



BACKGROUND PAPER

Root and Tuber Crops (Cassava, Yam, Potato and Sweet Potato)

Roots and Tubers

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EXECUTIVE SUMMARY

Root and tuber crops, including cassava, sweet potato, potato and yam are the most important food crops for direct human consumption in Africa. These four crops are grown in varied agro-ecologies and production systems contributing to more than 240 million tons annually, covering around 23 million hectares. The aggregate value of yam, cassava, potato and sweet potato exceeds all other African staples, including cereal crops (cereals annually producing on average 169 million tons on 108 million ha of land).

There are many compelling reasons for encouraging these humble root and tuber crops for sustainable food production in Africa: (i) they are versatile staples to address food and nutrition security and produce more food per unit area of land, compared to many other crops; (ii) potato and sweet potato are short cycle crops (3 to 4 months), and thus well suited to the double cropping seasons particularly the rain-fed system; (iii) yam and cassava, though longer in their cropping cycle, are vital in the annual cycle of food availability due to their broader agro-ecological adaptation, diverse maturity period and in-ground storage capability, permitting flexibility in harvesting period for sustained food availability; (iv) these crops are also capable in efficiently converting natural resources into a more usable product, caloric energy in the growing season, which is the highest of all major arable crops; almost double that of wheat and rice; (v) they are a cheap but nutritionally rich staple food that contributes protein, vitamin C, vitamin A, zinc, and iron to meeting the dietary demands of the region's fast-growing towns and cities; (vi) they have high demand in local and national markets; (vii) they are far less susceptible to large-scale market shocks and price speculation experienced by more widely traded staples, such as grains, during international market crises (as in the food crisis of 2007–2008). As such they contribute to a more stable food system and predictable source of income.

The four crops have common and unique challenges related to quality seed production, new variety adoption, losses due to insects and diseases, low productivity in poor soils, tolerance to stress associated with heat and drought, consumer preferences, and storage of harvested products.

As pressure on agricultural land increases, improved productivity of these crops will be needed. Women play a critical role in the production of these crops; therefore, it is critical consider improvement of these crops as a means to relieve gender in-equality within African agricultural systems.

More general challenges in Africa impact the root and tuber crops more than others. The lack of research funding, limited research capacity and poor infrastructure (for research and on-farm) greatly diminishes the development of a competitive agricultural sector in Africa, and particularly for root and tuber crops.

There are a growing number of programs of research in Africa on yam, cassava, potato and sweet potato addressing genetic enhancement, seed systems, production, marketing and nutrition impacts. Different approaches to improve the quality of production technologies used by smallholder farmers have been developed. New varieties were developed and distributed to farmers. Farmers were trained to produce quality seed for their own use, for local seed provision and opportunities for small-scale seed enterprises were explored. Partnerships involving both national and international actors were created to expedite access and availability of the improved technologies to African small holders. Real and potential opportunities exist to sustain and further elevate this work over the coming years.

Opportunities for the root and tuber crops are highlighted by the tremendous growth these crops have shown in recent years. The yellow root cassava and orange-flesh sweet potato are excellent examples of how research can be transferred to development on a continent-wide

scale. These crops will all benefit from applying product development concepts into approaches for technology transfer. There is a tremendous opportunity for transferring experiences across the root and tuber crops. Further investment can capture the following opportunities:

1. Accelerated breeding methods and tools for the breeding of improved varieties.
2. Guidelines, technologies, diagnostic tools, and business models for improving seed systems.
3. Guidelines and technologies for sustainable intensification of production.
4. Models and tools for nutrition and behavior change.
5. Models, tools, and technologies for upgrading value chains.
6. Evidence base, policy options and partnership models for going to commercial scale.
7. Capacity development, both institutional and human capacity.

Strategic investment would ensure effective variety development and adoption to accelerate impact of technology advances, including strengthening networks across the continent. Breeding African crops in Africa will be central to this work, especially considering yam is one of the few staple crops that originated in Africa. Improved seed systems are required for all crops, but the benefits gained in potato can reach crops like yam. Further understanding of the importance of promoting new varieties with enhanced nutritional properties will be acquired by building on previous investments in orange-flesh sweet potato and pro-vitamin A cassava. Improved value chains for these four crops will create new opportunities and increase income potential for all stakeholders. Going from research plot to wide-scale adoption requires different models for operation and should involve the private sector. Finally, capacity development on several levels is required to ensure that the sector can become more competitive and the research investments have the desired impacts.

Other strategic interventions are proposed for each of the four crops that will lead to significant impacts on the livelihoods of millions of consumers and actors along key commodity value chains. All value chain players will play key roles in implementation of the relevant programs. These will include: Farmers' Groups, Agro-Input Dealers, Financial Institutions, Academic and Research Institutions (e.g NARIs, AATF, CGIAR Centers and Advanced Research Institutes), Extension Institutions, NGOs and other development partners, Primary Processors, Traders/Marketers, Transporters, Industries/Industry Associations, Policy Makers/ Government Agencies, Consumers/ End-Users.

1. BACKGROUND

Root and tuber crops, including yam, cassava, potato and sweet potato are the most important food crops for direct human consumption in Africa. They are grown in varied agro-ecologies and production systems ranging from highland densely populated regions to lowland drier areas prone to droughts or floods. These four crops account for about 95% of the total root and tuber crops production in Africa and produce more than 240 million tons annually on 23 million hectares.

The aggregate value of yam, cassava, potato and sweet potato exceeds all other African staple crops, and is much higher than the value of cereal crops (cereals annually producing on average 169 million tons from 108 million ha of land). There are many compelling reasons for encouraging these humble root and tuber crops for sustainable food production in Africa. They are versatile staples to address food and nutrition security for millions of people, and produce more food per unit area of land. Potato and sweet potato, short cycle crops with three to four months cropping cycle, are well suited to the double cropping seasons particularly in rain-fed systems and have significant advantage over grain crops which require longer time to harvest. Their short growing cycle allows for flexible planting and harvesting times and also permits quick production of foods to augment “hunger months”—that is, a period of several months between harvests when people lack enough food to satisfy their hunger and meet their basic caloric and nutritional needs. Yam and cassava, though with longer cropping cycles, are vital for annual cycle of food availability. Their broader agro-ecological adaptation including the marginal environments, diverse maturity period and in-ground storage capability permit flexible harvesting periods which aids sustained food availability. These crops are also capable of efficiently converting natural resources into a more usable product, caloric energy in the growing season, which is the most productive of all major arable crops; almost double that of wheat and rice. Yam, cassava, potato and sweet potato are cheap but nutritionally rich staple foods that contribute protein, vitamin C, vitamin A, zinc, and iron towards the dietary demands of the region’s fast-growing towns and cities. Another advantage of these crops is that they are largely traded locally and nationally, as opposed to internationally. They are far less susceptible to large-scale market shocks and price speculation experienced by more widely traded staples, such as grains, during international market crises (e.g. the food crisis of 2007–2008). As such, they contribute to a more stable food system and predictable source of income.

These crops have shown tremendous growth over the past three decades relative to other crops (Figure 1). The growth has brought opportunity and food security to Africa but at a cost: 1) virtually all production increases have resulted from increasing the land area planted and not significant yield increases (Figure 2), thus using valuable soil and water resources; 2) The crops are plagued by diseases and pests and this has constrained yield improvement and produce quality, and 3) the phenomenon of global climate change is affecting yield increase by modifying growing environments and adding new stress factors. Fortunately, recent innovations have demonstrated the potential to mitigate these constraints and position the yam, cassava, potato and sweet potato crops to meet current and future food security and industry demands.

There is a growing program of research in Africa on yam, cassava, potato and sweet potato addressing genetic enhancement, seed systems, production, marketing and nutrition impacts supported by a number of national and international programs funded by the Africa Development Bank, African Union Regional Economic fora (e.g. ASARECA, CORAF, SADC, COMESA), BMGF, USAID, DFID, EU, GTZ, and others. Different approaches to improve the quality of production technologies used by smallholder farmers have been tried out over the last four decades in Africa. New varieties were developed and exposed to farmers,

farmers were trained to produce quality seed and opportunities for small-scale seed enterprises were explored, partnerships involving both national and international actors were created to expedite access and availability of improved technologies to African small holders. In addition, new employment and income generation opportunities, especially for rural youth, were created through improved value chains and development of novel products (value addition). Real and potential opportunities exist to sustain and further elevate this work over the coming years. Increasing choice of suitable technologies adapted to diverse agro-ecologies Africa and meeting consumer demands is instrumental for intensifying the role of these crops for food security and economic development in the continent.

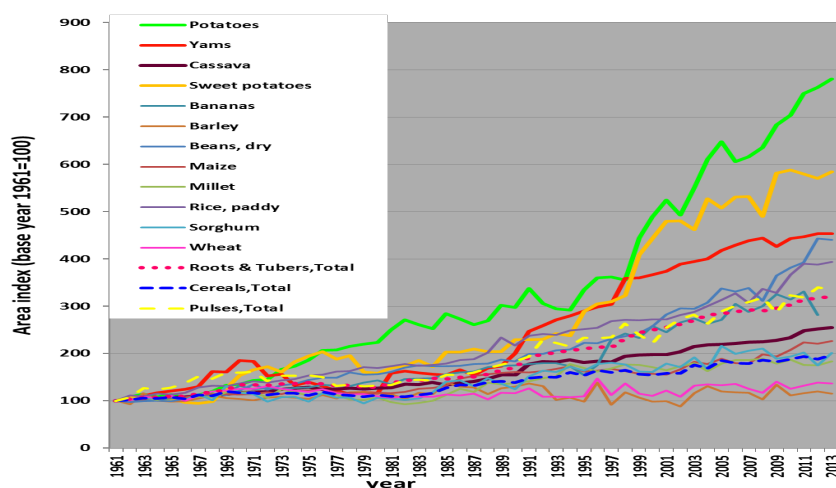


Figure 1. Major African field crops area growth 1961 – 2013 (Source: [www: faostat.org](http://www.faostat.org))

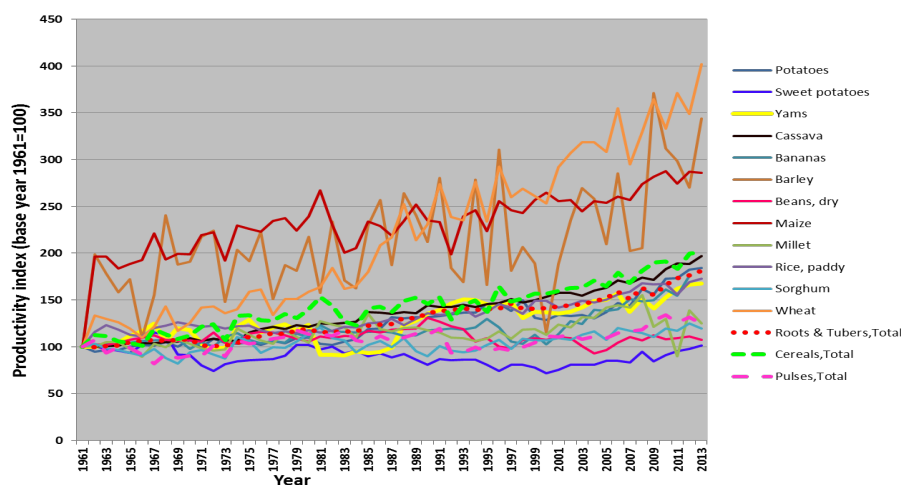


Figure 2. Major African field crops productivity growth 1961 – 2013 (Source: www: faostat.org)

2. CASSAVA

Cassava is one of the world's most important food crops, with annual global production at approximately 276 million metric tons (MT) in 2013. The top producing countries globally in 2013 were: Nigeria (accounting for ~19% of the total), Thailand (~11%), Indonesia (~9%), Brazil (~8%) and Democratic Republic of Congo (~6%). Global demand for the commodity has been growing significantly between 2004 and 2013 because of its appeal as a food security crop for growing populations in emerging markets, and the growing demand for industrially processed cassava products. Africa accounts for less than 1% of total exports and the cassava production space is dominated by smallholder farmers (25% women). The root crop is a source of livelihood for at least 300 million people. Virtually all cassava (90%) produced in Africa is used as a staple food for human consumption, providing calories for ~500 million people and constituting ~37% of the population's dietary energy requirements. However, in several

African countries, cassava is perceived, not only as a food security crop, but also as a raw material for various types of industries. In some countries, there are concerted efforts being initiated, sometimes with strong political support at the highest level to make cassava an engine of economic growth. Indeed cassava can be converted into a large number of products ranging from traditional and novel food products, livestock feeds, ethanol, starch and numerous other derivatives. Cassava can also provide locally produced products to substitute for imported commodities to reduce food imports, to improve foreign exchange balances and to provide local earning potential within Africa. The Global Cassava Development Strategy study commissioned by IFAD and FAO and the Vision 2020 study of the CGIAR on Root and Tuber crops stressed the great potential of cassava to spur rural industrial development, raise rural incomes, and contribute to food security. The New Partnership for African Development (NEPAD) has also recognized cassava as a powerful poverty fighter in Africa and recommended a Pan-African Cassava Initiative based on a transformation strategy which emphasizes better markets, better organization of producers for collective action, and better participation by the private sector. However, for cassava to be a contributor to development, the demand must grow more rapidly. This can only be made possible by the introduction and promotion of new uses for cassava. Despite widespread subsistence cultivation of cassava, especially in Africa, the crop's derivatives have enormous potential for use in industrial processing. Given its versatility and high starch content, cassava can be transformed into many important products. Cassava's derivatives can be broadly categorized into four product areas: cassava chips, high quality cassava flour (HQCF), starch, and ethanol. All of these products that can be derived from cassava are already in use in many parts of the world, demonstrating its high potential for value-addition and use in industry. Lessons can be drawn from success stories of agricultural transformation in other countries such as Thailand and Vietnam. The Federal Government of Nigeria launched the Agricultural Transformation Agenda (ATA) in 2012, as a private sector-driven, agri-business based, development of commodity value chains to create wealth, attain industrialization and sustain livelihood. This program which was built on commodity value chains drove Nigeria's cassava production to 54 million tons in 2015. Based on the impressive food production, Nigeria met the Millennium Development Goal of halving the number of hungry people (MDG 1 - poverty reduction) in 2013, two years ahead of 2015 target.

2.1 Challenges

The major challenges to the development of the cassava subsector in Africa include the following:

Low yields: The yields of African cassava producers are 37 - 64% below the global value. In 2013, Nigeria reached 14.1 tons/ha, similar to Brazil but ~37% less than Indonesia (22.5 tons/ha) and Thailand (21.8 tons/ha) (FAOSTATS accessed 2015). The yields of the other top African producers are also low. Cameroon's cassava yield in 2013 was at 14.7 MT/Ha, while Angola achieved yields similar to those of Nigeria at 14.1 tons/ha. DRC's 2013 yield was 8.0 tons/ha, less than 60% of Nigeria's yield. Yields are low by global standards, mainly due to the prevalence of traditional subsistence farming techniques with little or no use of inputs.

Fragmented, smaller-holder farms: In Africa, cassava production is carried out in predominantly smaller-holder and fragmented farms with rudimentary technologies, low use of inputs limited economy of scale. Six million small-scale farmers account for 90% of the production in Nigeria.

Limited adoption of improved seeds: Small-scale farmers rarely use improved planting materials (clean, healthy seeds), and the sub-sector is dominated by disease-prone local varieties with long maturation periods and low yield potential. IITA and African NARS have

played leading roles in the development of improved cassava varieties that are multiple disease and pest resistant, early maturing, and high yielding. These varieties have the potential to raise productivity by up to 30-40 tons/ha. Thirty-two African countries have released an estimated 384 high yielding varieties between 1970 and 2014. These varieties are high yielding with good levels of multiple disease and pest resistance as well as of acceptable quality for food, feed and industrial uses in Africa. While the combination of these new varieties and better agronomic practices could increase yields per unit area by at least 40%, the rate of adoption by smallholder farmers has been low. The dissemination of these varieties has often suffered from the lack of a reliable planting material distribution system from National Agricultural Research Systems (NARS) because of weak extension systems, insufficient quantities of planting material, and delays in distributing the approved planting materials. This compels farmers to continue to grow local, low yielding, varieties. This is exacerbated by inadequate location specific knowledge on fertilizer use, and other cultural practices such as weed and pest and disease management for cassava systems and late planting specifically in southern Africa region where maize comes first. Private companies are also not involved in distribution because cassava is propagated vegetatively, and it takes one year to produce cassava planting material compared to three to five months for grain seeds.

Low use of herbicides: Low use of herbicides and pesticides presents another obstacle. In the case of south-eastern Nigeria, only 3% of farmers use herbicides because they do not know about them, lack the technical skills to use them, are not able to afford them or are under pressure from local NGOs to avoid them. When they do use them, most use insufficient amounts of herbicides to save cost. Instead increasing herbicide use would reduce the need for weeding and free up labor for other activities.

Limited use of fertilizers and irrigation: Fertilizers are used infrequently, and even when used, the amounts are below the recommended levels because of the high cost. Use of irrigation techniques is also a constraint in almost all cassava farms in Africa as the system of cultivation is predominantly rain-fed.

High labor use: Cassava farming is highly labor-intensive and related costs can account for up to 90% of total production costs. For example, the cost of developing and preparing land is quite high. In Oyo and Benue states of Nigeria, 98% of the average cassava production cost of USD 700 per hectare is labor (ridging, planting, weeding, etc.) and 2% is inputs (fertilizers, seeds).

Low use of mechanization: Small-scale cultivation is characterized by a low level of mechanization. For example, tractors are used in just 10% of Nigeria's cassava cultivation. Harvesting is done manually and is therefore time-consuming and expensive. In both small-scale and commercial farming, 8-12% of cassava roots are lost due to sub-optimal harvesting methods. A survey conducted by the African Agricultural Technology Foundation (AATF) during the 2004 Triennial Symposium of the International Society for Tropical Root Crops – Africa Branch revealed a consensus among African cassava experts that the most important intervention to increase the competitiveness of the cassava industry was the adoption of mechanization in cassava production. Such mechanization will enable a reduction of labor costs, thus bringing down the cost of cassava as a raw material and stimulating reliance on local cassava as a competitive raw material for various industries.

High Prices of Cassava Roots: Cassava prices vary greatly from country to country as there is no global commodity market and production costs differ vastly due to varying levels of input use. For example, in 2012, the average price for cassava was USD 161/ton in Nigeria (10% mechanized), and USD 67/ton in Thailand (highly mechanized). Cassava derived products

must be price-competitive with their substitute products like corn starch and ethanol made from other sources.

Limited access to finance: Both commercial and smallholder farmers have limited access to finance. In Nigeria the agricultural sector accounts for 42% of GDP but has 2% of all formal credit flows. Reasons for this include: conditions to access a bank loan are stringent; interest rates are high (17-25%); and commercial banks do not offer conducive payment terms for agro-based activities (e.g., fixed repayment periods that may not match annual cropping, especially when loan release is not coordinated with growing cycles). As a result, commercial farmers may produce lower volumes.

Trade and transport: Smallholder cassava producers have weak and limited access to markets. The high transportation costs and the need to process cassava within 48 hours of harvesting because of its perishability, makes small producers to sell most of their product at local markets. The high fragmentation (scattered farms) and poor infrastructure make it difficult to develop commercial-scale aggregation. Poor roads and inadequate storage facilities drive up prices and increase postharvest losses.

Weak access to markets: Agricultural markets world-wide are characterized by market structures, both quantitative – aggregation, storage, and processing facilities, and qualitative – quality standards, information services, logistics for distribution of agricultural products. Many of these structures do not exist in many African countries for cassava distribution.

Contributions towards addressing the challenges: IITA has pioneered since the 1970s and will continue to propel the cassava research improvement in Africa to increase and sustain cassava production and utilization in sub-Saharan Africa. The Institute, working with national partners, has been actively involved in the development of value chains of the cassava subsector in Africa since the 2000s. Examples include the Rural Sector Enhancement Program, Pre-emptive management of cassava Mosaic disease in Nigeria, and the Cassava Transformation Agenda all in Nigeria. Under the Nigeria Cassava Presidential Initiative on Cassava (1999 – 2007) IITA research efforts increased cassava production by 10 million tons, making Nigeria global top producer. Similar efforts in Cameroon also helped the country to double cassava production. Other projects such as the Support for Agricultural Research for Development of Strategic Crops which is funded by the Africa Development Bank, and the Cassava Enterprise Development Project are also driving the production and productivity of cassava. In 2004, the New Partnership for Africa's Development (NEPAD) launched the NEPAD Pan African Cassava Initiative (NPACI) as a means to tap on the enormous potential of cassava in Africa for food security and income generation. The project made significant contributions towards cassava production, commercialization and social marketing in Southern Africa with specific emphasis in Malawi, Zimbabwe and Mozambique. These efforts have contributed to food security and incomes in those countries. Other projects such as Great Lakes Cassava Initiative and Cassava Weed Management Project are also having an impact.

2.2 Opportunities

The huge and untapped market opportunities of cassava in Africa can be effectively exploited for transforming Africa's agriculture. The challenge today is to increase productivity, marketing opportunities and profitability through effective and efficient cassava value chain development.

Cassava has diverse end-uses (Figure 2) despite its widespread subsistence cultivation in Africa for mainly food. Given its versatility and high starch content, it can be transformed into many important products/derivatives (cassava chips, high quality cassava flour (HQCF), starch, and ethanol).

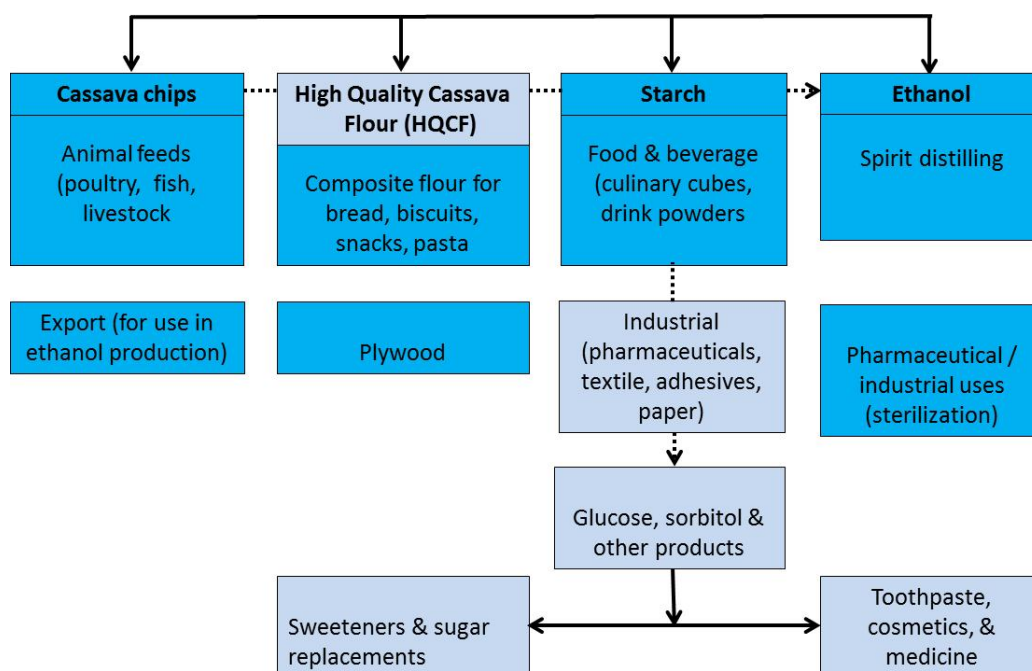


Figure 3. Cassava derivatives and their uses

The development of the cassava value chains will focus on the following top 20 cassava producing countries in Africa (In decreasing order of annual production: Nigeria, Democratic Republic of the Congo, Angola, Ghana, Mozambique, Uganda, Malawi, United Republic of Tanzania, Cameroon, Sierra Leone, Benin, Madagascar, Rwanda, Côte d'Ivoire, Burundi, Congo, Guinea, Kenya, Zambia, Togo)

2.3 Suggested Actions/Ways Forward

To overcome the challenges and tap into the opportunities for industrialization which exists in several African countries, there must be:

- Efficient and effective development of the various cassava value chains (to increase the productivity of the entire cassava value chains and drive down the price of cassava to rural and urban consumers (R&D),
- Agricultural competitiveness of cassava must be addressed through:
- Large investments in industries using cassava as a raw material (e.g. food, feed, ethanol and starch) to foster demand for cassava (public-private partnerships, PPP);
- Effective promotion of high-yielding improved varieties to increase adoption by farmers;

- Small and medium scale investments by entrepreneurs to enhance production, processing and delivery of high quality and quantity of cassava products to the larger industries (PPP);
- Adoption of labor saving devices in cassava production and processing to ensure more efficient field production, better services to field production, more attention to postharvest systems (Pre and Post-harvest Mechanization);
- Accelerated development and delivery of technologies geared to more efficient production/postharvest operations (R&D);
- Improve quantity and quality of cassava products for diversified uses to attract urban consumers and industries, create demand for the crop, stimulate increased production and provide more income for producers, processors, and traders (R&D —Value addition, Capacity development).
- Networking, partnership and cooperation to strengthen national organizations (Public and private extension); and
- Policy, regulatory and procedural change to innovative financing, market linkages and access, and youth and gender inclusiveness (Government)
- Development and delivery/promotion of technologies that will drive down costs of production, harvesting, processing and marketing to make cassava products competitive with other raw materials (R&D and pre and postharvest mechanization).
- Promotion of effective integrated pest/pathogen management (IPM) programs to counter emerging and endemic pests and diseases for yield stabilization and increasing productivity (especially cassava brown streak disease (CBSD), cassava mosaic, cassava bacterial blight, spiralling whitefly, papaya mealybug invasion on cassava and reducing mycotoxin contamination in cassava chips and flour.
- Developing the capacity for advanced R&D platforms within different regions in Africa to spur innovation and employment in advance research technologies including biotechnology, engineering and food technologies.

2.4.1 What should be done in the short-term, medium term: To address the challenges currently constraining the full realization of cassava subsector for the agricultural transformation of African economies, there are number of recommendations that stakeholders across the cassava value chain should act upon:

1. Develop a market-oriented strategy with emphasis on value-addition and productivity enhancement along the whole value-chain.
2. Launch a roadmap for the cassava sub-sector reform setting out clear implementation plans focusing on the integration of food production, storage, food processing and industrial manufacturing by value chains ('farm to fork') where countries have comparative advantages to resolve the challenges of the subsector, and setting the path for its improvement in the short (1-5 years) and medium (5-10 years) terms. This should be a deliberate, strategic, sustained set of actions for a private-sector-led agricultural transformation as there are no "quick fixes" for sustained economic growth and poverty alleviation (Short term).
3. Deploy integrated pest/pathogen management (IPM) programs backed with clean seed production, and effective surveillance to prevent geographic expansion of cassava brown streak disease (CBSD) and also to control endemic diseases like cassava mosaic and cassava bacterial blight, and control emerging insect pests on cassava, such as spiralling whitefly and papaya mealybug (short to medium term).

4. Change **mindset** of small and medium farmers to treat agriculture as a business and create **incentives and efficient input delivery systems** including private-sector enabled Agricultural Equipment and Mechanization: Leasing Services to make cassava production financially attractive to end-users (Short term).
5. Increase **awareness** of potential to produce and use cassava substitutes through targeted and frequent advocacy efforts for cassava value chains (short term).
6. Develop **infrastructure** to reduce the costs of aggregation and transport that currently make many locally-made products non-competitive (Medium term).
7. Continue funding R & D on: (i) using advance breeding technologies to rapidly produce varieties more suited for production and processing, and pilot efforts to **demonstrate feasibility of substituting** cassava products for imported goods; (ii) **climate-smart agriculture** that promote sustainable agricultural management systems, and (iii) Research and development that enhance efficiency of production along the value chain as well as strengthening of the national agricultural systems. (Short to medium term).
8. Build **strong farmer groups and linkages** with appropriate financing that level the playing field so that they are able to effectively access inputs and markets and receive fairer product and input prices, and promote backward integration into commercial farming to buttress supply (short term).
9. Provide access to expertise and know-how through **Technical Assistance** to increase productivity and competitiveness of the commercial cassava farming sector (Short to medium term).
10. Create **output markets** links for farmers, primary and secondary processors, aggregators, farmer cooperatives, small and large traders by improving regional and global market links for increased value chain efficiency and to access to regional and global agricultural trade (short to medium term).
11. Facilitate **public-private partnerships** (PPPs) to encourage cross-sector collaboration and knowledge sharing especially in research and development, and initiatives along the agricultural value chain to develop infrastructure and/or build stronger farmer linkages, e.g Agricultural Enterprise Processing Zones (medium term).
12. Develop new **policies, institutions and financing** structures to drive sector growth (Short to medium term): Deregulation of seed and fertilizer sectors; marketing reforms to structure markets; innovative financing for agriculture for farmers inputs and credit guarantees and low interest rate, long-term debt products for construction of new processing facilities; new agricultural investment framework.
13. Improve the legal framework in **land acquisition** and transfer to ensure ownership and right of use, and facilitate development of a system for making available unutilized government and communal lands for agricultural use in order to facilitate contiguous farming for farmers' groups/organizations and industries (Short to medium term).

14. Develop **sustainable market information**, e.g. private-led; develop warehousing system (Bonded system for easy access to finance); develop bulking system for primary product, e.g. fresh tubers; and upgrading of informal markets, especially for primary commodities (short term).
15. **Capacity building** for all actors of the value chain including farmer education and commercialization through public and private extension (short to medium term).
17. Create specific **women and youth in cassava agribusiness programs** (short term)

2.4.2 Vision for sustainability: African cassava industrialization will create wealth, jobs and promote sector-wide efficiency and productivity growth. It will enhance and meet the demand of emerging industrial needs, traditional products and global demand by reducing production costs and increasing the output of high quality industrial products to strengthen the continent's position in the global context for competition.

Five major cassava value chains are proposed for industrialization based on the demand and supply side targets for various African countries and elsewhere as estimated from the FAOSTATS database: High Quality Cassava Flour (HQCF), starch, chips, high fructose cassava syrup (HFCS) and ethanol. These value chains offer tremendous potential to fuel the economic growth in the continent as this will create jobs for women and youth, improve food security and generate wealth. Production should be expanded to: (i) meet domestic, industrial demand and export markets through promotion of industrial applications of key value chains (HQCF, livestock feed, starch, ethanol, etc.); (ii) encourage the involvement of large scale farming as a driving force for industrialization; and encourage private sector investment and engagement. Each country can develop its industry according to its available resources and market opportunities within a globally competitive framework.

2.5 Estimated Costs

The proposal is for individual African governments of the top 20 producing countries to commit at least US\$625 million over 5 years and US\$625 million for outscaling in the subsequent 5 years to fully implement the specified value chains. This can be done through PPP arrangements.

Value Chain	Indicative funding (million US\$)	
	2016-2020	2020-2024
High Quality Cassava Flour (HQCF)		
- Personnel (10%)	10	10
- Operations (Services & Recurrent costs) (40 %)	40	40
- Infrastructure (50%)	50	50
<i>Sub total</i>	100	100
Starch		
- Personnel (10%)	12.5	12.5
- Operations (Services & Recurrent costs) (40 %)	50	50
- Infrastructure (50%)	62.5	62.5
<i>Sub total</i>	125	125
Chips		
- Personnel (10%)	10	10
- Operations (Services & Recurrent costs) (40 %)	40	40
- Infrastructure (50%)	50	50
<i>Sub total</i>	100	100
High Fructose Cassava Sweeteners (HFCS)		

- Personnel (10%)	15	15
- Operations (Services & Recurrent costs) (40 %)	60	60
- Infrastructure (50%)	75	75
<i>Sub total</i>	150	150
Ethanol		
- Personnel (10%)	15	15
- Operations (Services & Recurrent costs) (40 %)	60	60
- Infrastructure (50%)	75	75
<i>Sub total</i>	150	150
Total	625	625

3. YAM

Yam (*Dioscorea* spp.) plays a very important part in ensuring food security and livelihood systems of at least 60 million people in West Africa. It is cultivated mostly in the Derived and Southern Guinea Savanna. About 57 million tons of yams (about 93% of global production) are produced on 4.7 million hectares annually in this sub-region, mainly in five countries i.e. Benin, Côte d'Ivoire, Ghana, Nigeria and Togo. Nigeria alone accounts for ~68% of global production (40.5 million tons on 3.2 million ha). Yams rank as the most important source of calories in Côte d'Ivoire and among the top three contributors in Benin and Ghana. The crop also makes a substantial contribution to protein in the diet, ranking as the third most important source of protein supply, much greater than the more widely grown cassava, and even above animal protein sources. Farmers engage in yam cultivation for household food supply; income generation through marketing ware yams; and production of planting material to meet their own needs and generate some income from the sale of surplus seed yams. It is also important to emphasize that yams are used in traditional rituals such as marriage ceremonies and annual festivals, making the crop a measure of wealth. Yams therefore have significance over and above other crops in the region. While productivity and even total production are stagnating or even declining in some areas, the amount of crop and forest land allocated to the crop is still growing rapidly. At the regional level, yam is a superior economic good in all countries. As incomes increase, consumers shift from cassava to yam. This is related in part to cultural preferences.

Yam production is marred by many constraints, the key among them being the scarcity of high quality seed yam of local popular and improved varieties, high levels of post-harvest losses (almost 40%), high production costs (high cost of seed, labour at land clearing and harvest, and staking all contributing almost 70% of the total production costs). Low and declining soil fertility, moisture stress as well as pests and diseases, mainly viruses, fungi and nematodes, were also earmarked as limiting factors to increased yam production. These obstacles not only undermine food production and farmers' ability to generate sustainable incomes, but also disproportionately impact on rural women.

3.1 Challenges

A broad range of stakeholders and value chain actors in the key yam producing countries, Nigeria, Benin, Togo, Ghana, and Cote d'Ivoire, listed and prioritized major constraints affecting yam sector in West Africa during the stakeholders consultation meeting supported by Bill and Melinda Gates Foundation (BMGF) in 2010. These constraints include:

(i) Scarcity and high cost of quality seed yams: Seed yams are accounting as much as 63% of total variable production costs, and are bulky to transport. The multiplication ratio of tubers is very low (less than 1:10) compared, for instance, to some cereals (1:300). Poor quality planting

materials carry problems (viruses, fungi and nematodes) from the storage barns to the field resulting in low tuber yields, followed by poor shelf life. The seed yam system in West Africa is mainly informal and entirely market driven. IITA and various organizations have put in more research efforts into developing and adapting emerging technologies such as micropropagation and vine propagation to produce minitubers of 50 to 150 g for generating seed yams of about 500 g. The project ‘Yam Improvement for Income and Food Security in West Africa (YIIFSWA)’ was initiated in 2011 and its major research successes include improvements in tissue culture, development of Temporary Immersion Bioreactor System (TIBs), development of aeroponics system (AS), sensitive virus indexing tools to generate quality clean seed yam, and the development of seed quality management protocols which should have a significant impact on the seed yam value chain.

ii) On-farm harvest and post-harvest losses: Tuber rot due to poor farm practices during harvesting, transportation from the farms and storage causes high rates of tuber losses. This is mainly from pests and diseases as a result of bruises and wounding. Short shelf-life and sprouting in storage barns also reduces tuber quality. Research work is ongoing in YIIFSWA in collaboration with the Natural Resources Institute (NRI) and NARS partners in Ghana and Nigeria to identify best technologies on curing and extension of shelf-life. These technologies are being refined and can be disseminated widely.

iii) Low soil fertility: The deteriorating soil structure and fertility associated with shortening fallow periods has been blamed for the declining yam production. The management of soil fertility to achieve sustainable high productivity in intensifying yam systems in West Africa is a serious challenge. Field studies are in progress at IITA on use-efficiency of major nutrients and development of participatory ISFM interventions. Complementary studies are needed to address the field crop management factors (e.g. soil testing, timing of nutrient application; plant population density; placement of nutrients; nutrient balance and application rate) that influence the benefits from fertilizer application to yam in West Africa. Preliminary results of ISFM interventions using landraces indicate that yield can be increased above 30% when arbuscular mycorrhiza is applied in combination with organic manure and synthetic fertilizers.

iv) Lack of robust varieties adapted to stress environments of the savannah agro-ecologies and also adequately respond to the requirement of various actors in the value-chain: With shrinking land availability and changes in weather, yam is being cultivated in the savannah agro-ecologies under drier conditions and increasingly lower soil fertility. IITA and NARS partners aim to develop stress tolerant varieties, with a focus on low fertility of soil, drought tolerance and virus resistance. Currently this is supported in part in Nigeria, Benin, Ghana, and Cote d’Ivoire by the AfricaYam project funded by the BMGF, and the Government of Japan (MAFF project). However, breeding efforts matching cultivars to production environments and customer-desire is still not having the aspired scale. Development and delivery of robust yam varieties with good yield potential, market appeal and greater resistance to the primary yield-limiting diseases, pests and abiotic factors has become a pressing need.

v) Increasing pressure of diseases and pests: Yam mosaic virus disease, anthracnose disease caused by *Colletotrichum gloeosporioides* and nematodes, *Scutellonema bradys* and *Meloidogyne* spp., are the major biotic threats to yam production in West Africa. Most farmers’ yam varieties are susceptible to these threats. Detailed studies are in progress on the causal agents in order to map out the most efficient strategies for managing them. Robust diagnostic tools have been developed in the YIIFSWA project that is important in producing the quality of seed yams.

iv) Unexploited potential of yam (ware and seed) markets by smallholder farmers: Yam has good value in form of fresh tuber but there are challenges in marketing associated with storage

facilities to maintain quality, transportation costs and impact on quality, taxation, access to markets for smallholder farmers and higher pricing. The YIIFSWA project has been investigating challenges to market access towards proposing measures to reduce the risk that the introduction of technological innovations to stimulate productivity will create over supply to the market leading to a reduction in farm-gate prices.

vi) Limited opportunities for smallholder farmers mainly rural women, in yam production and marketing: Women play an important role in the yam value chain, although their specific activities and involvement vary across the region. Analyses of gender and diversity survey data of YIIFSWA are contributing to a fuller understanding of the constraints and opportunities to improve the benefits to youth and women from yam cultivation and marketing. Partnership between IITA, ITC (UN), Ministry of trade and Industry, Ministry of women and children, Fair Trade, Cocoa Merchant, Ministry of Agriculture, CSIR, women organizations and other support institutions in Ghana is addressing several of these constraints through a multi-crops and multichannel value chain platform with emphasis on yam.

vii) Limitation in current breeding capacity to develop resilient and nutritious yam varieties. Currently breeding efforts by conventional phenotyping and clonal selection is inefficient. Screening techniques of breeding populations for biotic and abiotic stress traits is slow and resource intensive. Moreover a lack of better understanding of the underlying genetics and physiology mechanisms impend further deployment of tolerance genes in agronomically preferred backgrounds. Yam crop uses different tolerance mechanisms including avoidance, escape, and resistance to withstand biotic and abiotic stresses. Depending on the target stress scenario, varying mechanisms could be focused on and combined by breeders for enhanced and stable yield. However, several traits that are key to biotic and abiotic stress tolerance are multi-genic and show a strong G x E interaction thus making it difficult to improve through phenotypic selection using current breeding practices.

3.2 Opportunities

Technologies from regional and country projects available for validation and dissemination: A few on-going projects are generating important technologies at pilot sites that can be disseminated widely. The YIIFSWA project operating in Nigeria and Ghana has generated novel technologies for rapid propagation of clean seed yam using bioreactors, protocol for cleaning infected plants through tissue culture, efficient molecular diagnostics for virus detection, improved nematode control methods, an aeroponics system for seed yam production, and a quality management protocol for seed yam production. These and improvements in vine propagation are valuable and ready for dissemination and strengthening of the capacity of relevant agencies in the public and private sectors in their wider application in the two countries as well as the other yam producing countries.

The AfricaYam project is building capacity for yam breeding to accelerate genetic gain and lead to a strong pipeline of products to meet the needs of farmers and the markets. The project on 'Increasing Productivity and Utilization of Food Yams in Africa' has identified varieties with good performance and farmers acceptability for production in soils of low fertility and also ISFM interventions based on mycorrhizae, organic manure and synthetic fertilizer increasing land races yield above 30%. This project also is developing a protocol integrating genomic tools to select yam varieties with good potential for soils of low fertility. Investments in yam R&D by countries such as Ghana and Nigeria, especially through the West Africa Productivity Program (WAAPP) demonstrate the commitment of the governments to improvement of the yam sector. In particular Ghana has a country strategy for the crop (policy

document) that provides a framework that brings private and public sector agencies together towards development of the sector with a prospective vision based on food security and human development. Community Action in Improving the Quality of Farmer-saved seed (CAY-Seed) project is working with smallholder farmers in Ghana and Nigeria to enhance the productivity of their yam crop.

Active informal network of trained staff in NARS and links with yam scientists elsewhere:

Research and development workers in yam have collaborated very well within an informal network for more than a decade often through joint projects. The readiness to share responsibilities, resources, and experience gives them a strength that has contributed to the major regional projects currently in operation that also link them with the few yam research groups outside West Africa.

Yam is an indigenous and preferred staple with high potential for assuring food security and income generation:

As a highly preferred staple there are several traditional ways of converting fresh yam tubers into primary food products based on boiling, pounding into a dough (pounded yam), mashing (mashed yam), roasting, baking and frying. Pieces of peeled tubers are also parboiled, dried (chips or elubo) and later ground into flour which is reconstituted into thick paste (amala) for consumption. Processing into a broader range of products for different domestic, regional, and international markets is still at an early stage and offers good potential for contribution to income generation for yam farmers and processors into the future. Partnership between IITA and food industry private sector has recently identified varieties for fries and flour.

Presence of diverse germplasm: Several species of yam, including the most commercialized *Dioscorea rotundata*, originated from West Africa and have genetic potential that is yet to be exploited through breeding. IITA gene bank holds >3200 diverse germplasm of several species of yam that could serve as novel genetic variation for traits deploying in a breeding program. These diversities will provide huge opportunity to develop new breeding pools for key pathogen resistances, traits relative to climate change, end-user and market preferences.

3.3 Suggested Actions/Ways forward

For the yam sector to continue to make its key contributions to livelihoods in West Africa there is need to enhance continual access of farmers to affordable quality seeds of high yielding, climate-resilient, and market preferred varieties through profitable seed systems, fair market access, affordable financial support and reliable and sustainable technical support. More effective integrated soil, pest, pathogen and crop management options are necessary to raise and sustain crop yields and limit postharvest losses. Three strategic interventions are proposed below that address these and as well as the need to diversify the range of products from yam.

Strategic Intervention 1: more effective yam variety development and adoption for accelerated impact

Yam variety development system in West Africa will be strengthened to improve its effectiveness in development and delivery of end-user preferred varieties. Breeding for “customer preferences” has the potential to increase wide-spread adoption by small-scale farmers. **Activities will include:** (i) capturing and mapping customer preference defining yam variety choice in the value chain; (ii) test customer-expressed preference for portfolio of currently used and new genotypes; (iii) identify new selection traits and develop new tools to accelerate variety development; (iv) identifying the factors leading to low adoption of new yam

varieties; (v) Strengthening of the yam variety development network by clearly defining roles and responsibilities and (vi) Develop the capacity within West Africa to promote and market new yam varieties.

Expected benefits: (a) customer-desired attributes defining yam variety choice for marketability, production efficiency and consumption identified, characterized and mapped for targeting in the breeding program; (b) new traits and selection tools developed to accelerate breeding gains; (c) next generation of customer-desired yam breeding lines with high likelihood of uptake developed and available for testing by multi-stakeholders; (d) more productive and resilient yam varieties to meet end-user preferences; (e) Increased income potential for all sectors of the yam industry

Strategic Intervention 2: Improving the Seed Sector for yam

The paucity of seed across West Africa compels the use of inferior quality seed and artificially maintains high prices, even of poor stock. Quality seed yams offer the opportunities to control diseases and pests, increase yield, and reduce storage losses. Multiple additional benefits are also realized, due to improved storability and reduced losses during storage, while yam held back for seed in the following year are much less likely to be infested. It is important to support the sustainable supply of high quality pre-basic and basic seed yam, a seed yam certification system, and the sustainable supply of high quality seed yams through commercial seed entrepreneurs. In part this will be achieved through outscaling of seed technologies developed in Nigeria and Ghana through the YIIFSWA project.

Activities will include: (i) facilitate partnerships, linkages and coordination of key stakeholders in the seed yam value chain; (ii) improve the informal seed yam sector through training in technologies that ensure high quality and multiplication rates for traditional and improved cultivars (iii) disseminate technologies for enhanced seed yam production and build capacity of seed growers; (iv) promote robust and cost-effective propagation technologies for production of clean seed yams of recommended varieties; (v) identify and train entrepreneurs for commercial production of certified seed yams; (vi) support implementation of standards and protocols for inspection and certification of ‘clean’ and quality seed yam.

Expected benefits: (a) productivity enhancement by 20 - 50%; (b) sustainable access to high quality seed yams of end-user preferred varieties; and (c) commercial seed yam production by seed yam growers and entrepreneurs (d) creation of employment/business opportunities for youth entrepreneurs to generate clean seed yam (e) strengthened national seed yam sector to support regulatory monitoring for pest and diseases, quality certification of seed and ware yam; (f) increase in area under quality seed production.

Strategic Intervention 3: Disseminate technological innovations for raising productivity, reducing pre- and post-harvest losses and minimizing production costs

It is important to validate and disseminate biophysically and economically feasible technologies for ware yam production to increase productivity and profitability. Testing and disseminating new varieties that are efficient in nutrient use and responsive to the application of fertilizers should also be a priority. Longer storage of fresh yam is important to yam producers and traders, giving them additional flexibility to respond to market opportunities, avoid waste and meet consistent food security demands.

Activities will include: (i) integrated pest/pathogen management (IPM) approach to control biotic threats from farm to markets to raise yields and quality; (ii) strengthen institutional

capacities (especially NARES and NPPOs) for improved monitoring and deployment of control measures. (iii) conduct participatory evaluation and promotion of ISFM; (iv) develop and disseminate improved techniques to control virus diseases and nematode pests developed in YIIFSWA; (v) test and disseminate new end-user preferred varieties that combine high yield, resistance to diseases, good tuber quality, as well as nutrient use efficiency; (vi) increase farmers, traders, and transporters' knowledge and skills in postharvest handling (e.g. curing to heal wounds created by harvesting instruments and handling before storage) to limit harvest and post-harvest losses to < 15% and extend shelf-life of yam tubers; (vii) promote mechanization of yam farming (planting and harvesting).

Expected benefits: Improved livelihoods of value chain through (a) at least 40% increase in on-farm tuber yield; (b) reduced pest and disease incidence, 50% reduction in losses of fresh yam tubers in the supply chain; (c) increased income for farmers; (d) ready availability of yam tubers to processing sector; (e) increased market access of high quality ware tubers; (f) strategy (policy document) by country to support the implementation and the activities to achieve these benefits with specific demands for IITA and other support institutions.

Strategic Intervention 4: Expanding the production and marketing of diverse traditional and novel yam-based products

The limited number of processed forms of yam, poor market linkages and inconsistent policies affecting prices of other cheap energy sources lead to inconsistency in demand or prices of yam tubers for producers. A broader and more diverse range of products will help make the demand for yam more constant and thus reduce risks for yam producers, processors, and traders. Increased conversion of fresh ware yams to products with longer shelf life through processing combined with improvements in marketing channels will bring the benefits from the crop to a broader range of consumers and value chain actors. It will reduce the annual postharvest losses; extend the period of availability; increase competitiveness in terms of affordability to increase yam consumption when compared to rice, maize and wheat; and give actors in the yam value chains additional flexibility to respond to market opportunities (seasonally fluctuating market prices). The conversion of fresh ware yams to other products which are more convenient for the rapidly expanding urban populations to handle and prepare into food will cater better to their needs and broaden the range of regular yam consumers.

Activities will include: (i) study and document the status and potential of manufacturing and marketing of novel yam products; (ii) conduct workshops to promote opportunities for novel yam products among the value chain actors (producers, processors, traders, transporters, exporters, consumers, policy makers, input suppliers, and R&D agencies); (iii) organize consultation meetings with value chain actors; (iv) undertake industrial trials with processors/factories to identify suitable yam varieties; (v) develop, and assess consumer acceptability and market potential of novel yam-based products; (vi) promote consumption of novel and improved traditional yam-based products through social marketing; (vii) train processors in the preparation of new yam-based products and in improving processing efficiency, nutritional quality, food safety (including avoidance of mycotoxin accumulation), and storage of traditional products; (viii) adapt, fabricate, and introduce appropriate yam processing equipment for small- and medium-scale processors and train them in their use.

Expected benefits: (a) Increased availability in domestic and export markets, and consumption of diverse new and traditional food products from yam; (b) Yam products meet all established standards of quality, packaging and safety in the relevant markets (e.g. mycotoxin content below the threshold levels); (b) entrepreneurs make better evidence-based decisions on

production and marketing of non-traditional yam products; (c) increased income for farmers and other value chain actors; (d) extended availability of yam products through the year as supermarkets sell new yam-based products on a regular basis.

3.4. Estimated Costs

Strategic interventions	Indicative funding for 5 countries (Nigeria, Benin, Togo, Ghana, Cote d'Ivoire) (in million US\$)	
	2016-2020	2020-2024
1: customer-oriented robust yam variety development for accelerated impact		
Personnel	4.0	4.0
Operations (Services & Recurrent costs)	20.0	20.0
Infrastructure	10.0	9.0
<i>Sub total</i>	34.00	33.00
2: Improving the Seed Sector for yam		
- Personnel	5.0	4.5
- Operations (Services & Recurrent costs)	35.0	31.5
- Infrastructure	10.0	9.0
<i>Sub total</i>	50.0	45.0
3: Disseminate technological innovations for raising productivity, reducing pre- and post-harvest losses and minimizing production costs		
- Personnel	6.0	5.5
- Operations (Services & Recurrent costs)	42.0	38.5
- Infrastructure	12.0	11.0
<i>Sub total</i>	60.0	55.0
4. Expanding the production and marketing of diverse traditional and novel yam-based products		
- Personnel	3.0	2.5
- Operations (Services & Recurrent costs)	26.0	22.5
- Infrastructure	6.0	5.0
<i>Sub total</i>	30.0	25.0
Total	174.0	158.0

4. POTATO

Farmers in sub-Saharan Africa (SSA) face significant challenges in meeting their year-long food requirements and generating income from agriculture. Smallholder farmers in particular are discovering that the potato can help them overcome these challenges because it is a high-yielding cash crop with a short growing season. Highland potato farmers enjoy a comparative advantage in exploiting an ever-growing, high market demand for the crop, as potato production requires the cool temperatures typical of mid- to high altitudes—roughly 1,000–3,000 meters above sea level (masl)—to form tubers. Furthermore, potato production is important in North Africa, where the crop offers a huge export market to Europe and under irrigation in Harmattan season in the Sahel Zones in West Africa.

There are many compelling reasons for encouraging more wide-scale adoption of potato into the livelihoods of Africa smallholder farmers. Potato is multifaceted as a staple crop that addresses food security and a horticultural crop for its high value per unit area of land. The crop's short cropping cycle of three to four months is well-suited to the double cropping seasons in the African highlands, particularly in rain-fed systems. Harvestable tubers are available 60-100 days after the onset of the rainy season—a significant advantage over grains, which require six to nine months. This makes potato one of the first crops that can be harvested in any growing season, thus an important crop for the “hunger months”—that is, a period of several months between harvests when people lack enough food to satisfy their hunger and meet their basic caloric and nutritional needs. Potato further distinguishes itself for its water-use efficiency, yielding more food per unit of water than any other major crop. With a yield potential of more than 51,000 calories/ha per day in a short growing season, its productivity in terms of energy produced is the highest of all major arable crops, almost double that of wheat and rice. Potato is a cheap but nutritionally rich staple food for the fast growing cities of SSA, contributing protein, vitamin C, zinc, and iron to the diet. Along with groundnut, onion, and carrots, the “nutritional productivity” of potato is especially high: for every cubic meter of water applied, 5,600 calories of dietary energy are produced, compared to 3,860 in maize, 2,300 in wheat, and only 2,000 in rice. For the same cubic meter, potato yields 150 g of protein; double that of wheat and maize, and 540 mg of calcium, double that of wheat and four times that of rice.

These qualities make potato an important food security and cash crop for smallholder farmers with limited options. However, yields in SSA range from 6 to 10 MT/ha, far below attainable yields of 25–35 MT/ha and the 2010 global average of 17.4 MT/ha. Demand for potato is increasing in SSA, but the trend is to increase the area under production rather than tackle productivity constraints (yields). This is unsustainable, given the threat to forested areas in mid- and high-altitude regions. Although the solution is to increase productivity, major bottlenecks are limited access to quality seed of suitable varieties, poor agronomic and disease management which reduces yields, food availability, and farmers' incomes. The health status of the seed defines the potential yield of the potato crop. Typically, farmers often use unmarketable ware potato for planting that is generally of low quality and sourced from their own fields or markets. As a result, diseases accumulate and spread in farmer-saved seed stocks. Farmers' lack of knowledge to select quality seed is compounded by limited access to varieties with robust traits (such as drought, heat, and disease tolerance and/or biofortified with essential micronutrients, specifically iron and zinc), lack of knowledge of good agricultural practices, and minimal capacity to store. Although seed certification standards exist, most national policies do not recognize more practical quality standards, such as Quality Declared Planting Material (QDPM). This further limits access to quality seed. Policy advocacy for more practical quality standards is required at national levels. Strategic partnerships for going to scale, accompanied with strategic research to assess cost-effectiveness, pro-poor focus, and gender inclusiveness constitute necessary next steps.

4.1 Challenges

The hilly, fertile terrain of East, Central, West, and Southern Africa—from Ethiopia to the north down to Mozambique on the coastal south, from the volcanic highland regions of the Democratic Republic of the Congo, Burundi, and Rwanda, to the highland plateaus of West Africa in Cameroon and Nigeria, is home to more than seven million smallholder potato farmer HH's. High altitudes, a temperate climate, and generally dependable rains make for near ideal growing conditions for potato—one of the few cash crops available to small-scale farmers

throughout these regions. Cropping cycles, however, differ between the region: two or more distinct cycles in East, Central and West Africa, only one growing cycle in Southern Africa. Potato farmers here commonly practice mixed farming that involves crops (maize, legumes, vegetables, and sometimes tea, wheat, or barley) and livestock on average landholding sizes of usually less than 2 ha. As population size increases, landholdings shrink and pressure mounts to increase productivity and boost farm incomes. Highland farmers have few choices for cash crops other than potato; consequently, they repeatedly plant it at the same site. This causes proliferation of diseases a decrease in yields. An issue of concern is that farmers are meeting the growing demand for potato by expanding the areas under production, not by improving productivity (yields per hectare). As agriculture continues to encroach onto non-farmland, forested mid- and high-altitude regions are lost, with consequential threats to the carbon sinks that these forests represent and, in many cases, to wildlife habitats and biodiversity. Critical to improving potato production and productivity is greater supply and access to high-quality seed potato, alongside improvements in plant nutrition, disease management, and post-harvest management.

As farm sizes shrink, there is strong pressure to increase farm incomes as a way to offset the loss in acreage.^{1 2 3} Meanwhile potatoes are considered the main cash crop in these regions.^{4 5} Farmers tend to grow potatoes in very close rotations or even, in some cases, in monocropping. They basically have few alternatives of other high-value cash crops, inadequate knowledge of good agricultural practices, and low yields.^{6 7} As a consequence they experience detrimental effects on soil fertility, farm viability, and reduced yields. Moreover, by depending on the performance of a handful of crops they face higher risks of complete crop failures. These are caused by specific abiotic and biotic stress conditions, chiefly the build-up of crop-specific soil-borne pest and diseases.^{8 9 10 11} CIP recently found in a survey conducted in Kenya, Rwanda, and Uganda that about 15–25% of potato farmers do not practice crop rotation at all; whereas another 20–40% has only one crop in between potatoes.¹² Muthoni and Kabira (2010) showed in trials at KARI Tigoni Station that widened crop rotations and organic fertilization improved soil characteristics and yield after a relatively short time.¹³ Crop diversification in

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- 1 Shepherd, K.D., Soule, M.J., 1998. Soil fertility management in west Kenya: dynamic simulation of productivity, profitability and sustainability at different resource endowment levels. *Agriculture Ecosystems and Environment* 71 (1–3), 131–145.
 - 2 Thornton, P.K., Kristjanson, P.M., Thorne, P.J., 2003. Measuring the potential impacts of improved food–feed crops: methods for ex ante assessment. *Field Crops Research* 84 (1–2), 199–212.
 - 3 Waithaka, M.M., Thornton, P.K., Herrero, M., Shepherd, K.D., Stoorvogel, J.J., Salasya, B., Ndiwa, N., Bekele, N., Croucher, M., Karanja, S., Booltink, H., 2005. System Prototyping and Impact Assessment for Sustainable Alternatives in Mixed Farming Systems in High-Potential Areas of Eastern Africa. Final Program Report to the Ecoregional Fund to Support Methodological Initiatives.
 - 4 Kaguongo, W. 2009. Baseline study on farmers willingness to pay for high quality seed. Funded by GTZ, Kenya, project report
 - 5 Obado J. 2010: 3G Baseline Report for Kenya, Rwanda and Uganda in the USAID funded project: Tackling the food price crisis in Eastern and Central Africa with the humble potato: Enhanced productivity and uptake through the “3G” revolution. March 2010, unpublished
 - 6 Gildemacher PR, Maina P, Nyongesa M, Kinyae P, Gebremedhin W, Lema Y, Damene B, Shiferaw T, Kakuhenzire R, Kashaia I, Musoke C, Mudiope J, Kahiu I, Ortiz O (2009) Participatory analysis of the potato knowledge and information system in Ethiopia, Kenya and Uganda. In: Sanginga PC, Waters-Bayer A, Kaaria S, Njuki J, Wettasinha C (eds) *Innovation Africa: enriching farmers’ livelihoods*. Earthscan, London, pp 153–167
 - 7 Schulte-Geldermann, E., Gildemacher, P.R., Struik, P.C., 2012: Improving seed health and seed performance by positive selection in three Kenyan potato varieties. *Am. J. Pot Res* (2012) 89:429–437
 - 8 Turkensteen LJ (1987) Survey of diseases and pests in Africa: fungal and bacterial diseases. *Acta Hort* 213:151–159
 - 9 Low JW (1997) Potato in southwest Uganda: threats to sustainable production. *Afr Crop Sci J* 5:395–412
 - 10 Lemaga B, Kakuhenzire R, Kassa B, Ewell P, Priou S (2005) Integrated control of potato bacterial wilt in eastern Africa: the experience of African highlands initiative. In: Allen C, Prior P, Hayward A (eds.). *Bacterial wilt disease and the *Ralstonia solanacearum* species complex*. American Phytopathological Society, St Paul, pp 145–157
 - 11 Gildemacher PR, Maina P, Nyongesa M, Kinyae P, Gebremedhin W, Lema Y, Damene B, Shiferaw T, Kakuhenzire R, Kashaia I, Musoke C, Mudiope J, Kahiu I, Ortiz O (2009) Participatory analysis of the potato knowledge and information system in Ethiopia, Kenya and Uganda. In: Sanginga PC, Waters-Bayer A, Kaaria S, Njuki J, Wettasinha C (eds) *Innovation Africa: enriching farmers’ livelihoods*. Earthscan, London, pp 153–167
 - 12 CIP 2009–2011: Project baseline and impact studies conducted in Ethiopia, Kenya, Rwanda and Uganda, unpublished
 - 13 Muthoni J and Kabira JN (2010). Effects of crop rotation on soil macronutrient content and pH in potato producing areas in Kenya: A case study of KARI Tigoni station. *J. Soil Sci. Environ. Manage*, 1:227–233.

terms of time and space is one of the major agronomic measures of integrated management to reduce the risk of disease and increase nutrient-use efficiency in low-input systems. This also minimizes the dependence from external inputs such as synthetic nitrogen fertilizers by the integration of legume crops.¹⁴

4.2 Opportunities

Potato is among the fastest expanding crops in Africa, measured by area under cultivation. Reasons for this development include the resilience of the crop that continues to yield reliably high harvests under variable climatic conditions, provides better food and income opportunities with decreasing landholding sizes than most other staples in highland regions and the fast increasing demand from urban centers. The private sector's continued investment in seed potato production is increasing due to high demand for seed and opportunities along the seed value chain. But this involvement is still minimal and seed systems, if they are to be sustainable, need the private sector to become more involved. There is a huge opportunity to exploit this largely untapped potential, creating entrepreneurial opportunities for all levels along the seed value chain, with a special focus on women and youth farmers.

In order to realize the full potential of potato as a source of reliable food and nutrition security, and income for women and men in Africa, it is essential to increase productivity and strengthen diversified market opportunities. Six investment areas have been identified that together can deliver on this potential. These investment areas are further described in Section "Suggested Actions/Ways Forward" and can be summarized as follows:

1. Breeding of robust, market-demanded candidate varieties.
2. Seed technologies and seed production business models for a vibrant local seed sector.
3. Integrated crop management technologies.
4. Locally adapted protocols for seed quality control.
5. Options for market development for seed and ware potato.
6. Scaling strategies and evidence base.

4.3 Suggested actions/Ways forward

As major intervention for increased productivity client-oriented (i.e., small-scale potato farmers in SSA) approaches to rapidly access quality seed are recommended. This investment should integrate specialized, early-generation seed production with decentralized multiplication and on-farm seed quality maintenance. This will accelerate much-needed access to and adoption of varieties possessing in-demand traits through an efficient seed system. Accompanied with efficient research and knowledge transfer systems in areas of good agricultural practices, post-harvest management and combined with innovative business arrangements at key points along the potato value chain this interventions have the potential to increase potato yields by 50% and HH incomes by at least US \$800/ha per season for 3 million potato farmers by 2025 and provides business opportunities along the value chain for another 1 million women and men.

1. ***Robust, market-demanded candidate varieties.*** Increase potato-breeding efficiency and delivery, for population improvement and variety development against major biotic and abiotic stresses with user-preferred table, processing, and nutritional qualities, taking into

¹⁴ Østergård H., M. R. Finckh, L. Fontaine, I. Goldringer, S. P. Hoad, K. Kristensen, E. T. Lammerts van Bueren, F. Mascher, L. Munki and M.S Wolfe, 2009. Time for a shift in crop production: embracing complexity through diversity at all levels. J Sci Food Agric 89: 1439–1445

consideration special needs of vulnerable groups in SSA. Research themes include producing and disseminating large numbers of advanced clones (e.g., through seed directories), engaging farmers and breeding companies in the selection process, conducting genotype-by-environment evaluations to help identify markers for trait selection, and addressing intellectual property (IP) issues.

2. **Seed technologies and business models.** Targets specialized and local seed multipliers. Adaptive research on and implementation of Rapid Multiplication Technologies for in-vitro, minituber, and field generation seed categories, and equitable business models to stimulate the seed sector through PPPs, including socioeconomic and cost-benefit analyses.
3. **ICM technologies.** Targets adaptive research on technologies for on-farm seed quality management (positive/negative selection, small seed-plot technique, improved storage, etc.), ICM (control of major pests and diseases, postharvest management, etc.), and postharvest storage for seed and ware potato producers. Improving and maintaining soil fertility will receive special emphasis. Research on modeling seed degeneration, pest and disease epidemiology, and yield gaps will provide scientific basis to improve current ICM technologies.
4. **Locally adapted protocols for seed quality control.** Research and evidence-based advocacy actions for adapting and implementing (1) protocols for seed quality control, such as QDPM, to be used at national or regional levels to complement regulations of formal seed standards; (2) affordable disease diagnostic techniques; and (3) risk studies monitoring the introduction of new pests and diseases.
5. **Options for market development for seed and ware potato.** The focus here is on (1) studies of current and shifting user preferences and demands along potato value chains to address changing food habits, and (2) activities to increase the use of seed and ware potato through identifying, adapting, implementing, and documenting effective methodologies to raise awareness of the value of potato, quality seed, and improved varieties. Participatory organoleptic panels are key to supporting adoption of improved varieties and better target specific markets. These activities will draw upon successful interventions from other crops (e.g., sweet potato) and regions (e.g., Latin America¹⁵), and seek partnerships with food technology experts.
6. **Scaling strategies and evidence base.** Testing and implementing methodologies to generate innovations on large-scale production and use of quality seed, as well as on effective linkages among value chain actors, paying special attention to private companies. Conduct identification, documentation, and promotion of replicable and scalable methodologies to reach new areas and users with suitable varieties.

These investments will focus on the following **priority countries** where there is current momentum for growth in the sweet potato sector and where the crop can make a difference for food and nutrition security, and income generation: **Angola, Burundi, Cameroon, DR Congo, Ethiopia, Kenya, Madagascar, Malawi, Mozambique, Nigeria, Rwanda, Tanzania and Uganda.** In these countries, an additional 3 million households can become successful potato producers.

¹⁵ Devaux, A., Ordinola, M., and Horton, D. (eds.). 2011. *Innovation for Development: The Papa Andina Experience*. International Potato Center, Lima, Peru. pp. 431.

Country	Potato as a Priority Crop ^a	Effective Partners ^a	Institutional Context ^a	Potato Area (ha x ,000) ^b	Potato Farmers (x 1,000) ^b	Potential Adopters (%) ^c	No. of Beneficiaries (x 1,000) ^d
Angola	2	2	2	150	400	20	80
Burundi	2	3	3	20	110	30	33
Cameroon	2	2	3	60	240	30	72
DR Congo	2	2	2	40	200	20	40
Ethiopia	4	4	4	164	1,100	50	550
Kenya	4	4	4	152	850	60	510
Madagascar	2	2	2	45	160	30	48
Malawi	3	4	3	60	440	50	220
Mozambique	3	3	3	18	50	40	20
Nigeria	2	2	2	280	800	40	320
Rwanda	5	4	4	160	1,100	70	770
Tanzania	3	3	3	170	600	40	240
Uganda	3	3	3	102	540	40	216
Total				1,421	6,270		3,079

^a 1–5 (poor–excellent)

^b Based on information from surveys conducted by CIP (baseline and end line studies from the Willingness to Pay, 3G, and CFC projects) and country profiles.

^c Adoption is considered successful if farmers buy quality seed at least once every five seasons and if they use at least one of the technologies to maintain the quality of their own seed and produce quality ware potatoes (positive/negative selection; small seed-plot technique; ICM to produce quality potatoes and manage key pests and diseases; improved storage).

^d Potato farmers X potential no. of potato adopters/100.

4.4 Estimated Costs

In order to scale up the benefits from potato in Africa over the next five to ten years, additional support is required to complement and expand current funding. Estimated costs (in USD) across the main intervention areas are as follows:

Potato intervention areas	Approximate current annual funding levels	Indicative additional funding required (5 years)	
		2016-2020	2020-2024
Breeding	0.5m	8m	12m
Seed production	5m	25m	15m
Integrated crop management	1.5m	15m	20m
Protocols for seed quality control	1m	10 m	5m
Market development	2m	15m	20m
Scaling strategies	2m	12m	15m

5. SWEET POTATO

Sweet potato grown in most parts of Africa and is well established as a food security crop in many countries with high population density such as the African Great Lakes Region and parts of Nigeria. In other countries, sweet potato is often a second or third crop after maize, bananas, or cassava in mixed smallholder farming systems. Sweet potato enjoys high productivity per unit land area and labor even on more marginal lands (4–6 MT/ha). Its short growing cycle either allows for flexible planting and harvesting times in high rainfall regions or, in drier areas or areas prone to droughts or floods, permits quick production within a 4- to 5-month window.

At present, FAO estimates that there are 805 million chronically undernourished people on the planet, down more than 100 million over the last decade. In the same period, the prevalence of

undernourishment has fallen to 13.5 percent for developing countries¹⁶. Nevertheless, almost two billion suffer from “hidden hunger,” or micronutrient deficiency, particularly iron, vitamin A, zinc, iodine, and folic acid deficiencies. Globally, 163 million children under 5 years of age suffer from vitamin A deficiency (VAD), with the highest prevalence rates found in sub-Saharan Africa and South Asia¹⁷. In many countries in these regions, the problem of undernutrition has actually been increasing.

The use of biofortified orange sweet potato (OFSP) rich in beta-carotene, when introduced along with nutrition education at the community level, is a proven cost-effective strategy for providing vitamin A at high levels of bioavailability to vulnerable populations, in particular young children and pregnant and lactating women.¹⁸ OFSP production from 500 m² can provide sufficient vitamin A for a family of five¹⁹ and is a good source of energy, a number of B vitamins, and vitamins C and K.²⁰ Builds on this evidence, CIP, NARS, and research and development partners at national, regional and global levels are working together to bring the economic and nutritional benefits of sweet potato to African farmers and consumers. As a result, nutritious and resilient sweet potato varieties have been adopted by at least 1.1 million smallholder farmers in Africa over the past five years. With further support, this success can be scaled up to a further 10 million households over the coming 10 years.

Agricultural technologies that can produce nutritious and marketable food in agro-ecologies and socioeconomic contexts are urgently needed. Sweet potato offers strategic opportunities to improve nutrition and rural incomes in several countries and regions affected by micronutrient deficiency. It is already an important component of the cropping systems in Africa because of its robustness to produce under difficult conditions. It will become more important in the face of a changing climate. In many settings, it is also considered a “women’s crop” reflecting the relatively strong control women have in decision making in production and marketing. While this often provides particular opportunities to use sweet potato as an entry point to strengthen nutrition and economic outcomes for women and their children, cultural and gender-defined roles need to be addressed to improve outcomes at household and community levels.

At the core of the approach is an increasing range of nutritious, productive, and locally adapted OFSP varieties that become available to smallholder farmers through a more efficient and equitable research-development value chain. This calls for scaling up of the use of these varieties through improved technologies, methodologies and practices at each stage of this value chain, including support for accelerated breeding by NARS, improved multiplication techniques for private and public seed enterprises, diversified market chain development, and evidence-based policies.

¹⁶ FAO, IFAD and WFP. 2014. The State of Food Insecurity in the World 2014. Strengthening the enabling environment for food security and nutrition. Rome, FAO <http://www.fao.org/3/a-i4030e.pdf>

¹⁷ Standing Committee On Nutrition. 2011. 6th Report On The World Nutrition Situation: Progress In Nutrition. Geneva: United Nations System.

¹⁸ Van Jaarsveld, P. et al. 2005. Beta-carotene-rich orange-fleshed sweet potato improves the vitamin A status of primary school children assessed with the modified-relative-dose-response test. *American Journal of Clinical Nutrition* 81: 1080–1087. Low, J. et al. 2007. Food-based approach introducing orange-fleshed sweet potatoes increased vitamin intake and serum retinol concentrations in young children in rural Mozambique. *Journal of Nutrition* 137: 1320–1327.

¹⁹ Low, J. et al. 2009. Sweetpotato in Sub-Saharan Africa. In: Loebenstein, G. and Thottappilly, G. (eds.) *The Sweetpotato*. Dordrecht: Springer Science + Business Media B.V.

²⁰ U.S. Department of Agriculture, Agricultural Research Service. 2012. USDA National Nutrient Database for Standard Reference, Release 25. Nutrient Data Laboratory Home Page, <http://www.ars.usda.gov/ba/bhnrc/ndl>

5.1 Challenges

Sweet potato's role varies greatly in local farming systems across Africa, and our strategy addresses two basic scenarios. In several countries, such as in the high population areas of the African Great Lakes Region, it is well established as a food security crop, though the fit in farming systems differs. In other countries, it is often a second or third crop after maize, bananas, or cassava in mixed smallholder farming systems. Sweet potato enjoys high productivity per unit land area and labor even on more marginal lands (4–6 MT/ha). Its short growing cycle either allows for flexible planting and harvesting times in high rainfall regions or, in drier areas or areas prone to droughts or floods, permits quick production within a 4- to 5-month window. Farmers appreciate additional agronomic benefits such as good groundcover, availability of surplus biomass from vines for animal feed, and the possibility of using planting material from own fields. On all these accounts, it enhances the resilience of smallholder farming that is frequently affected by low yields or crop failure of other staple crops due to weather or disease (maize, cassava, and bananas have all been affected by major diseases over the past years in Africa). Sweet potato is not a regionally or internationally traded crop, so has proven to be less affected by food price fluctuations than most of the main cereals. It continues to provide affordable food during times of high food prices.

In parts of Ethiopia, West Africa, and Southern Africa, sweet potato is a relatively new crop and much less prevalent. Dry or high-altitude conditions limit its use. In these locations, farmers have started to adopt new OFSP varieties for their nutritional qualities and view it mainly as a supplementary crop, grown on small plots, to meet nutritional needs of children or specific market opportunities. Still, high productivity, short growing periods, and resilience under difficult agronomic conditions are key qualities that motivate farmers to grow it in mixed farms. Supporting larger numbers of farmers to realize the benefits of sweet potato production requires continued investments in technology delivery and innovation. R&D is needed to facilitate integration of the crop into a complex set of local systems, including crop production, water use, labor and land allocation, gender relations, food preparation and consumption, and agricultural markets.

CIP and partners have built a strong evidence base on the nutritional efficacy of OFSP. Strategic partnerships are in place with advanced research institutions (ARIs) and delivery-focused organizations to meet the demand of expanding and diversifying the use of OFSP. Breeding programs at regional and country levels in Africa will continue to generate improved vitamin A-rich OFSP varieties and other nutritious and resilient varieties. CIP's OFSP germplasm, together with regionally networked germplasm facilities and expertise from global partners, is supporting increasingly effective national breeding programs. Key sub-regional traits such as drought tolerance, virus resistance, or low sugar content are incorporated in sub-regional parent populations that provide starting points for varietal development by NARS. Along with national partners and farmers in Africa, researchers have developed methodologies and tools for accelerating varietal development, seed system development, intensification of production systems, and improved postharvest management, to support scaling-up of sweet potato interventions in the region. Expanding and extending this network approach will help facilitate transfer of experience, skills, and germplasm to new sites where development impacts can be achieved.

Gender is a key factor for achieving impact on nutrition and income. Increasing opportunities for women can have a powerful impact on productivity and agriculture-led growth and sweet potato provides a ready entry point for achieving this goal. Women play a pivotal role in ensuring sweet potato adoption and utilization within the household, as well as in managing diet diversification, food preparation, and household consumption including infant and child

feeding. Different preferences of women and men as farmers and consumers are an important to ensure sustained adoption of new varieties. Gender is often a critical differentiator for preference of traits, such as, taste, suitability as infant food, cooking time, suitability for partial harvesting, seasonality, labor requirements, agronomic performance on more marginal plots, and others. A second important concern is that increased agricultural labor by women may lead to over-burdening and declining household capacity for food preparation, child care and infant and child feeding, thus potentially jeopardizing the developmental gains from agricultural innovation.

5.2 Opportunities

Sweet potato is among the fastest expanding crops in Africa, measured by area under cultivation (Fig 1). Reasons for this development include the resilience of the crop that continues to yield reliably high harvests under variable rainfall and on more marginal soils. While not without its own challenges from pests and diseases, sweet potato is relatively robust compared to grains and other roots and tubers, and farmers turn to it when these other crops fail.

In order to realize the its full potential as a source of good nutrition, reliable food security, and income for women and men in Africa, it is essential to increase productivity and strengthen diversified market opportunities for both women and men. Seven investments areas have been identified that together can deliver on this potential. These areas are further described in Section “Suggested Actions/Ways Forward” and can be summarized as follows: (i) accelerated breeding methods and tools; (ii) guidelines, technologies, and diagnostic tools for improving OFSP seed systems; (iii) guidelines and technologies for sustainable OFSP intensification.; (iv) models and tools for nutrition and behavior change; (v) models, tools, and technologies for upgrading OFSP value chains; (vi) evidence base, policy options and partnership models for going to scale; and (vii) Capacity development, both institutional and human capacity.

5.3 Suggested Actions/Ways Forward

At the core of investments in sweet potato is resilient, nutritious varieties that are adapted to the local environment, perform well, and meet consumer taste preferences. The way forward is to support sub-regional breeding platforms to develop sweet potato populations that reflect sub-regionally important traits, include virus and drought tolerance, vine survival, high dry matter, low sugar, salinity tolerance, weevil resistance or avoidance, and early maturity. NARS breeding programs will be able to use these populations to develop and release new varieties more efficiently, supported through training in accelerated breeding methods that incorporate genomic approaches and high throughput phenotyping approaches. Sweet potato varieties, however, can only achieve broad impacts at scale if they are connected to auxiliary technologies and drivers for delivery at scale. The following seven priority investment opportunities have been identified in consultation with stakeholders:

1. Accelerated breeding methods and tools. Advances in breeding technology using genomic approaches and cost-effective, field-relevant high throughput phenotyping approaches will be applied consistently to accelerate and improve the development of parent populations and nationally released varieties of biofortified sweet potato. National partners will adapt these methodologies and use parents from regional population development programs; linkages with seed systems and farmers demand will be strengthened.

2. Guidelines, technologies, and diagnostic tools for improving sweet potato seed systems.

Priority is to develop sweet potato “seed value chains” that link vine multiplication at farmer and rural enterprise level to foundational materials derived from on basic and pre-basic seed at research stations. It is important to take an enterprise-focused approach to accelerate movement of new sweet potato varieties through this chain, with an emphasis on women’s involvement. This effort will be supported by new technologies to enhance vine multiplication and conservation, and improved diagnostic tools for affordable and effective quality control in decentralized seed systems.

3. Guidelines and technologies for sustainable sweet potato intensification. To enable both women and men farmers to realize the full production potential of OFSP in different agro-ecologies, it is necessary to develop, test, and promote improved agronomic practices (e.g., small-scale irrigation for vine conservation, soil enhancement, and intercropping). Adapting to climate change effects in drier and flood-prone production zones will need to receive special attention. Where crop-livestock integration is important, we will promote use of dual-purpose sweet potato varieties in animal feed (fresh vines, silage, reject roots) and human nutrition. In areas with high demand from urban markets and food processing, commercial sweet potato production, including under irrigation, is emerging and these investments need to be assessed and potentially further supported.

4. Models and tools for nutrition and behavior change. An up-to-date evidence base, built in partnership with nutrition and social research institutions, will capture nutritional values and benefits and consumer acceptance of new sweet potato varieties, including roots and leaves, and sweet potato -based products. Training, counseling and education materials and successful extension approaches can be scaled-up.

5. Models, tools, and technologies for upgrading sweet potato value chains. Process models, technologies, and implementation tools are becoming available for scaling up that support integrating OFSP into multiple value chains, ranging from community-based nutrition/agriculture and school-feeding programs to higher-value urban market chains for bakery products and healthy-choice snack food. These technical and organizational tools will enable stakeholders to better manage the perishability of sweet potato roots and position it as a healthy food for all in the market place.

6. Evidence base, policy options and partnership models for going to scale. Research on partnerships and policies that can support large-scale use of sweet potato will generate organizational models and guidelines, metrics for measuring effectiveness and efficiency of scaling up agriculture–nutrition linkages, and evidence-based policy recommendations to support this expansion. These research products will inform policy and development forums on agriculture and nutrition at the national to global levels.

7. Capacity development. Building on successful experiences working through regional and sub-regional “support platforms” in Africa, support is required to promote communities of practice in key technical areas to share knowledge, strengthen collaborative research and dissemination, and accelerate and broaden uptake amongst next users. The “breeding in Africa for Africa” approach will be deepened through the breeding community of practice to accelerate development of nutritious and locally adapted varieties. Sub-regional breeding platforms will provide direct training and technology exchange support to national breeding programs. Communities of practice in seed systems, agronomy, processing and marketing, nutrition, and Monitoring, Learning and Evaluation will be further developed and linked to explicit capacity development activities organized around development and delivery of lead and linked products and involving project-level implementing partners. The comprehensive multi-module training-of-trainers course on “Everything you ever wanted to know about sweet

potato” will be further rolled out by lead national training institutes and adapted to the demand by a wide range of partners from government and NGOs that want to strengthen their capacity. Several university and ARI partners will provide advanced training opportunities for researchers, students and technical staff at degree and certificate level. The current successful collaboration with AGRA can be further expanded to make research and training grants available to NARS scientists. As part of the scaling-up strategy, linkages can be built with wider training and innovation programs beyond the specific agricultural sector to integrate sweet potato into curricula and initiatives in school-based education, vocational training, youth entrepreneurship, student internships, post-graduate innovation funds, and collaboration with the private sector. In all these capacity development efforts, it is important to create opportunities for women and men and to adapt training and dissemination approaches and contents to improve gender equity of access, and increase relevance and value based on participation for both women and men.

These investments will focus on the following **priority countries** where there is current momentum for growth in the sweet potato sector and where the crop can make a difference for nutrition, food security, and income generation: **Angola, Benin, Burkina Faso, Burundi, Ethiopia, Ghana, Kenya, Madagascar, Malawi, Mozambique, Nigeria, Rwanda, Tanzania, Uganda and Zambia**. In these countries, an additional 10 million households can become successful sweet potato producers and consumers.

5.4 Estimated Costs

In order to scale up the benefits from sweet potato in Africa over the next five to ten years, additional support is required to complement and expand current funding. Estimated costs (in USD) across the main areas of intervention are as follows:

Sweet potato intervention areas	Approximate current annual funding levels	Indicative additional funding required (5 years)	
		2016-2020	2020-2024
Variety development and germplasm management	4m	20m	30m
Sustainable seed systems	6m	20m	25m
Sustainable intensification including irrigation	1m	25m	30m
Nutrition education, demand creation, and behaviour change communications	3m	15m	20m
Value chain development, including postharvest management	3m	24m	28m
Information systems, policy, and impact assessments	2m	12m	15m
Capacity strengthening (institutional and human capacity)	2m	20m	30m