 Agenda for Sustainable Development (United Nations, 2015). It requires transformative action, embracing the principles of sustainability and finding ways to increase the income and assets of rural people living in developing countries. Agriculture is the main driving force of rural economies (IFPRI, 2009), with great potential to strengthen livelihoods, provide nutritious foods for healthy wellbeing, revitalize rural and urban landscapes, and deliver inclusive and sustainable national growth. Therefore, there is no doubt that promoting enabling agricultural policies that improve incomes of the poor and the sources from which they draw their sustenance is a wise public investment.

In the case of Uganda, the majority of its 40 million people live in rural areas. Agriculture is a core sector of the economy and the largest employer. The sector accounted for 79% of national poverty reduction between 2006 and 2013 implying that investment in the sector is critical for poverty reduction. The sector also contributes to half of Uganda's export earnings and a quarter of the country's gross domestic product (GDP) (UBOS, 2020). At the household level, agriculture provides the main income for almost all forms of rural livelihoods options. With a thorny youth unemployment challenge, raising agriculture incomes is critical to reducing poverty, creating job opportunities and generating incomes (Roepstorff et al., 2011). This aim is the centerpiece of Uganda's National Development Plan III, the Agriculture Sector Strategic Plan (ASSP) and Uganda's Vision 2040. These policy documents prioritize agriculture as a growth opportunity that will fuel the socio-economic transformation of Uganda into a middle-income country by 2040.

Although agriculture-led growth played an important role in reducing food and nutrition insecurity and transforming the economies of many Asian and Latin American countries, most countries in Africa have not yet met the criteria for a successful agricultural revolution. In Uganda, the average Total Factor Productivity (TFP) growth in agriculture has been negative for the last two decades (World Bank, 2018), implying that on balance the country is now getting less output for equal or greater input. Similarly, the national agricultural output has grown at only 2% per annum over the last five years, compared to agricultural output growth of 3 to 5% in other East Africa Community member countries and 3.3% per annum growth in Uganda's population over the same period (World Bank, 2018). This is attributed to weakening of the public institutional base for promoting agricultural productivity, inefficiencies in agricultural public expenditures, inadequate agricultural regulation and policies, and a lack of collateralizable farm assets.

These challenges are compounded by climate change and other frequent shocks (such as outbreaks of pests and diseases), which result in large numbers of people being plunged into an almost permanent state of fragility (Ansah et al., 2019). Poverty head count in Uganda stands at 21.4% with eastern and northern regions comprising three quarters of the monetary poor, and the most chronically poor; 21.6% and 10.7% respectively, compared to western and central regions at 4.9% and 0.5% respectively (UBOS, 2020). The looming poverty in these regions has been partly linked to lack of a well-paying cash crop and reliance on a limited number of food crops for subsistence whose productivity is highly sensitive to climatic variations (Wichern et al., 2017). These households are vulnerable to both food security and economic shocks.

1.2 Overarching national agricultural policies

For the last 33 years (since 1987), the Government of Uganda has enacted and implemented several policies, strategies and programs to support the food and agriculture sector in the country. These can

be grouped into overarching national policies and specific agricultural and rural development initiatives (FAO, 2013). Like most countries in sub-Saharan Africa (SSA), the economic recovery program (ERP) was the first phase of reforms with an impact on the agricultural sector and focused on the liberalization of trade including agricultural inputs and outputs. This was followed by the Public Enterprise Reform and Divestiture Act of 1993 (privatization policy) that saw the privatization of stateowned enterprises such as the Coffee Marketing Board (CMB), Lint Marketing Board (LMB), and Produce Marketing Board (PMB) (FAO, 2013). Following the ERP, the Poverty Eradication Action Plan (PEAP) was formulated in 1997 as the country's 10-year planning framework for accelerating growth, reducing poverty and promoting sustainable development. The major goal of PEAP was to reduce the poverty level in Uganda from 35% in 2000 to less than 10% by the year 2017 (MFPED, 2000). One of the pillars for PEAP was the modernization of the agricultural sector that considered the country's comparative advantage at home, regionally and globally. This related directly to selection and promotion of enterprises where the country could carry out production and marketing more efficiently than another activity/enterprise. After the expiry of the PEAP (2008), a National Development Plan (NDP) was developed. Three waves of the NDP have so far been implemented with the current NDP III (2020-2025) having an overarching goal of "Increased Household Incomes and Improved Quality of Life of Ugandans" (NPA, 2020).

In parallel, the Plan for Modernization of Agriculture (PMA), a multi-sectoral policy framework for agriculture and rural development was launched in 2001. The plan aimed to modernize the agricultural sector through the promotion of a "profitable, competitive, sustainable and dynamic agro-industrial sector". This was followed by the Rural Development Strategy (RDS) with the overall objective of raising household incomes. In 2006, the Government formulated a much broader vision of Prosperity For All (PFA). Other related policies and strategies include; the Agricultural Sector Development Strategy and Investment Plan (DSIP), Agricultural Sector Strategic Plan (ASSP) and the Agricultural Zoning Strategy. To enhance the efficiency of the delivery of the agricultural goods and services, several statutory bodies were formed under MAAIF. The crop-related bodies are; National Agricultural Research Systems (NARS), National Agricultural Advisory Services (NAADS), Uganda Coffee Development Authority (UCDA), Cotton Development Organization (CDO), and the PMA Secretariat for multi-sectoral coordination.

Uganda is still highly vulnerable to climatic changes, particularly affecting the large proportion (60%) of the population that depends on agriculture for their livelihood. As such, the country's development pathway, described in its Vision 2040 and NDP III recognizes the potential for climatic changes to undo substantive developments made already and prioritizes climate adaptation and mitigation actions. The National Climate Change Policy (2015) aims to ensure that all stakeholders address climate change impacts and their causes through appropriate measures, while promoting sustainable development and a green economy. Other major undertakings in Uganda's climate change mitigation efforts include the development of the National Green Growth strategy and the Nationally Determined Contributions support project, and the National Adaptation Plan for the agricultural sector.

The main thrust of these strategies and plans is to enhance sustainable economic and social development through boosting rural incomes by raising farm productivity, improving quality of life, increasing the share of agricultural production that is marketed and creating more on-farm and off-farm employment opportunities, and sustainable wealth creation.

1.3 Historical perspectives of crop agriculture in Uganda

Crop agriculture in Uganda has undergone three phases, namely: 1) introduction of new crops and testing their suitability to grow under Uganda's climatic and soil conditions; 2) selection of suitable crop types and varieties for adoption and rejections of unstable ones; and 3) popularization and scaling up of various selected crops. Different crops were indeed introduced and approved at different times. Some have been grown for such a long time that they may look as if they are indigenous Ugandan crops. Such crops include maize, millets, grain legumes, bananas and coffee. Due to previous political instability, lack of organized production and unstable markets, some crops which were previously produced in Uganda as major crops are presently treated as minor or have been phased out completely. If some of these phased out crops are mentioned, one might get the impression that they have never been grown in Uganda at all and may need a fresh introduction. Cocoa, for example, is currently being promoted by NAADS, but to a majority of Ugandans this looks like a new idea, and in some cases they are questioning the rationale for selection of such crops by the Government. In addition, there are a few indigenous crops like shea nut which are of high value with a huge demand on the world market but which have been locally neglected for research, domestication or cultivation.

Under the ASSP (MAAIF, 2016), nine crop commodities, namely bananas, beans, maize, rice, cassava, tea, coffee, fruits and vegetables, and four strategic commodities, namely cocoa, cotton, oil seeds and oil palm are prioritized. However, these are rather too few in relation to Uganda's capacity to produce crop commodities where there is enormous potential and comparative advantage to exploit the zoning structure. It is important therefore that the status of crop agriculture be reviewed and fresh planning instituted to revitalize the key crops that would diversify incomes of the people and contribute to sustainable poverty reduction as stipulated in the various national strategic frameworks. Such efforts would also go a long way in broadening the national export base and saving foreign exchange through import substitutions.

Based on the background, the current study reviewed aspects of Uganda's crop sector, focusing on crops which were introduced and either declined or were phased out, to inform policymakers and researchers of the existing gaps and prospects for enhancing agricultural performance, and contributing to food security and incomes of smallholder farmers, and resilience of farming systems.

2 Methods

2.1 Data collection and analysis

Narrative literature review methodology was used to critique the available literature and summarize the body of literature. Through this process, conclusions were drawn about the performance of target crops and gaps identified that can be addressed to enhance the performance of the specific crops, contributing to enhanced crop agriculture performance. The review focused on the following elements: crop history, production volumes and trends, product demand and market prospects (both local and export), and production challenges including impacts of climate change both historic and future projections. We also reviewed the information in journal articles; published statistics; policy documents, acts and decrees; websites, online multimedia articles and databases; newspaper articles; and websites. Based on this, recommendations for improvement were made targeting policy and research.

2.2 Limitations and delimitations of the study

A general lack of recent data and information on some crops was a key limitation, leading to reliance on old literature. While there are various crops with high potential, the review focused on crops which were introduced and either declined or were phased out or those that have global market potential. However, some crops were neither researched nor promoted, yet they continue to form part of the farming systems for locals with known value globally, and adaptation to local climatic conditions. Such crops were also included in this review. The review also includes some of the crops which are currently prioritized by the government but seem to require more focused planning and investment to achieve optimum output. Six categories of crops are discussed: traditional cash crops (cotton, cocoa), nut trees (cashew nut, shea nut, macadamia), cereals (wheat, barley, rice), fibre crops (sisal, jute, kenaf), horticultural crops (garlic, citrus) and oil crops (castor oil).

3 Results

3.1 Traditional cash crops

3.1.1 Cotton (Gossypium spp.)

Cotton used to be one of the two major traditional cash crops in Uganda next to coffee, used both as an export good and as a raw material for the domestic textile and edible oil industries. Commercial cotton production in Uganda started around 1903 (Mukiibi, 2001). Later, various infrastructures were developed for handling cotton which included ginneries, spinning mills and textile industries. Cotton became Uganda's second export crop or at times the first overtaking coffee in terms of foreign exchange earnings. Peak production was obtained around 1969/70 with a production of 84,000 metric tonnes of cotton, contributing 40% of foreign exchange earnings in that year. In 1976, cotton production collapsed to 14,000 metric tonnes, and production continued at a substantially lower rate, reaching a record low of 2,000 metric tonnes in 1987 (Baffes, 2009). The causes of the decline mainly included civil strife and economic uncertainty.

The Uganda economic recovery program in 1987 aimed at diversifying its exports and reducing dependence on coffee for its earnings. Under this policy, the Government rehabilitated the cotton subsector so that it could supply raw materials to meet the needs of the local industry, reduce importation, and produce cotton for export. A Cotton Development Organization (CDO) was established by the Cotton Development Statute of 1994 (now the Cotton Development Act of 2000) to promote the cotton sector. Subsequently, there was a significant increase in cultivated area under cotton and productivity resulting from the introduction of improved varieties. However, the current picture is still bleak as production has stagnated at about 25,000 metric tonnes per year (Figure 1), and the available cotton cannot by itself sustain the local industries. This consistent fluctuation in production is partly attributed to inadequate funding for research and technology development, climate change and overdependence on rain-fed production, high cost of production inputs, and competition for land and labour from other agricultural enterprises (UNCTAD, 2018), which has led farmers to opt for other enterprises. For example, EPRC (2018) study showed that 40% of the revenue gained from cotton goes toward production costs, compared to 11-24% for crops such as cassava, groundnuts, rice, sesame and sugarcane.

The low production of cotton has resulted in low utilization of the installed capacity at all the cottonseed-based processing firms, adversely affecting the industry's operations and overall profitability of these firms. Besides, there is also growing competition from cheaper imports and second-hand clothes affecting demand for locally produced fabrics and garments. In 2015/16, there were 39 ginneries in Uganda with an installed ginning capacity of close to one million bales (217,724 metric tonnes), and two operational textile firms - Southern Range Nyanza Limited and Fine Spinners Uganda Ltd – which were also not operating at full installed capacity (UNCTAD, 2018). Idle spinning capacity also exists, in the form of the non-functioning Lira Spinning Mill (UNCTAD, 2018).



Figure 1. Production quantities of cotton lint in Uganda (1961–2018)

Cotton is grown across approximately two-thirds of Uganda's land area, either as a monoculture or intercropped with food crops, providing a source of income, food security, employment and raw materials. The CDO estimates that the cotton value chain employs a total of 2.5 million people, directly and indirectly, in the production and marketing of its primary products, such as textiles and garments, as well as its by-products, such as soap, edible oil and animal feed. A rejuvenated sector holds the potential to greatly contribute to reduced poverty in Uganda, if production and market challenges are effectively addressed. There is need to provide farmers with affordable finance to purchase the required quality inputs, tractor hire services to ease farm preparations, short-duration cotton and varieties with high ginning out turn, providing subsidy for production inputs, offering a competitive price for the seed cotton, and aggregating land through cooperatives or farmer organization for large scale centralized production. Katunze et al. (2017) affirm that reinstating the warehouse receipt system for cotton marketing is key for achieving better access to markets and credit.

3.1.2 Cocoa (Theobroma cacao)

Cocoa is among the top ten agricultural commodities in the world, providing a livelihood for over six million farmers in Africa, South America and Asia (Utro et al., 2012). Cocoa beans are used in the production of chocolate and other confectionery products, and cocoa butter is used in the pharmaceutical and cosmeceutical industries. A variety of by-products can be made from the fruit (pod) walls or the mucilaginous pulp of the seeds (Oddoye et al., 2013). The west coast of Africa contributes more than 70% of the world's cocoa supply with Ivory Coast, Ghana, Nigeria and Cameroon being the leading producers (Wessel & Quist-Wessel, 2015). In Uganda, cocoa was introduced in 1905 from Kew Gardens in Britain and planted in Entebbe Botanical Gardens. Commercial export started around 1917 having been grown on plantation scale by Europeans and Asians. The crop was abandoned around 1924 when world prices fell to a very low level. The crop was reintroduced in 1958 by small-scale farmers in order to diversify foreign exchange earnings and farmer incomes in Robusta coffee-growing areas of Uganda. However, Government neglect, lack of finance and price fluctuations throttled the sub-sector in the 1970s and 1980s affecting production of the crop. The major cocoa producing areas in Uganda are the greater districts of Bundibugyo in the Western Region and Mukono in the Central Region. Several other districts also contribute to cocoa cultivation in the country, for example, Iganga, Hoima, Jinja, Kamuli, Mpigi, Masindi, Luwero and Kibale. Recent statistics show that Uganda exported 34,176 metric tonnes of dry cocoa beans in 2019,

fetching total export earnings of about US\$ 77.548 million (UBOS, 2020). In the same year, cocoa growing and value addition activities registered a growth of 12.2% compared to 2018. Cocoa is currently the fourth top foreign exchange earner for Uganda after coffee, fish and tea.

This upward trend in cocoa growing activities is in part attributed to the renewed efforts by the government to promote the crop. Under the ASSP (2015/16 – 2019/20), cocoa is one of the strategic enterprises, and through NAADS millions of free seedlings have been distributed to farmers. With suitable land for cocoa production still available, the crop has great potential for increasing Uganda's foreign exchange earning if more effort is directed towards increasing production through increased planting. Nevertheless, the current mean annual farm yield of 550 kg per ha in Uganda (reported by National Crops Resources Research Institute, NaCRRI) falls below that of other producing nations' such as Cote d'Ivoire and Indonesia with an estimated yield of 1.4 metric tonnes and one tonne per hectare, respectively (Cocoa Research Institute of Ghana, 2017). Therefore a further increase in production has to come from an increase in yield of the existing mature trees and the replanting of old unproductive cocoa farms with improved planting materials, appropriate agronomic practices, replacing the mined nutrients through fertilizer and manure application, and appropriate pest and disease management, the reported common causes of low yield in most cocoa growing areas (Cocoa Research Institute of Ghana, 2017; Wessel & Quist-Wessel, 2015).

However, cocoa is sensitive to temperature and humidity and future climate scenarios show that 50% of the world's current cocoa growing regions will significantly drop in suitability requiring crop change or adaptations in agronomic management. Adoption of agroforestry shade systems has been associated with adaptation to marginal climatic conditions, and at the same time increase yield and provide agroforestry products to the farmers (Abdulai et al., 2018; Wessel & Quist-Wessel, 2015). Systemic transformation, such as improved soil management, optimization of fertilization and adoption of more resistant varieties of cocoa trees are other recommended adaptation measures (Bunn et al., 2017). The seedling package by NAADS therefore should be accompanied by appropriate extension and advisory services to ensure high yield and adaptation of cocoa farming to future climate.

3.2 Nut trees

3.2.1 Cashew nut (Anacardium occidentale)

Cashew tree growing in Uganda was introduced by individuals, missionaries, and the Department of Agriculture, although the exact date of first introduction is not known. When President Idi Amin took over leadership in 1971, he, amongst others emphasized the importance of cashew production. In 1972 the Department of Agriculture imported bulk seed nuts from Kenya to promote the crop. From 1972 to 1978, the government established plantations in a bid to promote the sustainable supply of quality seeds. The established plantations were 40 ha in Ongom (Lira district), 10 ha in Kigge (Kamuli district) and 10 ha in Odina (Soroti district) (Mujuni et al., 2018). Simultaneously, a processing factory was established that led to the first steps to develop an organized value chain for Ugandan cashew. However, the political turmoil in 1979 disrupted government plans and the then newly built processing facility, which was not yet operational, was destroyed, and consequently the cashew sector collapsed due to inadequate management, technical services and especially marketing.

There was a concerted government effort to expand acreage through an FAO funded project from 1990 to 1993. By 1991, there were 93,666 trees spread over all districts of Uganda with Soroti having the highest number at 76,000 trees followed by Nebbi with 17,017 trees. In 2005, more efforts were put into reviving the sector with the establishment of the Regional Cashew Improvement Network for Eastern and Southern Africa through funding from the Common Fund for Commodities (CFC) (RECINESA 2004 – 2011) project (Esegu et al., 2013). National Forestry Resources Research Institute

(NaFORRI) also introduced improved high yielding and short rotation varieties from Tanzania and Brazil, and over 41,000 trees were planted in the districts of Kumi, Ngora, Serere, Soroti, Arua and Lira. The old neglected tree stands were rehabilitated; cashew farmers were trained and equipped with skills in all aspects of cashew production and management. Consequently, the tree population increased to about 150,000 trees (2,000 ha) and production increased from 3 kg to 10 kg per tree annually (Esegu et al., 2013).

Cashew has the potential to become an important cash crop for the drier areas of this country, particularly eastern and northern regions. Integration of the cashew nut tree as a perennial cash crop seems to be an opportunity to increase farmer income as these regions do not have a well-paying cash crop. It can tolerate drought where rainfall is 900 mm per year and an altitude of up to 1500 metres above sea level, and tends to thrive in harsh environments where other trees cannot survive, which allows farmers the opportunity to utilize otherwise unusable land. Lack of consistent research and multiplication of high yielding cashew varieties, and lack of appropriate postharvest handling and a quality control system remain key weaknesses for the development of the cashew sector in Uganda (Mujuni et al., 2018). Therefore, there is a need to develop and promote well-suited cashew varieties supported by efficient seed multiplication techniques and adoption of standard production and postharvest packages. Research may focus on the selection of superior trees for a breeding program from the already existing wide species variation in Uganda.

3.2.2 Shea nut (Vitellaria paradoxa)

Indigenous to Africa, shea trees (formerly Butyrospermum paradoxum, now called Vitellaria paradoxa) for thousands of years have been an irreplaceable resource for locals, a wonder to explorers and of undisputable commercial value to traders. Found north of the equator, shea trees grow in low latitude areas and cut across the savannah regions of nineteen African countries including Uganda (Allal et al., 2011). Although not cultivated or planted by locals, millennia of farm management practices, conscious selection and preservation by farmers/locals account for its current make-up as a 'semidomesticated tree'. The widespread usage of shea butter as a substitute for edible vegetable oils and fat in various food applications, and increasing demand for cocoa butter alternative in foods such as chocolates and margarine (Rousseau et al., 2015) have spurred the demand for shea butter. In 2013, the European Union (EU) policy change allowed the inclusion of up to 5% of shea butter into processed foods, further leading to a substantial increase in demand for shea nuts, butter and other by-products (Bockel et al., 2020). Moreover, the expected growth of greater than 10% annually in the global natural cosmetics market, which uses shea butter as a primary input, through 2019 (CBI, 2019) and likely beyond, will also boost the market growth. Refined shea butter market is anticipated to exceed 10% growth in terms of revenue by 2025 (Global Market Insights, 2019). These trends in the international market for shea nuts and shea butter signal opportunities for industry expansion among shea producing countries.

In Uganda, shea nut trees only grow in the northern and the West Nile regions. Uganda's shea butter is considered to be of high quality, with more similarities with olive oil, due to its characteristically high levels of oleic acid (59% compared to 47% and 39% for Nigeria and Burkina Faso respectively) (Warra et al., 2009). The high oleic acid content makes the butter more liquid at room temperature compared with the West African type that is solid at room temperature. Ferris et al. (2012) estimated that the potential levels of shea nut production in the Ugandan shea belt range from approximately 70,000 – 385,000 metric tonnes, which would yield between 15 – 80 million litres of oil using traditional methods at a value of US\$ 30 million per year. The Cooperative Office for Voluntary Organisations (COVOL), a local NGO dealing with shea marketing in Uganda, reports that with improved production, Uganda's production could reach US\$ 118 million per year. However, in

comparison with West Africa, particularly Ghana and Mali, where marketing channels are well defined and there has been a long-standing export of shea nuts and butter to European and North American countries, the commercial development of shea products in Uganda remains at an embryonic stage (Ferris et al., 2012). The current market sector can be described as almost entirely traditional in nature with low levels of nut collection and consumption. Shea tree numbers in northern Uganda are also on the decline, revealing a population gap of trees aged between 5 – 100 years (Lovett, 2013). The loss of younger trees has been linked with changing land-use practices and increased levels of more permanent arable farming. Increased population pressure has also led to higher levels of trees being felled for charcoal production and house construction (Okiror et al., 2012; Okulo et al., 2012).

Even with a low level of collection, COVOL reports that shea oil plays a significant role in household food and income security of northern Uganda. The crop is a particularly important source of income for rural women, implying the need to support the development of this crop. The only shortcoming with this crop however, is the long gestation period from planting to first harvesting which is about 24 years. This works as a disincentive to farmers interested in cultivating this crop and hence the tendency to leave the trees in the parklands. However, once trees start bearing, production can go on up to 200 years. As a crop with its unique oil that has a high international demand, Uganda should exploit this comparative advantage to carry out more research into the selection of highly productive varieties, intensify breeding programs to reduce the time required by trees to start production and promote the production of elite shea nut trees on farms to offer diverse income options for the rural population while expanding Uganda's foreign exchange base. At the same time, although it is affected by climate variability and change, the shea tree has characteristics that make it a resistant crop, while its genetic diversity gives it high spontaneous adaptive capacity (Venturini et al., 2016). Shea is well adapted to poor shallow soils and dry environments (Boffa, 2015), and is beneficial to the overall resilience of the ecosystem, maintaining soil fertility and biodiversity of flora and fauna (Venturini et al., 2016). Shea cultivation can therefore also be promoted as a long-term transformative climate adaptation option.

3.2.3 Macadamia (Macadamia ternifolia)

Macadamia is a nut fruit that is earning a lot of recognition in Uganda but is still on the fringes of widespread cultivation. Macadamia nuts are nutritious and valuable for eating and selling and can make macadamia butter. It has a high nutritional value and high market price driven by consumers' high demand for the nuts and products (Alam et al., 2019). The crop was introduced to Uganda in the 1960s and currently is being grown on some isolated farms like AMAFH Farm Ltd which owns over 700 acres at the Nambale Mityana estates. These initial varieties took about 20 years to start bearing fruit but there are varieties in Muranga and Kiambu counties, Kenya, that take only about three years to come into production. Macadamia is a high-value nut with a wide market in Europe, USA, Japan and other countries and Kenya is already exploiting these markets as it ranks third in the world production with a global market share of 13% (7,750 metric tonnes on kernel basis) (Quiroz et al., 2019). Macadamia is best suited to areas with annual mean temperatures (Tmean) ranging from $10 - 15^{\circ}$ C and a tolerable annual rainfall ranging from 510 to 4000 mm (Barrueto et al., 2018). As most of the suitable areas for macadamia production are currently utilized for the production of other crops, it can be promoted as an agroforestry crop and intercropped with other crops such as maize, groundnuts, soybeans and sunflower in the agricultural fields as an adaptation strategy to climate change and farm intensification due to limited land, particularly among smallholders (Zuza et al., 2021). Planting macadamia in small-scale agroforestry plots would also reduce risks from pests and disease in large mono-cropped orchards.

3.3 Cereals

3.3.1 Wheat (Tritium aestivum)

Bread wheat was first grown in Uganda on the slopes of the Rwenzori mountains in 1912. Since its introduction, wheat has traditionally been grown above 1500 m above sea level mainly on the slopes of Mt. Elgon, Mt Rwenzori and Mt. Muhavura. Presently, wheat is mainly produced in the districts of Kapchorwa, Kabale, Kisoro, Kaborole, Kasese, Buhweju, Isingiro and Zombo. However, production in these areas is very low and, in some instances, lacking altogether. The total area under production in 2018 was estimated at 14,504 ha, with a corresponding annual production of 23,206 metric tonnes (FAO, 2020; UBOS, 2019). Domestic consumption of wheat stands at an average of 631,634 metric tonnes (2018), and local production only provides about 4% of this demand (Table 1). According to the United Nations COMTRADE database on international trade, Uganda wheat and meslin imports from Russia in 2018 alone was US\$ 91.35 million.

	2014	2015	2016	2017	2018
Area planted (ha)	13,797	13,799	13,812	13,813	14,504
Production (MT)	22,076	22,078	22,100	22,100	23,206
Add imports (MT)	520,237	461,630	561,911	665,870	631,634
Less exports/re-exports (MT)	189	1,638	433	141	55
Domestic consumption (MT)	542,124	482,070	583,578	687,829	654,785
Domestic consumption met by local production (%)	4.1	4.6	3.8	3.2	3.5

Table 1.	Wheat pr	oduction and	l consumption	in Uganda
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Adapted from (FAO, 2020; UBOS, 2019)

Though traditionally wheat was not the leading staple crop in sub-Saharan Africa, and Uganda in particular, it is increasingly becoming an important food crop because of rapid population growth associated with increased urbanization and change in food preference e.g. bread, biscuits, pasta, noodles and porridge (Tadesse et al., 2019). This implies that a concerted effort must be made to increase local production to meet demand and avoid over-dependence on imports. This would go a long way in saving foreign exchange through import substitutions. Smallholder farmers would also benefit from wheat production which would increase their earnings.

The immediate interventions should focus on addressing the challenge of low productivity (2 t/ha) that has principally been blamed on abiotic factors (drought and heat) and biotic (yellow rust, stem rust, septoria and fusarium) stresses which are increasing in intensity and frequency associated with climate change (Tadesse et al., 2019). This calls for research into adaptable varieties given the climatic changes, besides targeted acquisition of high yielding, disease-resistant, short-maturing varieties, and increase in agricultural inputs like fertilizers and machinery to enhance farm operations while reducing labour costs.

3.3.2 Barley (Hordeum vulgare)

Barley has a close resemblance to wheat and is exotic to Uganda. Barely is produced in the same areas as wheat as the conditions for growth are similar. The crop is mainly grown in the highlands of eastern and south-western Uganda, West Nile and Mt. Rwenzori regions. The barley grain is a key ingredient in commercial human food, animal feeds and most importantly in the beer-making industry. In Uganda, the major buyers of barley are the brewing companies which take 90% of barley grown locally. To boost barley growing the Government extended a lower rate of excise duty of 40% for beer brewed using locally grown barley in 2009. The barley farming project has been supported on various fronts by brewery companies, the Government's PEAP and the USAID-funded Agricultural Productivity

Enhancement Program (APEP). The local demand for barley stands at about 100,000 metric tonnes annually. Farmers in Kapchorwa produce over 5,000 metric tonnes which is about 5% of the annual market demand while production from other areas is not well documented. However, the low supply has forced users to resort to using alternative products like sweet sorghum in beer brewing.

While Uganda can produce barley, farmers are limited by capital to access the machinery necessary for land preparation, planting and harvesting. Climate variability, in particular, reduced rainfall is mentioned as one reason for reduced production of barley. The inconsistent market for barley has also reduced farmers' confidence to produce the crop. Supporting farmer groups to access necessary machinery e.g. tractors and harvesters, access to drought-tolerant varieties and linkages to markets are key investment areas.

3.3.3 Rice (Oryza sativa)

Rice production in Uganda started in 1942 mainly to feed the World War II soldiers. However, due to various factors, rice production remained minimal until the 1970s. The area under rice fluctuated from 30,000 ha in the 1940s to less than 2000 ha in the 1960s. The construction of the Kibimba and Doho rice scheme in the 1970s was aimed at supporting the rejuvenation of rice production. However, the high yielding lowland varieties are water-intensive and require knowledge and labour; factors which slowed down the adoption of rice. Rice cultivation accelerated in early 2000 when upland rice varieties called NERICA (New Rice for Africa) were introduced in Uganda in the agro-ecological zones receiving annual rainfall of 1000 mm or more. Fifteen upland rice varieties were introduced such as Abilong, UK2, NP2 and NP3 which take between 110 to 118 days to mature. Additionally, they are non-shattering, moderately resistant to blast and yield 2 to 4 metric tonnes per hectare under good management. Subsequently the National Agricultural Research Organization (NARO) released six upland rice varieties are drought tolerant and mature in 90 days, allowing farmers to plant them during short rainy seasons, then they can plant other varieties that mature in four to five months during the long rainy season.

The growth rate of area under rainfed rice cultivation from 2000 to 2009 was 14% per year in the lowest zone and as high as 31% per year in the highest zone. Rice cultivation was further propelled by the then Vice President Prof. Gilbert Bukenya, who launched countrywide rice campaigns. The Vice President's campaign reduced rice imports into Uganda from \$90m to \$60m in a span of four years, and he won a US Congressional Gold Medal Award in 2007 for this initiative. Various other Government initiatives have been at play, which has seen an upward trend in rice production and consumption (MAAIF, 2012). Estimates show that Uganda produces 260,786 MT milled rice annually and area under production is 92,960 ha (FAO, 2020). Currently, domestic annual consumption of rice stands at 220,000 MT giving Uganda a surplus of 40 MT, a good start for export to other countries.

Despite the positive prospects, rice productivity in Uganda is still below potential. Musebe et al. (2013) report that NERICA-4 rice (most widely adopted upland variety) farmers in northern Uganda were achieving yield levels of 1,042 kg per ha against the potential yield of 4,000 kg per ha. Some studies report yield differences of up to 80% (van Ittersum et al., 2013). The low productivity is mostly attributed to allocative inefficiency (Okello et al., 2019) due to high labour demand for cultivation which necessitates farmers to use hired labour. Farmers could benefit more from the employment of appropriate labour-saving technologies such as the use of ox-ploughs, and integration of improved rice varieties, soil fertility amendment with fertilizer and proper crop management practices. With deliberate efforts put into this crop through individual farmers, farmer groups, and upcoming commercial farmers like Lukaya Natural Rice Farm in Kalungu district and Uganda-China South-South Cooperation Industrial Park in Luwero district, and enhanced development of climate resilient

varieties through breeding early maturing, drought tolerant and high yielding varieties by NARO, Uganda could in the near future become a net exporter of rice with importations from Vietnam and Pakistan in the recent past becoming history.

3.4 Fibre crops

3.4.1 Sisal (Agave sisalana)

Sisal is a naturalized plant in Uganda. Sisal is thought to have been imported from Mexico to East Africa in the 19th Century. Large plantations of this crop were quickly established in Kenya, Tanzania and Uganda. In Uganda, plantations are found around Butiaba Old Pier and Masindi Port. Sisal production in Uganda then declined until 1968, when there were no growers of sisal. From 2006, Uganda resumed production. However, by 2018, only 2 ha were under sisal production, compared to 2,000 ha in 1961. Traditionally, sisal has been the leading material for agricultural twine because of its strength, durability and versatility in terms of products. The products are also environmentally friendly. The importance of this traditional use diminished with competition from polypropylene. With the rising global inclination towards the use of biodegradable materials in packaging processes to conserve the environment, there is need to look into the ways and means of reviving sisal and grow it in a more competitive manner against the synthetic options.

Ironically, Uganda still uses sisal bags when exporting coffee beans and cocoa. This implies that a lot of foreign exchange goes into importation of these gunny bags. If sisal was grown in Uganda to substitute quantities imported into Uganda as packaging material, it would save the country in form of foreign exchange. Like most other crops that have declined over the years, it has been largely due to failure to compete due to high costs of production compared with returns from outputs, and availability of cheap but environmentally harmful substitutes such as polypropylenes. In this particular case, if the country wishes to stay aligned to the global environmentally conscious assemblage, then a total ban on the manufacture and importation of polypropylenes is not an option but rather a must. Such a policy directive will go a long way to promote the use of alternative packaging materials and by implication create demand for sisal products locally. Other policy interventions would also need to be instituted like price controls for processed sisal, provision of affordable inputs like fertilizers and machinery for production purposes to cut down on human labour that is generally very expensive.

3.4.2 Jute (Corchorus olitorius) and kenaf (Hibiscus cannabinus)

Jute also commonly known as Jew's Mallow or Nalta jute, is a natural fibre that is also named 'golden fibre' due to its versatile nature (Kalpana et al., 2018). Jute is the second most important vegetable fibre after cotton (*Gossypium* spp.) in the amount produced and variety of uses. It is used widely in manufacturing different types of packaging materials for various agricultural and industrial products. Jute falls into the bast fibre category along with kenaf, roselle (*Hibiscus sabdariffa*), sunn hemp (*Crotalaria juncea*), flax (linen) (*Linum usitatissimum*), ramie, etc. Jute is a rain-fed crop with little need for fertilizer or pesticides, in contrast to cotton's heavy requirements. Globally, the production of jute is concentrated in Bangladesh and India. Jute is in great demand due to its low cost of production, and the long uniform soft and lustre fibres that are much easier to process (Kalpana et al., 2018). Jute is also a culinary and medicinal herb, widely used as a vegetable in several countries in Asia and Africa (Kuete et al., 2017).

In Uganda, jute is reported as a wild or cultivated vegetable, mostly in northern Uganda. Although a kenaf and jute project was implemented in Uganda in the 1960s and early 1970s, no tangible results were reported in terms of varieties tested and crop performance. Consequently, these crops were not promoted. The country once had a jute processing factory in Tororo town (eastern Uganda) that was manufacturing gunny bags. However, the factory closed in the late 1990s due to low prices of gunny

bags as a result of stiff competition from the cheap substitute polypropylene products. Therefore, there is a need to re-evaluate these crops that would supplement the natural fibres and offer suitable alternatives to synthetic fibres.

3.5 Horticultural crops

3.5.1 Garlic (Allium sativum)

Garlic belongs to the family Alliaceae. Other crops in this family are onion (Allium cepa), leek (Allium ampeloprasum), shallot (Allium ascalonicum) and chive (Allium schoenoprasum). Garlic is the second most widely used of the cultivated bulb crops after onion. The main growing country is China which produces about 80% of the world's garlic followed by India, Bangladesh and Egypt. In Africa, apart from Egypt, some garlic is produced in Sudan, Mauritania, Tanzania and Kenya. In Uganda, garlic is grown mainly for local consumption using traditional varieties. Recently, a lot of importation of white garlic from China has taken place in Uganda. While we did not find the actual value of garlic imports from China, it is estimated that Uganda spent \$4.2m (Shs15.5bn) in 2019 on the importation of onions, garlic, shallots and leeks. According to the United Nations COMTRADE database on international trade, in East Africa, Tanzania is one of the large suppliers of frozen or chilled onions, shallots, garlic and leeks into Uganda with an estimated value of US\$2.2m in 2018. Since white garlic from China penetrated the Uganda market and seems to be liked by many consumers, there is a dire need to invest in research and/or importation of improved germplasm. If good performance is achieved, then massive production would follow which would save on the huge foreign exchange being spent on imports, while creating gainful employment for the rural farmers especially the youth. Garlic is adapted to tropical and sub-tropical conditions. It survives well in areas with 600 – 1200 mm annual rainfall, and may be a good adaptation crop.

3.5.2 Citrus (Citrus spp.)

Citrus was first introduced into Uganda in 1900 in the form of seeds of oranges, limes and lemons. Oranges proved to be successful leading to the importation of budded trees from South Africa and Jamaica in 1929 and further imports from Australia and Sri Lanka in 1932. Since that time, there have been several efforts by both government and private individuals to invest in the importation of germplasm and growing of citrus throughout the country. In the 1960s, the Government established nucleus plantations at Kiige (Kamuli district), Odina (formerly Teso district) and Ongom (Lira district), to popularize citrus crops and provide planting materials to farmers. Although there was remarkable adoption of citrus production especially in northern and eastern Uganda where it is rare to find a homestead without at least one orange tree, the Government schemes have since disappeared. This was mostly due to a lack of funding coupled with the outbreak of diseases like fruit and leaf spot (Pseudophaeoramularia angolensis). Under the Development of Horticulture project (1990 – 1993) several new varieties of citrus were introduced into the country and some are being grown on different Government farms like Kawanda, Mukono and Mityana DFIs. The new introductions have not been evaluated outside the farms where they were planted and hence have not been planted on farmers' farms. The bulk of the citrus found on farms comprise old varieties like Washington navel, Valencia and Hamlin, that were introduced long ago. In Soroti, a joint effort between farmers and the Government has recently set up a juice factory and is producing some juice blends. This initiative needs to be replicated in other areas like northern Uganda where substantial quantities of fruit are being produced. This would work as a stimulus to further increase production.

The overall problem underlying citrus production in Uganda has been lack of a systematic production pattern that would lead to the production of enough volumes to warrant investment into processing and value addition. Besides, lack of funding for maintenance of the germplasm wherever it was placed

coupled with inadequate research is likely to lead to germplasm disappearance. Therefore, stakeholders should put in every effort to develop a research and development agenda to develop further the citrus industry in Uganda.

3.6 Oil crops

3.6.1 Castor oil (Ricinus communis)

Castor is one of the oldest cultivated crops, but currently, it represents only 0.15% of the vegetable oil produced in the world (Severino et al., 2012). Castor is valued mainly for oil, which is largely used in pharmaceutical products. Ground seedcakes are used as fertilizers (castor oil pomace). Castor also has potential as an industrial oilseed crop because of its high seed oil content (> 480 g per kg), unique fatty acid composition (900 g per kg of ricinoleic acid), and potentially high oil yields (1,250 – 2,500 L per ha) (Severino et al., 2012). Castor cultivation in Uganda dates back to 1890 and export of the seed has its earliest records in 1917. There have been serious fluctuations in both prices and production over the years. Data from Tilasto (2021) shows that in the early 1960s, Uganda produced on average 2,600 metric tonnes of castor oil per year. Production fluctuated and in 1974, reached a low of 500 metric tonnes. From 2002 to date, average castor production was 1,000 metric tonnes per year. About 233 landraces were collected in 1991/92 by NARO and were evaluated at Serere Research Station. This effort and promotional activities only saw the average production increase marginally to 1,237 metric tonnes.

This crop has the potential to become important in drier and low rainfall areas of Uganda as it can be grown under drought and marginal soil conditions. The global demand for caster seed oil is expected to reach US\$1.7 billion. The surge in demand is due to the growing trends in the pharmaceutical and healthcare industries, the rising consumption of the product in biodiesel feedstock (Fior Markets, 2019), and in manufacture of bio-based plastics, lubricants and coatings. There is a need for the government to create an enabling policy environment piggybacked on the favourable global trends.

4 Conclusion

There are many crops which were once evaluated and even grown in Uganda. However, due to intrinsic and extrinsic factors, some of the would-be well-performing crops are becoming neglected. Other crops, such as cashew nuts, which are not lost are forming part of the natural vegetation in some abandoned fields. There are other crops with great potential such as shea nut, garlic and macadamia which could be developed to add to the list of high-value crops produced in Uganda and indeed in the East African region. We recommend the Government directs its new strategy to review and promote these crops especially with the current drive to diversify export earnings and save crucial foreign exchange through import substitution of some commodities. The call for diversification of farming activities is also particularly relevant as an adaptation strategy given the changing climatic conditions. This involves diversification to crops and varieties that are more resilient to climate stresses and deemed suitable to grow under future climatic conditions. The list of thirteen priority crops needs to be seriously revised upwards especially given the great potential of Uganda's substantial but largely redundant or underemployed youth population, a conducive climate and good soils. Diverse but intensive crop production coupled with the reduction in postharvest losses, processing and value addition would go a long way in contributing to an expanded agriculture sector output and increased food security of farming households.

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