# Expanding utilization of RTB crops and reducing their post-harvest losses

## Final Business Case

## Extending the shelf life of fresh cassava roots for increased incomes and postharvest loss reduction

**The Team**

(*It is expected that most of these individuals and institutions will also participate in implementation, though some changes in roles and participation are to be expected)*

**Project partners**

| Name | Institution | Role |
|---|---|---|
| Adebayo Abass | IITA | Project and partnership management |
| Kelly Wanda | IITA | Coordination of project activities; market analysis, value chain development and market linkages backstopping |
| Marcello Precoppe | IITA | Pilot plant establishment (Backstop the installation of waxing technologies and other equipment) |
| Gloria Okello | AFRII | Market assessment for fresh cassava and use of deteriorated cassava roots; Market assessment for shelf-life extended cassava roots |
| Pamela Nyamutoka | IIRR | Business Development Support, Training of farmers, traders and private sector; documentation and knowledge sharing |
| Harriet Muyinza | NARO | Lab-scale evaluation of cassava varieties for PPD; Testing and evaluating the waxing and RH polyethylene storage technologies & MSc student training |
| Moses Matovu | NARO | Pilot packing-house operations for fresh cassava storage |

**Collaborators**

| | | |
|---|---|---|
| Prof. Archileo Kaya | Makerere University | Supervision of 2 MSc students |
| Dr. Basil Mugolona | Gulu University | Supervision of 1 MSc student |
| Bernado Ospina & Dominique Dufour | CLAYUCA/CIAT /CIRAD | Training of partners on PPD assessment; root quality assessment; waxing technologies. |
| Vincent Tubenawe | Private sector | Market Promotion/ Marketing coordinator |
| Isingoma Amooti | Trader/Farmer | Farmer out-grower coordinator/business model |
| Okasai Opolot | MAAIF CROPS | Farmer coordinator |
| Stella Apolot | UNBS | Standards and safety of wax, packaging materials & roots |
| Kato Gafabusa | Private sector | Farmer enterprise coordinator/manager |
| Antony Pariyo | NARO | Seed systems supply support |

## A. Final Business Case

1. DEVELOPMENT PROBLEM/OPPORTUNITY (*specify in 1-2 paragraphs the development problem or opportunity related to postharvest or expanding utilization that this technical innovation will address, e.g. low profitability of RTB, opportunities to increase household incomes, increased farm productivity, )*

Cassava is the second most important staple and food security crop after banana in Uganda (Kleih et al., 2012). It is one of the ten commodities that have been prioritized by the Ugandan Government in its Agriculture Sector Development Strategy and Investment Plan (DSIP). Uganda is the sixth largest producer of the crop in Africa, with an estimated 5.2 million tons in 2013 (FAOSTAT; accessed 25 Sept. 2014). It is estimated that in some parts of Uganda, nearly 60% of the people grow cassava and nearly 90% of the people consume cassava in different forms at least once daily (EAAPP, 2011). Fresh cassava is widely consumed both in urban and rural areas as a snack and main meal. Fresh cassava marketing is currently an important source of income (Scoping study). Uganda has a policy of releasing "sweet varieties", i.e. varieties with low levels of cyanogens. These varieties are popular, with consumer demand increasing especially in urban areas, providing incomes to growers and traders. Retail trade in fresh cassava is dominated by women.

The major constraint faced by large-scale production and marketing of fresh cassava roots is the rapid postharvest physiological deterioration (PPD) that occurs within two days after harvesting. This substantially reduces the eating quality, transportation range, and financial value of cassava (Booth, 1976; Buschmann et al., 2000; Westby, 2002; Lyer et al., 2010). The consequence is a reduction in income for the growers and other value chain actors.

The perishability of the fresh roots leads to high level of discounting during marketing, sometimes causing economic losses up to 90% of the initial value with a very short marketing period. It also discourages farmers from participating in marketing activities in distant locations and forces farmers to adopt piece-meal harvesting. The poor road infrastructure in the remote locations where cassava is mostly cultivated further worsens the situation, especially during the rainy season. Consequently, fresh cassava roots are in short-supply in the urban market and are also expensive (Collison et al., 2003). High prices at retail level are to make up for the significant loss that occurred pre-retail marketing. These circumstances make it almost impossible for smallholder cassava farmers to shift out of poverty on their own.

In Uganda fresh cassava is predominantly sold in the open market. Farmers sell the fresh roots to wholesalers who in turn sell to retailers in the urban markets. Wholesalers pay according to the agreed truck load. They are responsible for harvesting, transportation, loading and off-loading in the market.

Fresh root total consumption is estimated at 1.32 Mt per annum out of which 309,528 tonnes is marketed. Demand for fresh cassava in Uganda is increasing with urbanization. It is estimated that demand for fresh cassava will reach 387,074 tonnes by 2018, an increase of 25%. It was estimated that 32 tonnes and about 18 tonnes of fresh cassava is sold per day in Kampala and Jinja markets respectively (Scoping study, 2014). Cassava supply varies with seasonality because harvesting during dry season is particularly labor-intensive and often results in broken roots. Such problems do not exist in the wet season and consequently supply tends to be higher. Traders prefer roots with extended shelf life. Other qualities preferences include roots with an outer bark-like skin that peels away easily and with a thick, often reddish,, flesh. Fresh cassava was sold by supermarkets in

Uganda but due to perishability of the roots, the operators of supermarkets discontinued the sale of fresh roots. Consequently, the majority of smallholder farmers linked to this market lost the market opportunity (Scoping study, 2014).

Fresh cassava is widely eaten across the country and postharvest deterioration is a big problem to traders. Any technology that will address this problem will benefit a large number of farmers and traders. Although it is sometimes assumed that consumption of cassava will drop with increased incomes, recent observations by operators of restaurants suggest that there was increased demand for farm-fresh food items such as cassava for breakfast instead of bread among the more affluent Ugandans. Given that Uganda is making progress in improving cassava genetics and production, physiological postharvest deterioration needs to be addressed to strengthen the links between small-scale producers and the emerging new markets (Wheatley et al., 1995*)*. To achieve this, there are prospects for applying shelf life extension technologies that have been applied successfully elsewhere (IFAD and FAO, 2001; IFAD and FAO, 2004). This project will thus evaluate technologies that extend shelf-life of fresh cassava roots in order to increase the utilization and marketing of fresh cassava in the open market. This will result in increased incomes for all the actors along the cassava value chain.

2. APPROACH (*indicate in 3-4 paragraphs how the proposed technical and other innovations address this problem/opportunity, and how the research builds on existing knowledge, ongoing/recent initiatives*)

Research will be carried out to establish the effectiveness of shelf-life extension technologies in increasing the range over which fresh roots can be marketed while retaining the desired quality traits, achieve price stability and increase demand. The varieties to be tested will include those that are commonly preferred by the consumers and tolerant to the major cassava diseases. These are NASE 14, 15, NAM 130, Nyaraboke and TME14. Waxing and high relative humidity storage will be evaluated and optimized for efficacy in extending shelf-life of these varieties. Then the optimized technologies and suitable cassava varieties will be piloted using two marketing models. Under the pilots, the technologies will be demonstrated with farmers and traders and the shelf-life extended roots market tested. One approach involves traders applying the storage technologies and targeting the sale of the shelf-life extended roots along the Masindi-Kampala supply axis, and the second approach will involve farmers applying the optimized storage methods and marketing along the Kampala-Kabarole supply axis. Studies on economic viability and benefits for participating traders and farmers will be evaluated. Gender considerations and lessons will be documented. It is expected that this shelf-life extension technologies will reduce the pressure on smallholder farmers to sell their cassava at low prices immediately after harvesting. It will also provide smallholder farmers an opportunity to collectively market their fresh cassava roots thus gain more bargaining power.

The research team has adopted the steps for product development proposed by Wheatley et al., (1995) comprising of idea generation and screening, and market research (scoping study). The next steps are location/beneficiary selection, technical and consumer research, and pilot testing. The team will improve on the market assessment that was already done during the scoping study. The conceptual framework for the research is shown in Annex 1.

## *1.0 Market assessment*

The major district towns where fresh cassava is sold (Jinja, Gulu, Kabarole, Lira, Mbale, and Mbarara and Kampala, largest market for fresh cassava roots) will be surveyed and stored cassava will be evaluated for acceptance. In order to link the technology innovation to fresh roots supply, we will target farmers and fresh cassava marketers in the districts of Masindi, Hoima, Masaka, Mubende, Kyenjojo, Kibale, Kiboga, Kiryadongo, and Kabarole for the innovation. These locations have better transport links with Kampala, making it easier to transport and market fresh cassava roots in Kampala (Kleih et al., 2012). In Kampala, the main wholesale markets for fresh cassava (Kalerwe, Balikuddembe or Owino, Kawempe, Nakawa, Ndeeba, Nakasero, Nateete, and Busega) will be prioritized for market and consumer test. Consumers have a preference for sweet, soft, and red-skinned varieties which fetch higher prices.

The market assessment will be done in two phases at the beginning of the project to understand the current market situation and characteristics and during the pilot testing phase. During the 1st phase, PMCA approach will be used to identify the existing supply chain and actors, with reference to the following characteristics: Market size, product, willingness to pay, gender disaggregated consumer preferences, prices, demand seasonality/ growth trends, varietal and quality characteristics, critical challenges, opportunities, level of post-harvest losses, existing PPD reduction technologies and gross margin analysis. In addition, an assessment will be done as regards to the current uses and values of deteriorated cassava. During the pilot phase another assessment will be done of the best marketing models and practices for shelf extended cassava roots.

## *2. Technology Innovations*

Storage technologies for extending shelf life of fresh cassava roots have been piloted successfully elsewhere (Wheatley et al., 1995). However, their applicability to the Ugandan conditions needs to be assessed and the best options need to be adapted. The project will test the following technologies:

*Technology 1 – Storage in cool and humid conditions:* Physiological deterioration and parenchymal blue–black vascular streaking, often starts within 24 hours after harvest. Traditionally farmers leave or store cassava underground un-harvested. Pruning of cassava plants for underground storage is also common. A study carried in Colombia (van Oirschot et al., 2000) showed that the susceptibility for fresh roots of pruned cassava plants drastically reduced within 25 days reaching a minimum of around 25% of the original value. However, pruning and underground storage method has limited application in fresh roots marketing.

Storage of carefully harvested and cleaned fresh roots in polyethylene bags after spraying with a fungicide (thiabendazole) shows promise in reducing postharvest losses of fresh roots (CIAT, 1989). Experience gained in Ghana suggests that, simply dipping healthy roots in water and maintaining them at high humidity will extend the useful shelf-life of the fresh cassava roots for a period of 7 – 10 days. Respiration by the roots in the polyethylene bags raises the relative humidity (RH). Temporary holding of the bagged roots at high temperature causes root curing, which promotes an extension of shelf-life (CIAT, 1989). However, Ndunguru et al. (1998) observed that given the limited financial resources available to the smallholder farmers, the Ghanaian option was most appropriate. This project will test the effectiveness of fresh root dipping in water and 4% bleach (Sodium hypochlorite) before storage in polyethylene bags. Quality and storability of the stored roots will be monitored.

*Technology 2 – Waxing:* Waxing has been proven elsewhere to also extend the shelf life of cassava considerably allowing for fresh roots to be marketed across continents without heavy fungicide application. The project beneficiaries will be trained on the unit operations involved in fresh cassava root waxing: (i) cleaning, streaming and sorting into uniform size suitable good for paraffin treatment; (ii) immersing the crates containing the roots in water followed by washing the roots with soft brush until they are clean. To ensure minimal impact on the environment, the water will be recycled periodically; (iii) the roots will be allowed to dry in normal air temperature, so that the paraffin coating treatment to be done functions better; (iv) melting the paraffin to boiling point and then immersing the trays with the cassava roots, for few seconds; and (v) marketing of the treated paraffin-coated cassava roots in the urban market (See Annex 2).

### *2.1 Laboratory testing: High RH storage and Waxing*

The technical feasibility of the above technologies will be tested for extending shelf-life, reducing postharvest loss of the current fresh market-dominant varieties, and effectiveness in maintaining consumer-preferred quality traits at the National Agricultural Research Laboratory at Kawanda. Two MSc candidates, registered with Makerere University will be involved in the study. Quality traits of atleast 5 popular cultivars will be tested over a period of 1-5 weeks to understand the effectiveness of the two technologies on consumer quality traits, acceptability and overall shelf life. The following parameters will be analysed sugar, starch contents, dry matter, fiber content, cyanogen, scopoletin, amylose and reducing sugars and the starch pasting properties the sugar/starch ratio, Vascular streaking enzymatic activity such as production of phenylalanine ammonia lyase, an enzyme associated with phenol biosynthesis; increased activity of peroxidase and polyphenol oxidase; formation of phenols/polyphenols including leucoanthocyanidins, catechins, and condensed tannins, weight loss, moisture content and appearance/color change will be monitored every other day. Apparent changes occurring in the roots tissue will be monitored using scanning electron microscopy (Kawabata and Sawayama, 1984). Consumer tests (boiled & roasted cassava) will be carried out to select the best storage method and determine the shelf life during which the roots retain acceptable appearance and consumer acceptability.

### *2.2 Pilot testing*

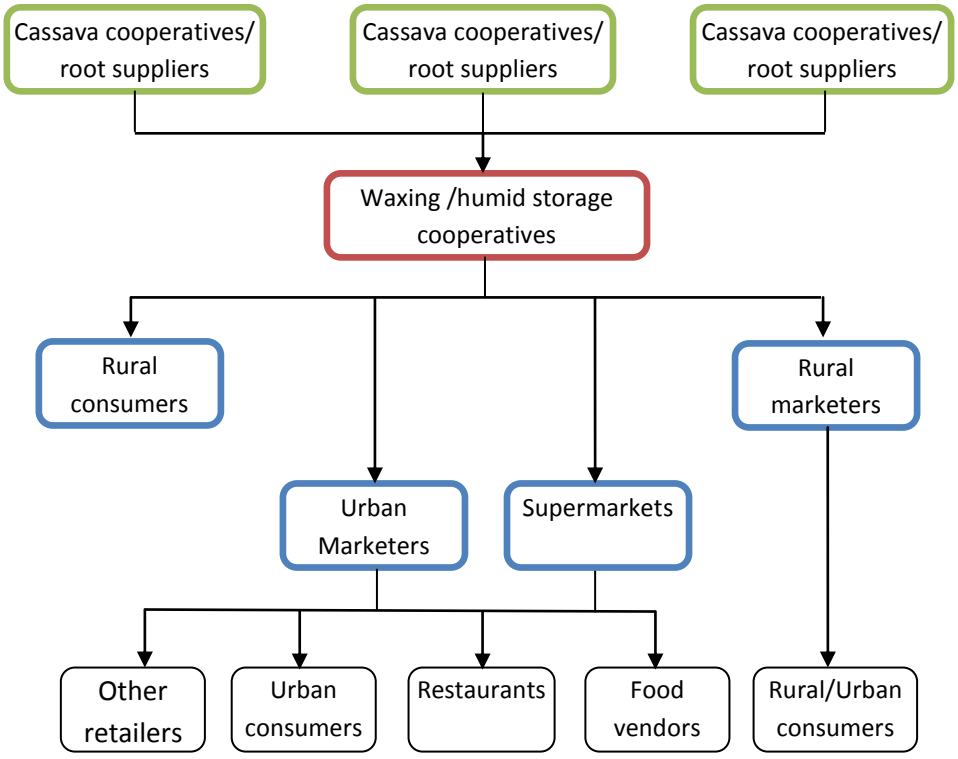
It is our hypothesis that high humidity storage and waxing of cassava roots are inexpensive and waxed roots will be widely accepted by consumers. The cost of applying these technologies is expected to be less than the current financial loss to the traders resulting from PPD/PHL loss considering the estimated 25% loss experienced by value chain actors (http://uganda.thebeehive.org/content/18/5144). The prices of non-waxed fresh cassava roots (sometimes with deteriorated sensory quality) are high in the urban centers (US$ 418.25/ton) while the farm gate price for fresh cassava is much lower (US$ 113.00/ton; see Annex 3).

Research in the technical application, pilot testing and eventual commercialization of a combination of the shelf life extension technologies could increase consumption, processing and market access for cassava, thereby boosting the incomes of the value chain actors, many of whom are women (IFAD and FAO, 2001; IFAD and FAO, 2004). Adoption of shelf life extension techniques seems to have been limited in Africa due to the laboratory scale or rudimentary farm-level methods used in testing of these technologies without a value chain or market integration approach. These technologies could be introduced using market-led approaches by involving smallholder farmers and associations of fresh root marketers. Most of these actors experience postharvest loss of cassava and they are

looking for a technology for reducing their financial losses. The value chain approach was successful for fried banana crisps and cassava fritters in Colombia, and dried potato in Peru (Wheatley et al., 1995). The approach was successful for high quality non-fermented cassava flour technology introduced in Nigeria in the 1990s. Over the years, private sector investments in both the processing, and industrial utilization of cassava flour in Nigeria has increased (Abass et al., 2001; Abass et al., 2011).

For this proposed research, pilot facilities will be located in two districts north-west of Kampala where the farmers are concentrated (Annex 4). The high humidity storage and waxing will be introduced as a packinghouse operation at: (1) farmer-led packing house in Kampala-Kabarole axis to be managed by a champion farmer working with small holder farmers in form of out grower scheme; (2) trader-led packing house in Masindi-Kampala axis to be managed by a fresh roots marketing traders association. We will work with the smallholder farmers, traders operating in the open market, major supermarket chains, and consumers to build a supply chain for shelf-life extended cassava roots (Figure 1).

Figure 1: Proposed supply chain and actors for shelf life extended cassava roots




The desirability of the technologies for shelf-life extension will be evaluated at the pilot phase based on consumer acceptability, gender appeal, potential market value (consumer price/willingness to pay), financial feasibility and demand projection. The study will investigate the proposed technologies in terms of costs and benefits to value chain actors, especially women, under the current handling transportation, and marketing conditions and the potential economic loss reduction to the cassava industry in Uganda. In addition the opportunity for promoting gender-balanced supply chains will be investigated. The research will investigate the possibility to trigger investments and guarantee financial returns on investments to the private sector.

Fresh cassava consumption is very extensive and the urban middle-class is growing. The middle-class are currently buying waxed fruits and more expensive food items from the supermarkets (see Annex 2). Therefore, there is a huge potential market for stored cassava roots. In addition, waxing or high RH storage is expected to significantly reduce losses and maintain or reduce market price for the fresh root since discounting for losses will be eliminated. Scoping study revealed that there is high potential for commercialization of fresh cassava in these districts. In addition, the operators of supermarkets (Uchumi and Capital Shoppers chain of supermarkets) have both indicated that once the technology works, for which they are ready to participate in testing; they will be supplying waxed cassava roots to national and EAC markets.

### *3.0 Knowledge sharing*

At the beginning of the project South-South collaboration will be established between Uganda National Research organizations, CIAT and private sector in Colombia to gain knowledge on fresh cassava waxing and other shelf-life extension technologies. Within Uganda the project will collaborate with other institutions involved in cassava technologies to share knowledge on fresh cassava value chain improvement in Uganda (CAVA, EAPP, COMESA-cassava project). The results of all market assessment and technology innovation during laboratory and pilot testing will be documented and shared with different stakeholders. Dissemination of these findings will be done through training of farmers and traders, private sector, documentation (Scientific publications, flyers, Posters, business plans, brochures), stakeholders workshops and Scientific conferences. This will enable actors along the value chain learn from the experience and use this knowledge to stimulate uptake of the technologies. This knowledge will also help policy makers to create an enabling environment for the commercialization of the fresh cassava storage technologies. The conceptual frame work for this approach is shown annex 3.

## 3. MAIN RESEARCH QUESTIONS (*indicating the knowledge gaps to be addressed*):

a) What are the characteristics of the different market segments for fresh cassava roots and the current uses of deteriorated cassava roots at trader and consumer level in Uganda?

b) What are the best models and practices (farmer cooperative enterprise and trader-driven) for marketing smallholder shelf-life extended roots to the different identified markets?

c) What are the varietal differences in PPD/PHL and eating quality of varieties?

d) What are the variety-specific effectiveness of high RH storage and waxing on delay of PPD/extending the shelf-life, retaining cooking quality and consumer acceptability?

e) How adaptable to Uganda are high RH storage and waxing technologies?

f) How will the proposed technologies affect the value chain actors especially women in terms of costs and benefits.

4. OUTPUTS/DELIVERABLES (*specify the outputs/deliverables to be produced and indicate when they will be available within a 2 year time frame*)

| **Research deliverables** | **Delivered output** | **Next User** | **Expected time Year/ quarter** |
|---|---|---|---|
| Knowledge on market segments for fresh cassava and use of deteriorated cassava roots generated | Market assessment report | Project partners and collaborators | Year1 /Q2 |
| Information on varietal differences in PPD and eating quality of varieties generated | Scientific publications, reports | Research community, traders, NGOs, Policy makers | Year1 /Q3 |
| Technologies for extending shelf-life of fresh cassava roots to increase access to fresh cassava of preferred quality traits over a long storage and marketing period developed | List of adaptable technologies, Manual of the use of technology, communication materials, flyers | Consumers, farmers, traders, local entrepreneurs, NGOs and NARO, extension | Year1/Q4 |
| Convenient presentation forms of fresh cassava of longer shelf-life reducing post-harvest losses and increasing acceptability in different market segments identified | | | |
| 2 MSc research in Food Science generated | MSc thesis on postharvest handling and storage of fresh cassava | NARO and policy makers | Year 2/ Q3 |
| 2 pilot packing houses established and operationalized | Guidelines and design of pilot pack houses | Local entrepreneurs and other investors, NGOs and NARO | Year1/ Q4 |
| Assessment of adaptability and profitability of the technologies in Uganda conducted | Scientific and business reports, investment pack | Local entrepreneurs and other investors, farmers, traders, NGOs, NARO, extension policy makers | Year2/ Q3 |
| 1 MSc research thesis on Post -harvest economics | MSc thesis on fresh cassava marketing generated | Project partners and collaborators | Year 2/ Q3 |

| | | | |
|---|---|---|---|
| Recommendation on best model of marketing shelf-life extended cassava roots generated | Report | Farmers, traders, local entrepreneurs, NGOs and NARO, extension | Year2/Q2-Q4 |
| Capacity of partners built on waxing, pruning, RH and marketing models in Colombia | Training report | Project partners | Year1/ Q2 |
| Capacity of farmers, traders , local entrepreneurs especially women built on technologies for extending shelf-life, business management | Training, report, communication materials | Farmers, traders, NGOs, extension | Year2/ Q4 |

For both remote and peri-urban farmers, we will investigate home consumption against marketing of cassava in relation to level of losses, farmers' perceptions and decision-making by both men and women. Initially, the commonly traded farmers' varieties will be used to investigate the improved storage technologies against current practices. The possibility to use varieties with good PH storage characteristics and resistant to brown streak disease from Ugandan breeding lines will be explored. A combination of formal questionnaires, laboratory tests (Physico-chemical characteristics of cassava roots) and consumer forms will be used to collect data on the quality traits, consumer acceptability and market potentials of the preserved roots in the project locations. The series of evaluation will be done in collaboration with farmers and the private sector that have the potential to uptake the shelf-life extension technology. During the scoping study discussion with different fresh root traders and farmers revealed that these technologies are in demand by all the value chain actors (farmers, transporters, retailers and major supermarkets). This project will build on these existing opportunities to evaluate ad promote fresh root shelf- life enhancing technologies along the value chain.

Thus capacity of farmers, traders, local entrepreneurs especially women will be built on the application of these technologies and tools for extending shelf-life and also for business management. The results from the research especially at the pilot phase will be used by the team to inform the next phase of the project. The outputs of the pilot test phase will include a feasibility study on the profitability of the marketing system for shelf-life extended cassava. Business packs will be developed for the packing-house operators in order to promote possible venture capital arrangements among local entrepreneurs after the pilot phase.

5. DEVELOPMENT GOAL (*indicate in one paragraph the overarching goal to be achieved after 10 years, for example: [number] producers and [number] small-scale processors of [crop] in the [name] region have improved their food security by [number] percent and their agricultural income by [number] percent. Explain the gender equity and environmental aspects of your goal as well* )

20,000 producer households (50% female headed) in the major producer regions of Central, Eastern, Northern, and Western Uganda will have achieved a 20% improvement in their food security and

30% increment in their income levels. In addition, 50 wholesalers countrywide will increase their incomes by 30% and also improve their food security situation by 20%. 500 retail traders will increase their incomes by 30%, with 80% of these being women. Physical and quality losses for fresh cassava postharvest handling and marketing will reduce by 25%. At least 125 farmers up-take the technology – transit into root-storage entrepreneurs (waxing, modified atmosphere) – and at least 25 (super) markets sell shelf-life extended cassava roots in Uganda. The project is expected to lead to very minimal environmental degradation from the cassava production activities but will reduce the pressure on rural farmers to seek incomes through deforestation activities.

6. EXPECTED OUTCOMES (for each research output mentioned above, *indicate the principal outcomes to be achieved after 10 years through scaling out and up the proposed innovations, and their likely effects on food security, gender, and the environment; outcomes are understood as change of behaviour of actors inside and outside of the value chain*)

| **Research output/deliverable** | **Users/beneficiaries** (*e.g., producers, small-scale processors, retailers*) | **# of Users/Beneficiaries after 10 years** | **Outcomes** *(expected use of technical and other innovations; e.g. farmers using on-farm storage technology, processors applying new procedures)* | **Food security**(*direct effects through products, or indirect effects through increased income and other effects*) | **Gender equity** (inclusiveness and benefit sharing among women, men and youth) | **Environmental performance** *(increase of positive or reduction of negative impacts on the environment)* |
|---|---|---|---|---|---|---|
| Knowledge on market segments for fresh cassava and use of deteriorated cassava roots generated | Scientists - Project partners and Collaborators | 100 | At least 5% agriculture research scientists increase market knowledge. | Increased availability of fresh cassava; expanded market/higher incomes; expanded consumption and industrial utilization ; export opportunities | Equitable incomes available to women and men farmers, traders and processors traders preventing income loss | Reduction of deteriorated cassava roots leading to less waste deposal in the environment |
| Recommendation on best model of marketing shelf-life extended cassava roots developed | Farmers and traders | 200,000 | Farmers increase their market reach by 14 days of marketing shelf-life extended roots and increase income by 25% | | | |
| | Local entrepreneurs | 20 | At least 10 entrepreneurs make investment in the shelf-life extended technologies | | | |
| | Extension (NGOs and NARO) | 1000 | 10% extension agent increase market knowledge to be extended to other non-project farmers and traders | | | |
| Information on varietal differences in PPD and eating quality of varieties generated | Research community | 100 | At least 100 scientists acquire knowledge on PPD assessment and research | | | |
| | Traders | 50 | Increase knowledge on varieties with longest shelf life, adopt them and increase reduce postharvest less to nearly zero from the current 25% | | | |

| | | | |
|---|---|---|---|
| | Extension (NGOs, NARO and policy makers) | 1000 | 10% extension agents increase their market knowledge and extend to non-project farmers and traders |
| Technologies for extending shelf-life of fresh cassava roots to increase access to fresh cassava of preferred quality traits over a long storage and marketing period evaluated | Farmers | 20,000 | At least 2% farmers reduce post-harvest loss of roots to almost zero from the current 25% |
| | Traders | 200 | At least 200 traders increase demand for fresh cassava by 10% and increase their income by 20% |
| | Local entrepreneurs , | 20 | At least 10 entrepreneurs start investment in storage of fresh cassava |
| | Extension personnel (NGOs) | 1000 | 25% extension personnel increase their knowledge in extending shelf-life of fresh cassava |
| Two pilot packing houses established and operationalized | Farmers, traders and/or local entrepreneurs | 20 | Investment in at least 10 fresh cassava packing houses |
| | Extension personnel (NGOs ) | 1000 | 25% extension personnel increase their knowledge in extending shelf-life of fresh cassava |
| Assessment of adaptability and profitability of the technologies in Uganda conducted | Farmers, traders and/or local entrepreneurs | 20 | Investment in fresh cassava packing houses |

| | | | | | | |
|---|---|---|---|---|---|---|
| Capacity of farmers, traders, local entrepreneurs especially women built on technologies for extending shelf-life, business management | Farmers and traders | 20,000 | 10% of women farmers and traders use the knowledge to increase shelf-life of cassava roots | | | |
| | Extension personnel | 100 | 20% extension personnel increase their knowledge on technologies for extending shelf-life of fresh cassava and on business management | | | |

7. FEASIBILITY:

a) Technical feasibility (*provide evidence that the proposed innovation is likely to be effective at an experimental level; e.g. that it has worked elsewhere*)

Cassava is a highly perishable good. A lot of research has been made elsewhere to understand the factors that aggravate PPD and the technologies to reduce losses due to PPD. A number of them exist and a few are already in use, including the high humidity treatments and root waxing proposed for this business. The polyethylene storage technique investigated by the NRI and CIAT involves dipping healthy roots in fungicide solution, packing in polyethylene bags and maintaining them at high humidity for several days in cool environment. This method has been replaced in Ghana where it was found that dipping roots in household bleach (0.95% active chlorine) before packaging is as effective as using a fungicide (Crentsil et al., 1995). In the case of waxing, cleared and dried roots are dipped in wax (melted paraffin) at $51.5^0$ C to $52.5^0$C for one second. This causes curing and adds a smooth thick surface coating to the root. Waxed roots are placed in clean, strong, well ventilated carton boxes for sale (See Annex 1). This coating helps to reduce root moisture loss while and it drastically extends the shelf life for up to two months and reduces discoloration due to vascular tissue. Waxing has been found to be effective in extending the shelf-life of cassava and has enabled countries like Costa Rica to export fresh cassava roots. The technology is known to be used on other commodities such as fruits, vegetables and candy to make them shiny with aesthetic appeal in addition to preventing moisture loss and spoilage. Waxing therefore has positive impact on aesthetic appeal and the market value of commodities. The technique has a potential to open up future research into using plant origin materials to reduce the cost. The two main techniques are easy to practice with simple basic postharvest handling and root treatment tools.

b) Economic feasibility (*provide a rough estimate of costs-benefits; a more precise analysis of costs-benefits will be carried out during scoping*)

The economic feasibility for extending the shelf life of fresh cassava roots was determined using the cost benefit analysis of the pack-house facility. Data on the economic costs and benefits of the proposed pack houses for producing shelf-life extended roots was gathered during the scoping study.

The potential costs and benefits that accrue to different value chain actors were extrapolated over a period of 10 years, the appraisal period of this project, and discounted to present value using a common public sector discount rate of 6%. The discounted present values of benefits and costs, the Net Present Values (NPV), and benefit cost ratios were then calculated as indicated in the table below.

**Table 1: Cost-benefit analysis of waxing technology**

| | **FARMER** | **PROCESSOR** | **TRADER** |
|---|---|---|---|
| Appraisal period (years) | 10 | 10 | 10 |
| Present Value of Benefits | $589,543 | $397,445 | $724,519 |
| Present Value of Costs | $55,200 | $147,201 | $110,401 |
| Benefit Cost Ratio | 10.7 | 2.7 | 6.56 |
| **Net Present Value** | **$534,343** | **$250,244** | **$614,118** |

Source: Scoping study 2014

The discounted present values of benefits are greater than the discounted present value of costs and benefit cost ratios are all greater than 1 for all the value chain actors. The cost benefit ratio for the farmers is 10.7, 2.7 for processor, 6.6 for distributors and traders, indicating the worthiness of the technologies.

c) Social feasibility (indicate if socio-cultural norms or practices facilitate or hamper adoption of technical and other innovations, considering gender and intergenerational differences)

The high relative humidity technology would be easily adapted by retailers who not only experience the highest post-harvest losses in the value chain but also apply traditional methods of extending shelf-life of fresh cassava roots. The current methods in use also aim at maintaining low temperatures and high relative humidity of fresh cassava roots in polythene bags. Thus high RH technology will be an improvement of the current methods by addition of dipping or spraying roots with fungicide solution. The main hurdle would be consumer acceptance of fungicide use on the fresh cassava roots.

Waxed food products are not new in the Ugandan market as waxed fruits like apples have been sold and consumed for many years. The market channels for waxed apples are not limited to supermarkets as they are also sold in the retail shops and open markets. This is expected to also occur in the case of waxed cassava. Indeed, women currently dominate the cassava retail business and are better placed to benefit from the new technologies. Thus waxing of cassava presents an opportunity to widen the market channels to include open markets, super markets and retail shops. According to retailers interviewed during the scoping study, consumers normally buy small heaps of cassava (equivalent to 3 roots) that is enough for one or two meals as the cassava changes in taste and color after only a day after purchase. Therefore, the technologies present opportunities for consumers to increase cassava consumption through purchase of larger quantities of cassava roots for storage at home.

*Gender:* Women are most likely to dominate at marketing level. At the end-user level, youth and men are likely to dominate. To ensure that women and elderly are not discriminated against at the level of sale of their cassava roots to the pilot centers and marketing, specific efforts will be made, to attract youth and women entrepreneurs to events aimed at promoting the project activities and inform them of the opportunities to be created. Some flexibility in implementation, specifically in the provision of additional support, will be necessary to ensure that desirable levels of female and youth participation can be achieved.

Where necessary, as part of the capacity development of national institutions, training will be given in order to increase internal awareness in institutions of the gender biases in their own activities and perceptions and to assist them to identify opportunities to develop more gender sensitive approaches and to build support for the political will to implement mainstreaming. This kind of activity will seek to reveal to project organizations and credit organizations the positive outcomes of supporting women in the use of new technologies, credit and trading, to identify possible hurdles, to learn from experiences and best practice elsewhere and help them to see how they can facilitate this.

The shelf-life extension pilot units offer advantages in terms of offering processing services that reduce losses to majority of women farmers. Care will be exercised in establishing the pilot centers

since (a) there is a need to ensure equality of access by gender and across social groups, and (b) how they will be managed in terms of male/female control. A key gender issue is whether women processors at the household level can be competitive against men. The latter currently tend to have better access to credit and also better access to land and so can probably operate on a larger scale. Women entrepreneurs tend to be more constrained in accessing finance (including guarantees etc.) and in obtaining technical information. Positive discrimination towards entrepreneurial women (or women's groups) may be necessary to ensure a desired level of participation. The ability of women processors in particular to operate in groups is thus important to ensure that they can participate and meet supply and quality issues demanded by the market To meet strategic gender interests, the project will support the formation of women and youth groups in the fresh cassava supply areas. The groups will provide opportunities for participatory learning and action to find ways of participate in the new market. For example, capacity building and training with the groups could focus on promoting women and youth's engagement in the cassava marketing by meeting quality and volume standards to maintain market access, providing training in group management, open book accounting and financial management etc.

8. DEMAND FOR THE INNOVATION (*provide evidence that there is immediate demand for the proposed technical innovations by targeted users/beneficiaries*)

All along the value chain for cassava roots, actors often desire to quickly sell the cassava roots due to the rapid deterioration. The market price of fresh cassava roots reduces significantly 48hr after harvesting. The scoping study showed that traders and retailers are using traditional methods for extending shelf-life of fresh cassava roots including: piling the roots in heaps and covering with plant material or keeping them moist by watering them daily. However, these methods partially extend the shelf-life for two days hence, the need for more effective technologies that can prolong the shelf-life of fresh cassava roots for more than 7 days.

In addition cassava roots for the fresh market are harvested late in the evening, packaged and transported overnight to try and reach markets when it is still fresh. A technology that extends the shelf-life has been demanded by the farmers and traders to relieve marketing pressures, especially for women. Labor is also limited in such late hours. Therefore, by allowing for more relaxed harvesting schedule and reduce losses, the technology will help stabilize prices.

Focus group discussions during Scoping study (2014) showed that the operators of the major supermarkets in Kampala and major district towns are eager to try the sale of shelf-life extended fresh cassava roots. Based on this market knowledge, the research will be market-led, will build on existing and past efforts on cassava postharvest management research done by partner institutions (Root and Tuber Crop Postharvest improvement of SARRNET-IITA, IITA-CFC project on Small-scale cassava processing in Uganda and other four countries in East and Southern Africa, C:AVA-NRI-AIIFT project in Uganda, Kilimo Trust, NARO postharvest research, and other successful postharvest initiatives of CIAT, CIRAD, IITA and CLAYUCA).

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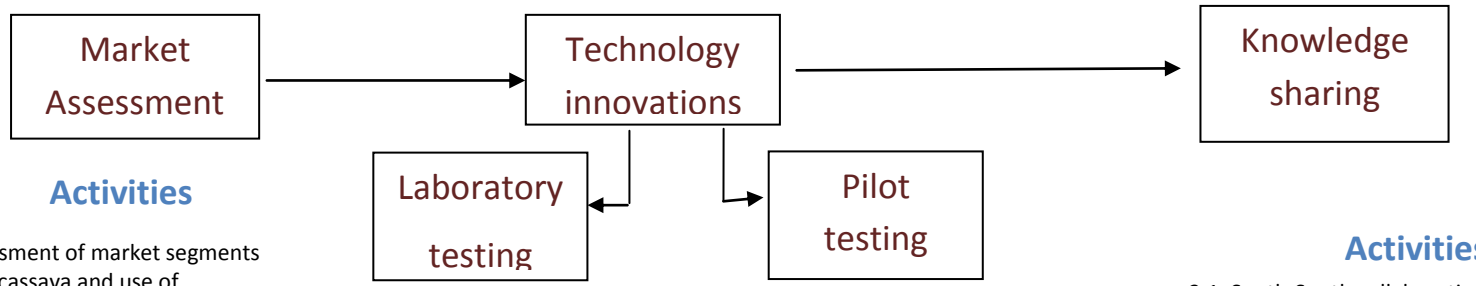
**Annex 1: Conceptual Framework**



**Annex 2:** *Waxing technology (Proposed Knowledge transfer from CIAT/CLAYUCA)*

*Receiving, pruning, cleaning*

**Cassava roots ready for washing**

**Washing of cassava roots**

Drying of cassava roots

Waxing of cassava roots

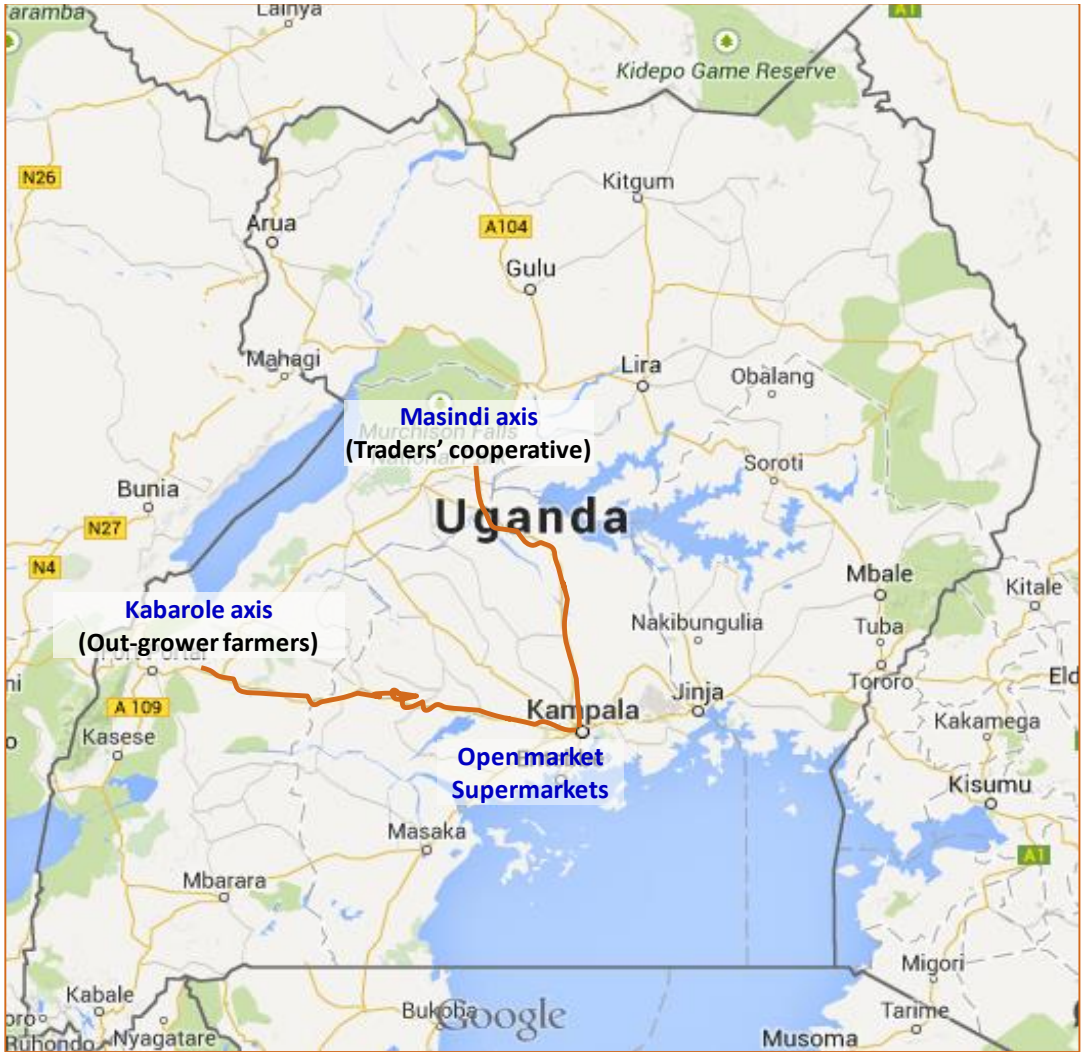
| Waxed cassava ready for marketing | Waxed cassava ready for transportation |
|---|---|
|  |  |

**Annex 3: Scoping data and costs and prices of major staple foods in Uganda**

| Parameters | Values |
|---|---|
| Price of fresh cassava in the open market (US$/ton) | 418.25 |
| Price of fresh cassava at the farm gate (US$/ton) | 113.00 |
| Price of banana in the open market (US$/ton) | 532.32 |
| Price of Rice in the open market (US$/ton) | 1901.14 |
| Price of maize flour in the open market (US$/ton) | 950.57 |
| Price of cassava flour in the open market (US$/ton) | 950.57 |
| Price of wheat flour in the open market (US$/ton) | 1140.68 |
| Labor cost/day in the region targeted for this research (US$/man/day) | 1.14 |
| Estimated cost of transporting fresh cassava from producing region targeted for this research to Kampala (US$/ton) | 22.81 |
| Estimated cost of transporting fresh cassava from farm to a waxing center in the same village (US$/ton) | 9.51 |
| Price of wax (US$/ton) | 2.58 |
| Quantity of wax used for 1ton cassava (max., kg) | 2.10 |

* Scoping results, Sept. 2014

**Annex 4: Map of proposed pilot locations and marketing axes**



*Gantt chart*

| | Y1Q1 | Y1Q2 | Y1Q3 | Y1Q4 | Y2Q1 | Y2Q2 | Y2Q3 | Y2Q4 |
|---|---|---|---|---|---|---|---|---|
| **Component 1: Market Assessment** | | | | | | | | |
| 1.1 Assessment of market segments for fresh cassava and use of deteriorated cassava roots. | | | | | | | | |
| 1.2 Best models on practices ( farmer and trader driven) for marketing of shelf-life extended cassava roots | | | | | | | | |
| **Component 2 Technology Innovations** | | | | | | | | |
| *2.1.0 Laboratory testing* | | | | | | | | |
| 2.1.1 Assessment of varietal differences on PPD/PHH | | | | | | | | |
| 2.1.2 Varietal specific effectiveness of relative humidity RH/waxing | | | | | | | | |
| 2.1.3 Training of students (3 MSc), partners and collaborators ( farmers, processors, traders) | | | | | | | | |
| *2.2.0 Pilot testing* | | | | | | | | |
| 2.2.1 Establishment of pilot packing house | | | | | | | | |
| 2.2.2 Assessment of adaptability of shelf-life extending technologies | | | | | | | | |
| 2.2.3 Economic impact of proposed technologies including gender effect | | | | | | | | |
| | | | | | | | | |
| **Component 3 Knowledge Sharing** | | | | | | | | |
| 3.1. South-South collaboration and knowledge sharing | | | | | | | | |
| 3.2. Training of farmers, traders and private sector | | | | | | | | |
| 3.3 Documentation (Scientific publications, flyers, Posters, business plans, brochures) | | | | | | | | |
| 3.4 Stakeholders workshop and Scientific conferences | | | | | | | | |