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

Proposed Business Case

Improving the shelf life of harvested sweetpotato roots in the market and household level

The Team

Name	Institution	Role
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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,)*

Sweetpotato is the third most important food security crop in Uganda after banana and cassava (Low, 2009), production is estimated at about 2.8 million tonnes (FAO, 2010); grown at least twice a

year (Gibson, 2009). The crop is grown in all districts in Uganda occupying 55% of the arable land under tuber crops (FAO, 2010); with the eastern region producing 46.6% (MAAIF, 2011). Sweetpotato is an important food and commercial crop (Andrade et al. 2009). In Kumi district, 99% of the women farmers reported that they grow it for both food and commercial purposes, while all the men farmers grow it for income (Field study, 2014). Similarly, UBOS (2013) observed that in the face of raising global food prices, sweetpotato is proving to be the best food secure and famine crop.

In spite of its increasing importance, there are high post-harvest (PH) losses due to weevil infestation, rotting, thin delicate skin, respiratory losses and sprouting of which up to 60% (Jenkins, 1982) occur at farmer level. Ray and Ravi (2007) contend that PH losses vary between 15 and 65% if stored for a period of one to four months. Losses during transportation and storage vary between 20-25% (Ali et al., 1991), while traders in various markets reported a loss of one out of 10 bags from transportation to retail attributed to poor harvesting methods, handling, packaging and transportation (Field study, 2014).

During peak harvest periods, (September - November), prices drop to as low as UGX 15,000/= (USD 6) per 120 kg bag, but can hike to as high as UGX 90,000/= (USD 36) during scarcity (February-June). The low prices discourage farmers from harvesting and selling their crop, thus causing heavy losses. These losses could be reduced by timely harvesting if farmers had appropriate storage technologies. In Bangladesh clamp storage increased shelf life of sweetpotatoes by four months (Jenkins, 1992). On the other hand, silos in Mali were reported to prolong sweetpotato shelf life for a period of five months (Kone, 1999; Dandongo and Gungular, 2011). The experience of working with clamps in East Africa has shown variable results in terms of weight loss, rotting and sprouting and varietal differences (Hall and Devereau, 2000). This is partly attributed to accumulation of carbon dioxide gas in the clamp during storage, which can be overcome through innovative removal of the gas. We also propose a modified silo which is an improved version of pit storage (common in East Africa. Other technologies like in-ground storage have been shown to prolong shelf life of harvested roots up to 3 months (Field study, 2014) and it is affordable, easy to apply and gender friendly.

This project is therefore intended to improve, adapt and promote clamp, silo and in-ground curing and storage innovations and techniques. This will ensure extended shelf life of the fresh sweetpotato roots and subsequently a sustainable supply of sweetpotato for household consumption and the market. Farmers, traders and consumers will benefit from such technologies through attainment of fairer prices arising out of reduced fluctuations in supply (Field study, 2014). This will also ultimately improve food security at household level. Chain actors will be facilitated to work together to address the challenge of sweetpotato shelflife and maximize the benefits from the new market opportunities that will be identified by the platform in an attempt to improve the sweetpotato ware chain. A robust sweetpotato ware chain will address the challenges chain actors face including barriers to entry currently faced by rural suppliers; price spikes hence more consumption due to stable consumer prices, .

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*)

Three technologies with potential to extend the shelf life of fresh sweetpotato roots are proposed, namely clamp, silo and in-ground storage.

The approach will consist of: a) improving storage methods b) establishing a functional multi-stakeholder platform c) up and out scaling of the technologies

a) Improving storage methods

Storage method 1:-Clamp

The preferred varieties with long storability will be trialed in three agroecologies (Kumi, Kamuli district - eastern Uganda and Masaka district - central Uganda). Kamuli and Masaka are located in the intensive banana coffee lake shore farming system while Kumi is located in the annual cropping and cattle Teso system. These areas are high production areas with different agro-ecological conditions. Thirty clamps with the capacity of not less than 2 tons (15 bags) will be constructed at selected farmer homesteads.

In clamp storage, roots are heaped on a plain surface in layers and each layer is covered with a thin layer of grass or paddy straw. The clamp will be modified by inserting perforated tubes that will remove carbon dioxide that hitherto had led to rapid deterioration of the stored sweetpotatoes (Hall and Devereau, 2000). In each area three varieties that have been identified in the field study will be evaluated for shelf life storability for three production seasons.

Storage method 2: Silo

A silo is an improved pit storage that has been successfully used in Mali, and could easily be adapted in Eastern Uganda. Thirty silos, with a capacity of 1.2 Mt will be constructed partially underground and roofed with locally available materials with access to the pit. The silo will be used to store three selected varieties identified in the field study in project areas with longer dry periods (about 3 months). Rigorous sorting and grading will be done to ensure high quality of the stored roots.

Storage method 3: In-ground storage

Farmers under the umbrella of sweetpotato and marketing association in Kumi district have reported storing selected sweetpotato varieties in-ground by delayed harvesting for better market prices and access to food at a later periods. Findings from the scoping study indicated that two preferred sweetpotato varieties namely Tanzania and Amongin are the ones stored in-ground for about 3 months. Amongin was reported to store in-ground for 3-4 months but has the challenge of taking long to mature (5 months). Tanzania is one of the most highly demanded varieties on the market, however, it is highly susceptible to sweetpotato virus disease (SPVD). The farmers also reported that the two varieties have a very high dry matter and that weevils do not infest them while in storage. We will investigate the conditions under which this in-ground storage takes place as well as the suitability of other varieties to store under this method. The project will enlist support from the sweetpotato program of the National Agricultural Research Organization (NARO) to clean, protect and multiply planting material to ensure continuous supply of Tanzania and Amongin vines. By the second season there will be enough roots of the preferred varieties to be used in the setup of the trials. . Because of the demand for the variety Tanzania, we will construct some net tunnels in Kumi and Kamuli to ensure continuous supply of clean planting material for the lifespan of the project and beyond. Preferred varieties which farmers have attested to having long storability (Field study, 2014) together with other popular varieties will be validated in the three agro-ecologies to confirm the maximum storage time at which roots retain their integrity (root quality, palatability, acceptability, physical attributes). Sixty trial plots of not less than 1.5 acres will be established for the sweetpotatoes planned to be sold during times of scarcity.

Monitoring and data collection

For all the three technologies, participatory monitoring and data collection on root quality, palatability, acceptability and physical attributes will be done periodically. A capacity building package will be developed to equip participating farmers with skills in proper harvesting, handling, storage and other related techniques. Participating female and male farmers will be selected from those who have willingly participated in previous post-harvest and commercialization trials undertaken by CIP and HarvestPlus. Strategies to ensure women participation will include a household approach, use of locally available materials, gender friendly training modules, schedules and locations, as well as sensitization to mitigate traditional issues that hinder access to equal opportunities, especially in Eastern Uganda (KIT, AgriProFocus and IIRR, 2012).

b) Establishment of functional multi-stakeholder platforms

Chain actors and supporters along the sweetpotato ware chain will be encouraged and facilitated to form multi-stakeholder platforms with the aim of upgrading and strengthening the chain. This will be done after a quick diagnostic study in which potential market opportunities around improving marketability ofsweetpotatoes will be identified. Following PMCA (Phase 2), each of the opportunities will be analyzed for technical, economic and social feasibility as well as gender responsiveness after which the platform will identify strategies to take advantage of the selected business opportunity (Mayoux and Mackie, 2008). Gender responsive business plans will be developed according to theme/market opportunity. The platform will explore opportunities of processing stored roots by having a processed products thematic group. As described in PMCA Phase 3, the platform will operationalize the gender responsive business plans that will result in development of technological, commercial and institutional innovations (Bernet *et al*., 2005). Close monitoring will be undertaken to ensure that equitable access to benefits arising out of the innovations by female and male chain actors.

c) Up and out scaling of the technologies:

Following identification and documentation of successful technologies several channels will be identified for scaling up and out. These will include channels such as the platform members, the sweetpotato knowledge portal, agricultural shows/fairs, and farmer field days.

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

a) Which sweetpotato varieties retain the desired consumer attributes and economic viability for longer periods after storage?
b) Which storage methods are efficient and affordable for prolonging shelf life of harvested sweetpotato roots?
c) What market opportunities provide the best bet to enable female and male chain actors to benefit from improved storability of sweetpotatoroots?
d) What is the most appropriate dissemination model to upscale proven shelf life extension technologies to male and female actors?

3. Table 1: OUTPUTS/DELIVERABLES (*specify the outputs/deliverables to be produced and indicate when they will be available within a 2 year time frame*)

Research output/deliverable	Expected time(year/quarter)
1. At least 2 Sweetpotato varieties which retain desirable consumer attributes after storage, identified and documented	Second quarter 2016
2. Two storage methods that best suit extension of shelf life of sweetpotato roots at household level identified and validated	First quarter 2016
3. At least 30% of the women in the project sites taking advantage of the proven shelf life prolonging technologies	Third quarter 2016
4. Most appropriate dissemination model to upscale proven shelf life extension technologies to male and female actors tested and validated	Second quarter 2016
5. Protocols for proper curing, storage and dissemination models developed	Third quarter 2016
6. A functional multi stakeholder platform established	Third quarter 2016

DEVELOPMENT GOAL

Goal: Increasing food security and incomes of sweetpotato farmers and traders in eastern and central Uganda through improved shelf life of harvested storage roots.

Out of about 4 million total agricultural households in Uganda, 10 % are involved in sweetpotato production. Besides, almost all households consume sweetpotatoes. During peak harvesting periods, there is significant decline in prices which increase post-harvest losses related to delay in harvesting. There is need to reduce losses during such periods and subsequently enhance income and food security.

The proposed intervention will increase food security of about 40,000 households (10%) involved in production of sweetpotato and increase their incomes by 20% in ten years as exemplified from the scoping during which storage of 10 bags in a season earned the farmer extra income of UGX 700,000. The scoping study established that about 90 % of women are involved in sweetpotato production. Similarly, the report also indicated that an indicative ratio of 3:2 (women: men) are involved in sweetpotato marketing. As such, the proposed interventions will be of benefit to women (60%) and to men (40%) at market level and more than 50% women at production level. Gender transformative strategies will be designed to ensure more equitable access to and control of resources at the various nodes of the chain, especially to increase participation and visibility of women in areas where profits are greatest.

The proposed technologies are all environmentally friendly since they will mostly use local materials that are degradable. Overall this will enhance the food security of more than 5 percent of the households especially in drought prone areas and increase incomes of both women and men at different marketing levels.

4. Table 2: 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)*
1. At least 2 Sweet potato varieties with economically appreciable storability attributes identified and documented	Commercial sweetpotato producers Traders Pig farmers Small scale processors	10,000 commercial sweetpoato producers, 50 Small-scale processors, 150 Assemblers 300 Wholesalers 1500 Retailers 150 commercial Pig farmers	At least 2 sustainable markets established Guaranteed supply during times of scarcity and satisfaction for consumers Commercial pig farmers have access to sweetpotato roots and vines for silage making	Urban and Peri-urban consumers have more consistent supply at more stable price Farmers and consumers have access to preferred varieties	Increased participation of marginalized gender in nodes with higher benefits Better sharing of resources and benefits from sweetpotato trade at household level	Reduced waste and reduced negative impact on environment Storage methods are environmentally friendly Materials are reusable The sweetpotato crop forms a good canopy which protects the soil from direct rain drops, hence helps to conserve the soil, and helps to reduce soil erosion

2. Storage methods that extend shelf life of sweetpotato roots at household level identified and validated	Producers	200,000 households	There is 5% adoption in 10 years	Improved food security at household level	Technologies accessible at household level Reduced drudgery for women in their roles of food provision for the family due to ease of storing roots for longer periods	Reduced waste and negative impact on environment
3. Gender transformative market opportunities implemented	Sweetpotato Producers, Small-scale processors, Traders Consumers	200,000 sweetpotato producers, 50 small-scale processors, 500 retailers	Increased use of the proven technologies that prolong shelf life Increased income	Improved food security and livelihood and productivity	Technology will benefit to both men and women	Reduced waste and negative impact on environment

4. Most appropriate dissemination model to upscale proven shelf life extension technologies to male and female actors tested and validated	Producers Small-scale processors, Retailers	200,000 producers, 50 small-scale processors, 500 retailers	Increase in consumption of stored processed products at expected times of sweetpotato scarcity	improve food security	Technology will benefit to men, women and the youth	Reduced waste andnegative impact on environment
5. Protocols for proper curing, storage and dissemination models documented	Next users of the technology- extension workers, CBOs, NGOs	All CBOs, NGOs, and extension workers promoting sweetpotatoes in the project area	Increased use of the proven technologies that prolong shelf life	Improved food security at household level	Information on the technology will benefit to men, women and the youth	Reduced waste and negative impact on environment
5. A functional multi-stakeholder platform established	Producers Small-scale processors, Retailers Researchers	50 producers, 50 small-scale processors, 50 retailers	Increased efficiency along the ware chain of sweetpotato	Improved marketing, and returns for producers, retailers	Improved efficiency will benefit both men and women	Reduced waste and negative impact on environment

2. FEASIBILITY:

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

Several technologies have been applied in the tropics to prolong the shelf life of sweetpotato roots. The technologies comprise pre-harvest and traditional post-harvest practices such as growing of varieties with desirable storability qualities, pre-harvest curing by cutting of vines prior to harvesting time, and post-harvest storage using pits and clamps. Countries where these technologies have been tried include Bangladesh (Jenkins, 1982), India (Prasad *et al*., 1981; Ray and Ravi, 2007), Kenya (Karuri and Ojijo, 1994, Karuri and Hagenimana, 1995), Malawi (Woolfe, 1992), Tanzania (Rees *et al*., 2003a; Tomlins *et al*., 2007) and Uganda (Hall and Devereau, 2000). However, variable results have been registered depending on country and materials used.

For instance in Bangladesh, roots piled on a bench-like structure made of bamboo plastered with mud stored roots for a period varying between 2-4 months with a post-harvest loss of 20 - 25% (Jenkins, 1982). In the Philippines, roots covered with sand and sheltered by a roof resulted in 35% decay and 45% sprouting after 50 days (Cadiz and Baustita, 1967).

In Uganda, clamps were tried on an experimental basis in Soroti (Hall and Devereau, 2000). The technique seemed effective for storing fresh sweetpotatoes for up to 3 months, long enough to make a difference when local food security is most uncertain (Hall and Devereau 2000) but post-harvest losses varied with cultivar.

On-going work in Uganda (BIOFORT annual report, 2013) revealed that curing sweetpotato roots by cutting off vines 4-5 days prior to harvest reduced rotting by 17% and the resulting roots stored under farmer conditions for 40 days. In Tanzania, in-ground curing for 14 days significantly reduced skinning injury at harvesting in roots that had been subjected to mechanical damage. Pre-harvest curing for 14 days further reduced rots in roots that had been subjected to mechanical damage and stored at ambient temperature for 14 days (Tomlins *et al*., 2002). Prasad *et al.* (1981) found bruised storage roots to rot first in storage; besides they associated increased occurrence of rots during storage to the injury, where damaged roots registered higher root loss of 55.5% compared to 27.2% in undamaged storage roots.

Findings by Hall and Devereau (2000) and Tomlins et al. (2007) concluded that improved storage offers benefits for food security and that families can be able to access food three months after harvest. Therefore, the proposed study will build on previous work by Hall and Devereau (2000) and Tomlins et al. (2002; 2007) to tackle the problems of limited shelf life of harvested sweetpotato roots. The shortcomings associated with the storage methods will be addressed with the different modifications proposed. Besides, storage, other practices that foster long term storage like pre-harvest curing, proper harvesting, sorting, packaging and proper handling of roots will be emphasized during trainings.

We have proposed that Robert Mwanga-Sweetpotato (SP) breeder with vast knowledge of SP research leads the proposed project. He will lead a team consisting of an Agronomist, Seed system specialist, Value chain experts, Socio-economists, post-harvest specialists etc. The agronomist and seed system specialist have a wealth of experience in post-harvest handling as well as SP production and SP varieties in Uganda. The team also has value chain and marketing experts as well as private

partners. For example the SP traders in Kumi will be very instrumental in the setup as well as marketing of the SP after storage. The team is therefore experienced and eager to work towards improving SP shelf life.

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

Table 3: Farm-level Gross Benefits (UGX) for sweetpotato during peak and off peak harvest seasons in Kumi in year 2014 (Namanda, 2013)

Description	Peak harvest months (Sept – Dec)	Off harvest season months (Jan – Jun)
Cumulative total production costs (variable costs)	544,500	744,500
Estimated Storage cost for 10 bag per season	0	600,000
Lost bags during storage (2%)	0	1
Av. Yield per acre (bags)	27	27
Adjusted yield per acre (bags)	27	26
Av. Farm gate price per bag of fresh roots at harvest/ after storage	30,000	100,000
Gross income	810,000	2,600,000
Farmer's Gross Benefits	265,500	1,255,500

During peak harvest periods, sweetpotato as a food based commodity becomes minor and very less market competitive and un-preferred for consumption. Reports from FoodNet Uganda and sweetpotato trading associations indicate that during general food scarcity, it becomes the most preferred crop for both rural and urban households especially by the low income dwellers. Table 3 shows that storing 10 bags of roots under clump store for 3 – 4 months increase the farmers' incomes by at least 4 times . Since sweetpotato is also a staple food in Kumi, prolonging shelf life would enhance access to food and save on household incomes as farmers during the scoping reported moving to distant markets to buy fresh roots at inflated prices during periods of scarcity. The farmer could recover the cost of construction of the clamp store within a season. Kumi sweetpotato traders association indicated that prices of fresh roots dropped to less than about 30,000/= per bag around October and rose up to 100,000/= per bag of roots during the period March to May 2013. Similarly, farmers in Mali reported extended fresh root utilisation and increased incomes through storing sweetpotato roots using silos.

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

Sweetpotato is a widely acceptable food that fits easily into many farming systems in Uganda. Dissemination and sensitization on Vitamin A nutritional benefit through community based organizations has greatly promoted its production and consumption. Sweetpotato is now available on menus offered by restaurants and hotels catering for low to medium urban consumers, unlike in the past. It is largely consumed as freshly boiled or steamed, and because of its short maturity it bridges the hunger gap in many households (Gibson, 2009). The crop is largely grown and retailed by

women, hence regarded as a woman's crop (Andrade 2009, Gibson, 2013). Acceptability cuts across the young and old in the family though adults prefer varieties with higher dry matter content. Given the limitation in storage of fresh sweetpotato roots, families face food scarcity during the dry months. This affects mostly women given their triple role of reproduction, production and caregivers in the family and the community at large (Apotheker et al., 2013). During intense food scarcity, women provide food to children and their husbands and only eat last if there is any left.

The proposed technologies will not only avert food insecurity, they will be easy to access, afford and utilize by women since the technologies are simple, some will be based at home and will be constructed from locally available materials. The technology will save time spent by women to collect food far from their homes. The youth will benefit through engaging in transportation of the stored roots to the market and also through provision of labor to construct the storage technologies. Men will be encouraged to invest in commercial sweetpotato production after realizing the benefits of off season trade.

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

Whereas sweetpotato is widely grown and consumed in all the districts in Uganda (UBOS, 2013), more than 40 percent is lost after maturity through weevil damage, rotting, and general root deterioration due to rotting, shriveling, sprouting etc. Gibson 2009). Throughout the entire production-marketing continuum, chain actors tend to opt to sell the fresh roots as soon as possible in an attempt to reduce losses incurred from post-harvest handling and storage. Farmers prefer to harvest before the beginning of long dry season to avoid losses caused by weevil and desiccation. Wholesalers prefer to hand over the produce to the retailers as soon as possible to avoid losses during transit and storage. Retailers need to sell at low attractive prices to stimulate turn-overs. Consequently these desperate decisions or actions by farmers and traders result into drastic supply gluts and shortages resulting into uneconomic returns, food availability instabilities and interrupted commodity-based occupation. Thus improving the shelf life of fresh roots would enhance food security and incomes especially during periods of general food shortage to stabilize commodity competitiveness on the market and strengthen chain actors' confidence.

Findings from the scoping study showed that, post-harvest technologies that prolong shelf life are highly demanded by the sweetpotato farmers since they will enable them to sell when there is high demand and, therefore, higher prices. The proposed technology will minimize rotting of the roots hence reduce losses especially at farmer level. Farmers and consumers also revealed that stored roots are sweeter than freshly harvested roots. Consumers further indicated that they would be willing to buy stored for as long as there are no significant changes in the desired attributes, especially during times of scarcity (Field study, 2014)

References

Ali, M.S., Bhuiyan, M.K.R., Mannan, M.A., and Rashid, M.M., 1991. Post-harvest handling and utilization of sweetpotato in Bangladesh, in *Sweetpotato in South Asia: Post-harvest Handling, Storage*. *Processing & Uses*. Dayal, T.R., Scott, G., Kurup, G.T., and Balagoplan, C., Eds., CIP- CTCRI, Trivandrum, India, 13.

Andrade, M. I. Barker, H. Dapaah, H. Elliot, S. Fuentes, W**.** Grüneberg, R. Kapinga, j. Kroschel, R. Labarta, B. Lemaga, C. Loechl, J. Low, J. Lynam, R. O.M. Mwanga, O. Ortiz, A. Oswald and G. Thiele. 2009. Unleashing the potential of sweetpotato in Sub-Saharan Africa: Current challenges and way forward. International Potato Center (CIP), Lima, Peru. Working Paper 2009-1. 197p

Apotheker, R., Pyburn, R. and Laven, A., 2012. Why focus on gender equity in agricultural value chains? *in* KIT, AgriProFocus and IIRR (2012). Challenging Chains to Change: Gender equity in agricultural value chain development. KIT Publishers, Royal Tropical Institute , Amsterdam.
Bernet, T., Devaux, A., Thiele, G., López, G., Velasco, C., Manrique, K., Ordinola, M., 2008. The Participatory Market Chain Approach: Stimulating pro-poor market-chain innovation. ILAC Brief 21, ILAC-CGIAR.

Cadiz, T.G., and Baustita, O.D.K., 1967. Sweetpotato, in *Vegetable Production in South East Asia*, College of Agriculture, University of Philippines, Los Banos, Laguna, Knott, J.E., and Deanon, J.R., Eds., 48.

FAOSTAT, 2010. FAO *FAOSTAT* (http://faostat.fao.org).

Gibson, R. W. M., Mwanga, R.O.M, Namanda, S; Jeremiah, S.C. and Barker, I., 2009. Review of sweetpotato seed systems in East and Southern Africa. Lima, Peru, , International Potato Center (CIP).

Gibson, R.W.M., 2013. How sweetpotato varieties are distributed in Uganda: actors, constraints and opportunities

Hall, A.J. and Devereau, A.D., 2000. Low-cost storage of fresh sweet potatoes in Uganda: lessons from participatory and on-station approaches to technology choice and adaptive testing. *Outlook on Agriculture* **29**,275 –282

Jenkins, P.D., 1982. Losses in sweetpotatoes (*Ipomoea batatas*) stored under traditional conditions in Bangladesh. *Trop. Sci.*, **24**:17.

Karuri, E.G. and Ojijo, N.K., 1994. Storage studies on sweet potato roots: experiences with KSP20 cultivar. *Acta Horticulturae* 368: 441-452.

Karuri, G.E. and Hagenimana, V., 1995. Use of ambient conditions and sawdust in storage of sweet potato (*Ipomoea batatas* L.) roots in Kenya. *Zimbabwe Journal of Agricultural Research* 33: 1-9.

KIT, AgriProFocus and IIRR, 2012. Challenging Chains to Change: Gender equity in agricultural value chain development. KIT Publishers, Royal Tropical Institute , Amsterdam.

Kone, S., 1991. Traditional methods for prolonged storage of sweetpotatoes in Mali. *Gate (Eschborn)*, **2**:14.

MAAIF, 2011. Ministry of Agriculture Animal Industry and Fisheries, Statistical Abstract 2011.

Mayoux, L and Mackie,G., 2008. Making the strongest links: A practical guide to mainstreaming gender analysis in value chain development. , ILO.

Prasad, S.M., Srinivasan, G. and Shanta, P., 1981. Post harvest loss in sweet potato in relation to common method of harvest and storage. *Journal of Root Crops* 7: 69-73.

Ray, R. C. and Ravi. V., 2007. Post Harvest Spoilage of Sweetpotato in Tropics and Control Measures. *Critical Reviews in Food Science and Nutrition: 623-664pp*

Rees, D., Kapinga, R., Mtunda, K., Chilosa, D., Rwiza, E., Kilima, M., Kiozya, H., and Munisi, R., 2001. Effect of damage on market value and shelf-life of sweet potato in urban markets of Tanzania. *Tropical Science* 41: 142-150.

Tomlins, K. I., Ndunguru, G. T., Rwiza, E. and Westby, A., 2002. Influence of pre-harvest curing and mechanical injury on the quality and shelf life of sweet potato (*Ipomoea batatas* (L) Lam) in East Africa. *Journal of Horticultural Science and Biotechnology*, 77: 399-403.

Tomlins, K., Ndunguru, G., Kimenya, F., Ngendello, T., Rwiza, E., Amour, R., van Oirschot, Q. E. A. and Westby, A., 2007. On Farm evaluation of methods for storing fresh sweet potato roots in East Africa. *Tropical Science*, 47: 197-210.

UBOS, 2013. Statistical abstracts November 2012. Uganda Bureau of statistics (UBOS) www.ubs.org.

Woolfe, J.A., 1992. *Sweet Potato an Uuntapped Food Resource*, Cambridge University Press, Cambridge, UK, ISBN 052140295, 643 pp.

Appendix 1: Gender sensitive sweetpotato value chain map for Kamuli and Kumi districts in Uganda