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

Proposed Business Case

Improving the Utilization of Sweetpotato and other Root and Tuber Crop Residues for Pig Feeds in Uganda

THE TEAM

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1. DEVELOPMENT PROBLEM/OPPORTUNITY

In Uganda, the demand for animal products is increasing due to the ever increasing human population, improved income and urbanization. Uganda smallholder pig industry is rapidly growing with 1.1 million of smallholder households rearing 3.5 million pigs (Peters et al., 2001; Tatwangire, 2013). Pigs are typically kept by women (Ouma et al., 2014). While the consumption of other livestock meat such as bovine meat is reducing, that of pork is increasing, and pork ranks fourth in terms of per capita meat consumption (Tatwangire, 2013). Pig raising has a high potential to provide economic gain for smallholder farmers. High feed conversion efficiency, and high fecundity as well as short generation intervals (Lekule and Kyvsgaard, 2003) make pigs convenient and profitable to rear, and quick way for income generation for improved livelihoods among poor household. Farmers in Uganda have identified feeding as the most important constraint in pig production (Ouma et al., 2014). A recent study undertaken by ILRI showed that the cost of feeds represents 62% of the total cost of pig production in peri-urban area of Uganda (Lule et al., 2014). Among all feeds, commercial concentrates are the most expensive. To reduce these costs, smallholder pig producers resort to feeding local feed resources such as chicken litter, swill, jack fruit, brewers waste, maize stover and other plant leaves (such as *Ficus natalensis*). Seasonal feed shortages, poor quality feed and limited supplementation are the major feed constraints in the pig production systems in Uganda (Ouma et al., 2014).

We propose to improve the utilization of sweetpotato vines, roots and peels as pig feed to help overcome this feed constraint. This is due to the fact that Uganda is the largest SP producing country in Africa. Sweetpotato (SP) contributes about 20% of total crop residues provided by roots and tuber crops (Ouma et al., 2014). The sweetpotato by-products that are currently used as feed resources include sweetpotato vines (SPV), non-commercial sweetpotato roots (SPR) and sweetpotato peels (SPP). Farmers in Soroti and Dokolo districts, northeastern Uganda feed 1.9-2.7 kg of SPR per day to pigs in addition to unknown amounts of SPP and cottage breweries wastes (Peters et al., 2001). This amount is within the range (1.3-2.8 kg/day) that smallholder farmers in Vietnam fed to their pigs (Tu P et al., 2010).

One major negative attribute of sweetpotato is that although it is a good source of energy (roots) and protein (vines), they are highly perishable. In order to make good use of SPR, SPV and SPP there is need to explore strategies that will conserve the resources during the time of abundance for use during the times of scarcity. (Bashaasha et al., 1995; Peters et al., 2001) have reported that there is a lot of wastage of SP products during period of abundance due to lack of suitable conservation techniques. A field study in Kamuli district estimated the amount of SP vines rejected at household level at 40% of the total produced annually (excess that could not be consumed either by people or by pigs). Hence, there is need to promote appropriate conservation methods to deal with the challenge posed by producing sweetpotato during the periods of abundance. Silage making is a potentially easy and affordable technology that farmers can use to conserve roots and vines for feeding pigs in times of shortage. However, the technology is not known amongst smallholder producers and has not been validated in Ugandan conditions.

Past studies show that feeding SPS has variable effects on economic gains in pigs (Huang et al., 2003b; Tewe, 2004; Kiragu, 2014). Depending on the additives used in the silage recipes, feeding SPS increases growth rates and reduces costs. A study by Peters et al., (2001) reported increased feed efficiency when chicken manure was the additive used in SPS preparation. A previous study has shown that when SPV and SPR are ensiled together with cassava leaves it replaces more than 70% of the protein from fish meal (or 35% of total diet crude protein), reducing feed costs without affecting growth and carcass quality of pigs (Nguyen et al., 2010).

Sweetpotato silage has potential to mitigate seasonal feed shortages and help cope with seasonal feed prices fluctuations that many smallholder pig producers experience. It also provides opportunity to reduce waste in urban market and at household level as well as can open up business opportunities for youth and women.

2. APPROACH

The proposed technical innovation

Silage making technology

Ensiling involves chopping the materials in small pieces and compressing the chopped materials in airtight silos. Ensiling vines requires highly fermentable carbohydrate source including cereal grains, molasses, and root meals from cassava or SP. It removes risk of toxicity due to anti-nutritional factors (e.g. trypsin and chymotrypsin inhibitors) and harmful microorganisms (Nguyen et al., 2001). It also degrades some unpalatable substances in the feeds and enhances their palatability (Kayouli and Lee, 1999). Silage can ensure off-season availability of feed for at least three months from materials which would otherwise go to waste due to high moisture content (Giang and Ly, 2004).

How the silage technology has been used with sweetpotato residues

Sweetpotato silage (SPS) is a method for preserving vines and roots in a succulent condition in a silo. Well-made SPS is a wholesome and nutritious feed for all classes of cattle and pigs. It can be made with chopped vines only or combined chopped vines with roots at different ratios. Many studies have showed that ensiling SPR and SPV hardly reduces the quality of the original materials (Giang and Ly, 2004; Khalid et al., 2013a). Experiences on silage production by the East Africa Dairy Development Project (EADD) led by Heifer International in Kenya realized high quality silage of 11.8% Crude Protein (CP) and 2200 Kcal/Kg metabolizable energy (Khalid et al.) and pig growth rates of 0.23 g/day when using 45% silage in the pig diet (Kiragu, 2014).

Improving SPS-based diets using strategic supplementation

Sweetpotato silage cannot provide the entire nutrients requirement for maintenance, growth and reproduction in pigs. Farmers use a number of other feed materials whose contribution to the nutrient budget in piggery cannot be ignored. In peri-urban and urban areas, tthese include cereal grains, agro-industrial by-products, weeds, industrial and cottage breweries wastes, blood, meat and bone meals, leguminous forages. In urban rural areas often the basal diet comprises pastures, crop residues, swills and home mixed feeds..

(Katongole et al., 2012). Rational choices among alternative feed resources will require a decision support tool to guide farmers.

Currently there is no systematic and rational supplementation strategies based on these feed resources for pig rearing among smallholder farmers in Uganda. Further, there are no SP based feed recipes for rearing pigs hence the need for investment in research ration balancing based on promising dual-purpose SP varieties and other local feed ingredients, improved silage making techniques and feed supplementation strategies.

The opportunities for replicating successful experiences from the above experiments exist in Uganda because of the abundant availability and access to residues from SP and other RTBs for making silage and local feed resources, thus creating a business case for SPS production and utilization for pig feed in Uganda.

The business model

The business case focuses on innovation and change in the organization of silage production to transform production and utilization of SPR and SPV by creating value to attenuate the constraint of pig feed shortages. The business model is designed to generate three benefits (figure 1): i) *create value propositions*, ii) *improve revenue streams*, and iii) *organize activities for silage production and utilization at various levels of the SP and SPV value chains for pig feeds and human food*.

Value propositions will be created at various levels of the SP value chains through reduced feed cost, increased availability of pig feed, increased nutritive value of SP feeds, employment, reduced labor costs, gender empowerment and social inclusion, employment for the youth, women and men, increased social acceptability, improved knowledge and environmental sustainability.

Revenue streams will be generated through employment and sales at various levels of the SPS value chain by engaging the youth, women and men in SP production as business, supply of SPRs and SPVs for silage making, and engaging in silage making and trade as a business.

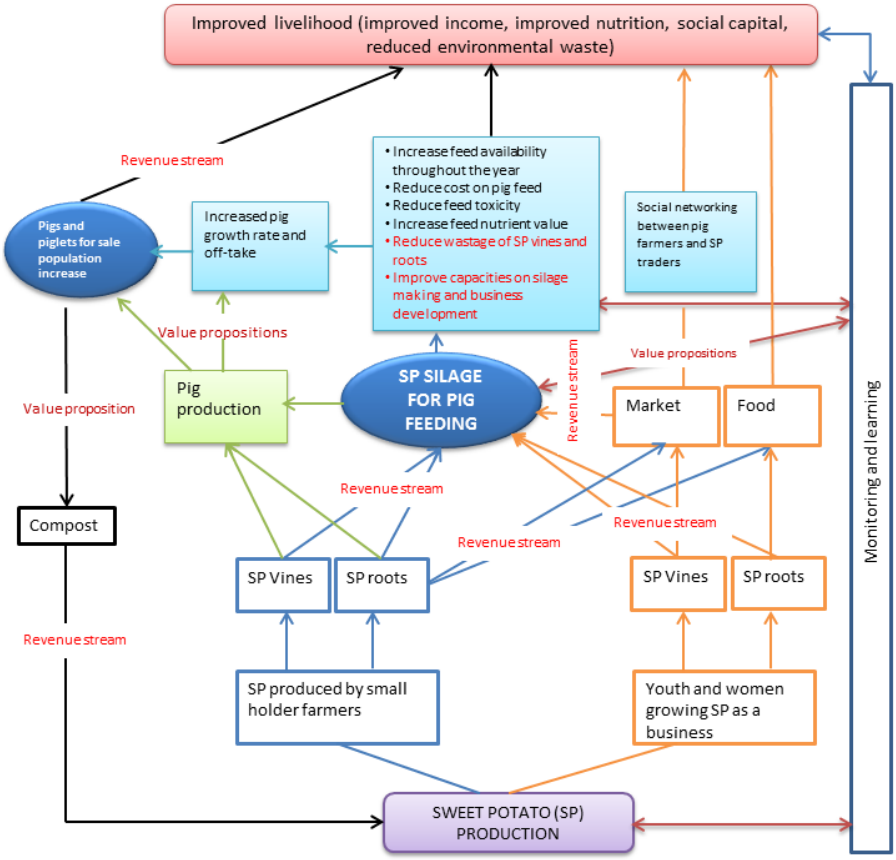

Figure 1: The multi-level business model of SPS in the smallholder pig value chain in Uganda

The business case will help to create a model for proper organization of silage production, conservation, marketing and use at various levels of the SPR and SPV value chains purposely for pig feeds. The existing linkages between pig farmers and SP traders in the peri-urban and urban SP markets will be strengthened to increase access of SP materials from the markets and other RTB farms.

Capacity building strategies

Capacity building for women, men and youth will be carried out on entrepreneurship and effective business operations on a regular basis coupled with business mentorship programs. In order to support various private sector actors to effectively operate their businesses and help move research outputs to scale; a number of 'tailor made' technical and business-oriented training modules targeted at different types of actors will be designed and offered at critical stages in the implementation of the project in Year 2. The project will design training modules designed at

(i) Enhancing uptake of new knowledge and practices by sweetpotato producers, processors (silage makers) and pig producers.

(ii) Institutions that are target to become the next-users of research results such as NARO and other NGOs. The capacity building at the stage will be a sustainability strategy to ensure information remains within each of these communities.

These training modules will be delivered through formal training sessions, on farm demonstration approaches, exchange visits amongst others. Finally the project will package

research outputs for use by extension and development agencies, or in the curriculums of training organizations and universities.

The business model will be implemented through platforms of key stakeholders in the SP and smallholder pig value chains. Key activities will include formation of gender transformative innovation platforms of farmers, scientists, students, change facilitators (extension officers, and NGOs), input and output marketing agents; and policy makers/opinion leaders.

Silage technology: a gender responsive innovation technology

A field study showed that women and youth are more invoved in activities such as feeding, watering and cleaning of the pig pen while men are more involved in house construction, swine health and marketing. Activities related to feeding are usually time and labor consuming especially during seasons of feed scarcity. These include the cooking of crop residues such as SPRs, walking for long distance to search for feeds especially swill and kitchen waste. Therefore, given the ability of silage to be preserved, for more than three months without adulteration, silage making will allow women and youth to reduce time for searching of feeds for their animals. It will also cut on the time they spend and the labor in feeding practices that involve cooking of SPR and other RTB, drying and pounding for pig feeding. Studies confirmed that silage making is more cost effective in terms of labor and fuel for cooking as compared to other practices such as cooking of SPR (Peters et al., 2006).

Execution plan for the business model

The business plan will be executed through pilot and monitoring activities. Two piloting channels are proposed:

1) *Collective action with farmers group*

Farmer groups in Masaka and Kamuli districts will be selected based on current and potential involvement in silage making. Groups such as "Kyanamukaka-Kabonera pig cooperative" in Masaka, which is a well-established group that aims at addressing marketing and production constraints such as feeding and feeds availability, will be involved. The same cooperative is already engaged in silage making using available materials on-farm. The business case will build on the ongoing activities and explore opportunities for organizing the on-going silage making into a business, by supporting the cooperative to set up a feed shop for selling and advising on silage feed. Synergies will be built for potential integration to other initiatives in the project areas such as the hub models that are being designed by ILRI smallholder pig development projects in the same areas (Masaka and Kamuli) with farmers group in order to engage them in collective marketing and access to services such as feeds, health and training. This will provides an opportunity for linking silage producers to market for pig feed.

2) Individual farmers (champions)

Individual farmers will be identified and selected in their communities to champion on-farm silage making and feeding especially in Kamuli where no farmer was reported to be

preparing and feeding pigs on silage. The study will benefit from the project's monitoring and evaluation strategy throughout the piloting exercise in order to assess the changes of farmers in feeding behavior and practices. It will also help assess the potential for uptake of the innovation by the stakeholders.

3) Proposed delivery mechanisms

Two delivery mechanisms are proposed for enhanced utilization of the technology:

a) Silage making in a central place and marketing to smallholder farmers.
In areas with high concentration of smallholder pig farmers, silage will be prepared in a central place. The silage will be packaged in various weights in a bid to respond to farmers' needs. This model would be more cost effective especially for farmers that have smaller numbers of pigs, who would pick up the desired volumes as and when needed. The silage making place could be individually owned, or run on a cooperative model.

b) Itinerant SPS making by rural enterprise moving (with equipment) from community to community to produce silage there.

Both delivery mechanisms will explore involvement of youth in silage making as commercial enterprise. This model will be ideal for young entrepreneurs, who will be trained to prepare the silage, and linked to lending institutions for the purchase of the necessary equipment. It will also have the advantage of bringing the youth back to agriculture, which is a big challenge currently. Business plans will be prepared for this model and afterwards initial pilots will be run in four project locations to assess best 'fits' for the various project areas.

3. MAIN RESEARCH QUESTIONS

The main research questions are:

- What are the best options for the use of land and feed resources that are technically feasible; economically viable; socially acceptable for SP- Pig System development in Uganda?
- What are the most effective, viable and socially acceptable SPS preparations and feeding regimes for smallholder pig production in Uganda?
- What are the best dual-purpose SP varieties for production in the targeted biophysical and socio-economic niches for SP and pigs production systems in Uganda?
- Which delivery mechanisms are most effective for producing and marketing SP silage to small and medium scale pig producers, especially women, in Uganda?

4. OUTPUT/DELIVERABLES

Details on project activities, expected outputs, deliverables, timeframes and responsibilities are presented in Table 1 and Table 2.

Table 1: Outputs, activities and deliverables

Research output/deliverable	Activities	Delivered outputs	Next users
1. Knowledge on pig feed resources (quantity, quality and seasonality) in Masaka and Kamuli districts in Uganda documented	1. Daily records of feeding in selected farms	Reports and scientific publications in peer reviewed journals	Pig and SP farmers
	2. Sampling of feeds		
	3. Laboratory analysis		
	4. Scientific partner meeting to discuss results		
	5. Feedback results to farmers		
2. At least 2 methods for SP silage preparation validated and piloted in the targeted districts	1. On station trial: (a) set up silage trial (b) conduct lab analysis of the silage (c) conduct feeding trials - (silage and supplementation) (d) assessment	Protocols for SP silage preparation, Reports, 1 MSc thesis (Makerere), Scientific papers	Pig and SP farmers; youth entrepreneurs; pork processors
	2. Economical optimum levels of energy and protein supplementation using available local resources determined and documented (on station)		
	3. Types and levels of additives for cost-effective SP silage production determined (on station)		
	4. On farm trial for validation during 2 cropping seasons: (a) set up silage trial (b) conduct lab analysis of the silo (c) conduct feeding trials - (silage and supplementation) (d) assess and select best feeding		
3. Dual purposes SP varieties and their cutting management identified and promoted	1. Identify potential dual purpose varieties suitable for pig feeding from the National SP programs	Report, 1 MSc thesis (Martyrs University), Sweetpotato varieties for silage and multiplication	Pig and SP farmers
	2. Establishment and assessment of on farm/on station trials		
4. Capacity for uptake of silage making as a business for the youth, women and men strengthened	1. Identify capacity needs of the participating farmers	Training reports (with assessment of strengthened capacity), Demonstration centers equipped, Report on silage up taking	Pig and SP farmers; entrepreneurs (youth, women and men); pork processors
	2. Train and equip selected demonstration centers for silage making		
	3. Monitor and evaluate up take of silage making		
5. Economic viability and social acceptability of SP pig systems validated and documented	1. Conduct willingness to pay studies	Reports, BSc theses	Pig and SP farmers; pork and SP consumers
	2. Conduct economic and social feasibility study of the proposed business models for silage production and marketing		
6. At least 2 dissemination models for the innovation tested and best models identified and promoted for scaling up	1. Select business models to pilot	Workshops, Trainings reports	Pig and SP farmers; entrepreneurs (youth, women and men); pork processors; pork and SP consumers
	2. Develop simple business plans for the pilots		
	3. Pilot set up (running, testing and validation)		
	4. Dissemination of the project results		
	5. Regular attendance of selected project participants to Pig Stakeholders Platform meetings		

Table 2: Timeframe of activities, leading and collaborating institutions

Research output/deliverable	Activities	Quarter								Leading Institution (Lead	Collaborating institutions
		Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8		
		H/S		H/S		H/S		H/S			
1. Knowledge on pig feed resources use (quantity, quality and seasonality) in Masaka and Kamuli districts in Uganda documented	1. Daily records of feeding in selected farms									ILRI	CHAIN UGANDA, VEDCO
	2. Sampling of feeds										CHAIN UGANDA, VEDCO
	3. Laboratory analysis										MAKERERE (bench fee)
	4. Scientific partner meeting to discuss results	From NARO and local markets									CIP, NARO, CHAIN UGANDA, VEDCO, MAKERERE, UMU, PPM
	5. Feedback results to farmers										CHAIN UGANDA, VEDCO
2. At least 2 methods for SP silage preparation validated and piloted in the targeted districts	1. On station trial: (a) set up silage trial (b) conduct lab analysis of the silage (c) conduct feeding trials - (silage and supplementaton) (d) assessment	X	X	X	X	X	X			ILRI	NARO, MAKERERE (David), Makerere (MSc student)
	2. Types and levels of additives for cost-effective SP silage production determined and promoted (on station)	X	X	X	X	X	X				NARO, MAKERERE (David), Makerere (MSc student)
	3. Economical optimum levels of energy and protein supplementation using available local resources determined and documented (on station)	X	X	X	X	X	X				NARO, MAKERERE (David), Makerere (MSc student)
	4. On farm trial for validation during 2 cropping seasons: (a) set up silage trial (b) conduct lab analysis of the silo (c) conduct feeding trials - (silage and supplimentaton) (d) assess and select best feeding option										NARO, MAKERERE (David), VEDCO, CHAIN UGANDA
3. Dual purposes SP identified and their suitability for silage and cutting management assessed	1. Identify potential dual purpose varieties suitable for pig feeding from the National SP programs									CIP	NARO
	2. Establishment and assessment of on farm/on station trials	X	X	X	X	X	X				VEDCO, CHAIN UGANDA, UMU (MSc Student), NARO
4. Capacity for uptake of silage making as a business for the youth, women and men strengthened	1. Identify capacity needs of the participating farmers									VEDCO (Kamuli) and CHAIN UG (Masaka)	PPM, NARO, Makerere
	2. Train and equip selected demonstration centers for silage making										PPM, Makerere (David)
	3. Monitor and evaluate up take of silage making										CIP, ILRI
5. Economic feasibility and social acceptability of SP pig systems assessed and documented	1.Conduct willingness to pay studies					X				ILRI	CIP, MAKERERE (1-2 undergraduate students in Kamuli), UMU (1-2 undergraduate students in Masaka)
	2. Conduct economic and social feasibility study of the proposed business models for silage production and marketing					X					CIP, MAKERERE (1-2 undergraduate students in Kamuli), UMU (1-2 undergraduate students in Masaka)
6. At least 2 dissemination models piloted and best models identified for promotion and scaling up	1.Select business models to pilot									CIP	All
	2.Develop simple business plans for the pilots										ILRI, CHAIN UGANDA, VEDCO, PPM
	3.Pilot set up (running, testing and validation)										ILRI, CHAIN UGANDA, VEDCO, PPM
	4. Dissemination of the project results										ILRI, CHAIN UGANDA, VEDCO, PPM
	5. Regular attendance of selected project particpants to Pig Stakeholders Platform meetings										All

H/S: Harvest and silage = Dec/Jan (planting in Aug/Sep) and July (planting in March)

X: Student involvement

5. DEVELOPMENT GOAL

Within a period of 10 year the overall goal of the Project is to improve food, nutrition and incomes security of at least 250,000 pig and SP producers and other off-farm feed supply chain stakeholders in the SP and pig value chains in Uganda through SP-pig value chain integration for enterprise diversification in ecologically sustainable production systems. This will be achieved through adoption of high yielding dual-purpose SP varieties that produce nutritious food for people and feed for pigs concurrently under smallholder settings. Use of vines and root off-cuts for pig feeding will contribute to management of urban and household wastes by Reducing environmental waste and pollution especially in urban market environment and increasing hygiene in the household and pig's sties for both humans and pigs. Increased productivity of SP and pigs leads to increased volumes of sales and revenues from the enterprise integration. Adoption of SPS is likely to stimulate market for vines and roots and SPS technologies that provide employment opportunities for youth in SPS-pig systems value chain. On-farm pig manure enriched by off-farm feed sources is useful for ecological integrity of the production system.

How research outputs will be taken to outcome

Research outputs will be taken to outcomes through several activities. Basic research involving feeds sampling and laboratory analysis coupled with on station and on farm trials will take place in order to validate SP silage preparation methods. Capacity building trough training of stakeholders on SP silage making will be implemented with local research organizations such as NARO and private sectors. Economic and social feasibilities will be assessed through market survey studies using cost-benefit analysis and willingness to pay methods. Innovative dissemination models will be tested and validate for up scaling through sensitization and promotion of the SP silage innovation for wider adoption.

6. EXPECTED OUTCOMES (Ref. Table 3)

Table 3: List of expected outcomes of the project

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. Knowledge on pig feed resources (quantity, quality and seasonality) in Masaka and Kamuli districts in Uganda documented	Pig farmers, SP producers Stakeholders in the off-farm feed supply chains	250,000 HH	• Adoption of rational land use in SP-pig system including dual-purpose SP varieties and strategic procurement of off-farm feed resources	• Improved food security	Women, men and youth will benefit	Reduce negative impact on environment
2. At least 2 methods for SP silage preparation validated and piloted in the targeted districts	Pig farmers	Men (100), Women (300), Youth(100)	• Increased adoption of SPS for SP-pig value chain integration; • Market opportunities for SP vines and roots generated; • Employment opportunities for youth and women created in service sector of SPS production and marketing	• Increased income sales of vines, roots and pigs ; • Employment in the service sector will increase the purchasing purpose of nutritious food from the market	Women, men and youth will benefit	• Reduce environmental waste and pollution especially in urban market environment; • Use of vines and root off-cuts for pig feeding will contribute to management of urban and household wastes
3. Dual purposes SP varieties and their cutting management identified and promoted	SP producers, Pig farmers, SP multipliers	1,000,000	• Improved food and feed availability; • Improved household income; • Change in knowledge, attitude and practices of silage making	• Improved food and feed availability through production and market systems	women empowerment through improved income	• Improved soil cover and water retention;
4. Capacity for uptake of silage making as a business for the youth, women and men strengthened	Pig farmers, SP producers, SP traders	10,000	• Improved household income; improved pig and human nutrition; • Increased social acceptability of pig farming as an enterprise; • Improved environmental sustainability; • Change in knowledge, attitude and practices of silage making	• Increase food availability through pig and SP production; • Improved animal and human nutrition; Increase food security through exchange of food and feed;	will increase social inclusion of the marginalized yet active gender SP pig systems especially women and youth; will empower women for own resources for production e.g equipment, knowledge, capital and pigs	• Reduce waste especially market, industrial and institutional (schools); Reduce wetland degradation
5. Economic viability and social acceptability of SP pig systems validated and documented	Pig farmers, SP producers, SP traders, development organization, research organizations	N/A	• Increased livelihood and social assets • Economic empowerment especially women and youth	• Improved food and nutrition security from consumption of on-farm and off-farm sources of food	All gender categories especially, women and children and elderly	• Increased opportunities for nutrient recycling through pig-SP integration
6. At least 2 dissemination models piloted and tested and best models identified for scaling up and out		10,000	• Better utilization of SP as feed for pigs Increase access to pig feed during time of scarcity • Adoption of dual purpose SP varieties • Validated best dissemination models (based on outreach)	• Improved livelihood of smallholder pig farmers; • Increase income for smallholder farmers; • Improved house hold nutrition	Increase number of women and youth participation in the pig and SP production	• Reduce environmental waste and pollution; improved soil fertility

7. FEASIBILITY

a) Technical feasibility

The roots are high in starch and low in fiber (Woolfe, 1992). The protein contents in the vines often exceed 150g/Kg of dry matter (Ondabu et al., 2005; Luyen and Preston, 2012). Hence SP is near-wholesome feed for pigs. In South East Asia and China SP growing and piggery are closely associated enterprises in smallholder households (Huang et al., 2003a). Uganda has similar biophysical and socioeconomic setting. SPS for pig feeding was extensively validated in Japan, Philippines, and Korea (Woolfe, 1992). Feeding trials have shown that there were no significant differences in growth rate and feed efficiency between pigs fed with fresh SP meals and ensiling SPRs and SPVs (Giang and Ly, 2004) indicating that ensiling does not reduce the feed quality. Using poultry manure as additives improved the amino acid profile and feed efficiency without risks of pathogens exposure to pigs (ZuoHua et al., 2001).

In East Africa, successful preparation of SP silage was reported in Tanzania but for goat feeding (Khalid et al., 2013a). Initiatives to introduce the technology in pigs in Uganda and Kenya are in progress. These reports show that making SPS is technically feasible and can be replicated in pigs in Uganda.

How the research builds on existing knowledge, ongoing/recent initiatives

The technical experience of ILRI and CIP in other contexts is convincing and the economics of the work in Kenya gives regional credence to the technology. The research project is building on information that ILRI through the CRP3.7 (Livestock and Fish) program has generated on the Smallholder Pig Value chain work in Uganda since 2012. It will use decision support tools viz: FEAST, TechFit and LIFESIM that ILRI and CIP have developed for characterizing of the feeding systems, targeting interventions and optimizing feeding systems. Through collaboration with CIP and NARO, the research program will tap into laboratory capacity for throughput feed evaluation using Near Infra-red Spectroscopy (NIRS) for the characterization of pig feeds. The project will work in the same sites identified by ILRI through the Value Chain Assessment and the pig value chain domains identified through ILRI's characterization activities. ILRI has just completed on-station trials at Kamuzinda farm in Masaka district to compare several options of pig feeding including SPS and other locally available feeds on pig performance. Quantitative inventorying and nutritional characterization of on-farm material will validate the results through on-farm trials that will be implemented under the proposed project. Capacity development of the smallholder farmers in several aspects including feeding is underway. Training packages on feeding option with more emphasis on SPS have been developed and will be disseminated. Synergies could be built between CIP and ILRI over this initiative and use the existing Pig Multistakholder's Platform to support the proposed research.

b) Economic feasibility

Studies have demonstrated that SPS is a cost effective feed conservation strategy for pig production, for instance, contributing to a reduction of costs by up to 17.3%, and an increase in farm study showed that part of the savings from SP silage making is from reduced labor

cost in preparation compared to processing SP meals (Giang et al., 2004). Farmers in Masaka and Kamuli districts, currently use SPR and SPV, and other RTBs for feeding pigs while supplementing with commercial feeds.

Pigs are fed on commercial feeds at different rates that vary with age, for instance the age of grown pig for slaughter in Masaka and Kamuli is between 18-24 weeks (Lule et al., 2014), with expected live weight of about 60kgs under good feeding and management, after weaning at 8 to 10 weeks (Table 4). For instance, finishers are estimated to consume a total of 126kg of commercial feed up to being ready for sale. This translates to a total cost of about UGX 102,690 for commercial feeds (Table 5). According to the field study, grown pigs for slaughter in Masaka and Kamuli are sold for UGX 130,000-150,000 each, implying that if the farmers were exclusively feeding the pigs on commercial feeds, they would be making a gross profit of between UGX 27,310 and UGX 47,310, considering cost of feed as the primary variable cost.

Table 4: Commercial feed consumption rates per pig

Animal	Weeks	Number of weeks	Number of days	Amount/kg fed per day	Total amount/ kg fed per period
Piglet	8-10	2.00	14.00	0.66	9.24
Weaner	10-12	2.00	14.00	1.00	14.00
Grower	12-16	4.00	28.00	2.00	56.00
Grower	16-18	2.00	14.00	2.50	35.00
Finisher	18-24	6.00	42.00	3.00	126.00

Source: Lule et al., 2014

Table 5: Cost of a homemade ration based on local feed ingredients in Masaka and Kamuli districts

Feed Stuff	(Kgs)	Cost of Feed (UGX)
Maize meal	70	35,000
Cotton cake meal	12	24,000
Fishmeal *(Mukene)*	5	14,000
Maize/Rice bran	10	5,000
Feed lime	2	0,000
Fine salt	0.5	500
Mineral and vitamin mixture *(Premix)*	0.5	3,000
Total Weight (Kgs) and cost of Feed Mixture (UgShs)*	**100.00**	**81,500**

Source: Composition of Feed stuffs is based on (Giang, Ly, & Ogle, 2002)

**Unit cost of commercial feed mixture is 815UGX*

Taking a 100kgs as unit cost for determining per unit value of feed (Moran, 2005; Preston, 1977), farmers would spend about UGX 100 to produce a kilogram of silage (Table 6). One pig is estimated to consume an average of 8.47Kg of silage per day[1] implying that when farmers exclusively feeding pigs on silage for finishers for a period of 14 weeks after weaning they would spend about UGX 60,000 on silage feed for pigs sold at between UGX 130,000-150,000. This implies that if farmers were exclusively feeding the pigs on silage they would

[1] 1 pig consumes an average of 8.47Kg of silage per day (http://www.pigtrop.cirad.fr)

make a gross profit of between UGX 70,000-90,000, making a bigger profit margin from utilization of silage compered to exclusive feeding using commercial feeds that are costly to the poor pig farmers.

Table 6: The cost of making silage based on local feed in Masaka and Kamuli districts

Feed stuff	**Unit Measure**	**Cost (UGX)**
Sweet potato roots	25Kgs	1,000
Sweet potato vines*	40 Kgs	0.00
Cassava peels and chop-offs*	12 Kgs	0.00
Cassava Leaves*	10 Kgs	0.00
Maize Bran/ Rice bran	9 kgs	1,500
Silver Fish	2kgs	6,000
Ant hill soil*	1 Kg	0.00
Salt	1 Kg	1,000
Total Cost, Ug Shs/kg	**100**	**10,000**

Note:

1. ** Items are not bought; they are available free either on farm, or through exchange of labour for cleaning market waste, or through fellow farmers.*
2. *Other additional costs in silage making include; labour, water, and materials (polythene, strings) that vary according to location and method of preparation*
3. *Maize bran/rice bran is used as a fermentation agent by putting I kg for every 10kgs of chopped material (Root, leaves, peels & Vines)*
4. *1 USD = 2600 UgShs*

Composition of feed stuffs is based on current farmer practices identified during the business case scoping study

Feed silage making and pig feeding would translate into labour saving for women. Women spend a total of 4 hours per day in search of pig feed, preparing the feed and feeding the pigs (Ouma et al., 2014) which translate into 120 hrs per month, worth UGX 48,000 (Lule et al., 2014; Kraybill and Kidoido, 2009). If they employ their labour for SPV silage making, they would require 12hrs to prepare 100kg silage that is required to feed the pig for 12 days at a consumption rate of 8.47 kg/day, totaling 254 kgs/per month of pig feed. To prepare the 254Kgs would require 30.5 hrs of woman labour that is worth UGX 12,192, feed conservation making the woman to save UGX 35,808 compared to if they had to use collected feeds.

Cost per unit weight gain of pigs is reduced; especially when SPS is ensiled with organic materials such as poultry manure intended to provide nutrient and protein (CIRAD, 2014). The practice of feeding pigs with organic materials is common among the farmers in Masaka and Kamuli by using materials such as; anthill soil, and ash intended to provide nutrients and in the nearby markets, and silver fish *(mukene)* powder and poultry manure intended to provide protein.

c) Social feasibility

The use of SP as a pig feed is a traditional practice. Harvesting of the vines for pig consumption is commonly done by women and children and is an acceptable practice among many communities. Therefore, participation of men, women and youth in SPS making and trade may not be against the social norms as long as the innovation does not impact negatively on their time burden. During the small holders pig value chain assessment undertaken by ILRI, both female and male farmers preferred the use of SPV to any other fodder types found in the villages because of several attributes: very palatable, give

satisfaction to pigs, boost growth and milk production and reduce fats in pigs (Ouma et al., 2014). The silage making of this feed resource will be an added advantage to the use of this crop in the communities. In terms of market acceptance, although livestock fodder markets are not common, huge potentials exist for SPS marketing especially during seasons of scarcity when most farmers are in need of feeds.

Table 7: Partner's roles and responsibilities

Institution	**Role/ and responsibility**
International Potato Center (CIP)	Coordination; joint research with other partners, variety selection and analysis
International Livestock Research Institute (ILRI)	Joint field trials; information sharing
CHAIN Uganda Ltd	Farmer training; enterprise development training, dissemination, monitoring field trials
Volunteers Efforts for Development Concerns (VEDCO), Kamuli	Farmer training; enterprise development training, dissemination, monitoring feed trials
Makerere University	MSc student research supervision; management of feed trials, Laboratory analysis
Uganda Martyrs University, Nkozi	MSc student research supervision; management of feed trials
Pig Production and Marketing (PPM), Uganda (Private sector)	Market research, linking pig farmers to market
National Agricultural Research Organization (NARO)	Feed trials (with MUK), Next-users of research results. Will be in charge of capacity building and implement sustainability strategy to ensure information remains within each of these communities. Dissemination of guidelines and technologies

8. DEMAND FOR THE INNOVATION

Because of growth in pig industry in Uganda, feeds prices in the market are not likely to decline in a foreseeable future; hence the need to explore alternative feed resources to make pig production a more profitable enterprise. SP is one the most convenient alternatives to farmers. But availability is seasonal in most parts of the country (Bashaasha et al., 1995). The field study confirmed this scenario in Masaka and Kamuli (Figures 2-5). Additionally in Masaka, growth of SP in wetlands is very common, making SP available even during dry season (July and August) when it is scarce in other areas (Figure 5). This practice seems adapted to increase feed availability during shortage but has a negative environmental impact contributing to land degradation. The coping mechanism to seasonality of SP is limited to dehydration of wilted vines under shade and roots under open sunshine and preservation of cooked roots and peels for 2-3 days before feeding.

During periods of scarcity of SP, farmers often resort to other RTBs (viz: as cassava, banana peels and leaves, yam leaves) and other materials (chicken manure, swill, jack fruit, brewers waste and maize stover, plant leaves such as *Ficus natalensis*) before they proceed to destocking the herd to a manageable size as a strategy to coping to feed scarcity. Such

expressions of desperation are indicative of the demand for a reliably durable SP conservation technology for feed crisis mitigation. The existence of high yielding, and preferred (especially by women) dual-purpose varieties in Masaka and Kamuli (Naspot-1 -*Bwengye*-, Naspot-11 and Naspot-12), provides an opportunity for surplus materials especially vines for an economy of scale. The demand for training in feed conservation further confirms the substantial demand and likelihood of adoption of SPS and dual-purpose SP varieties.

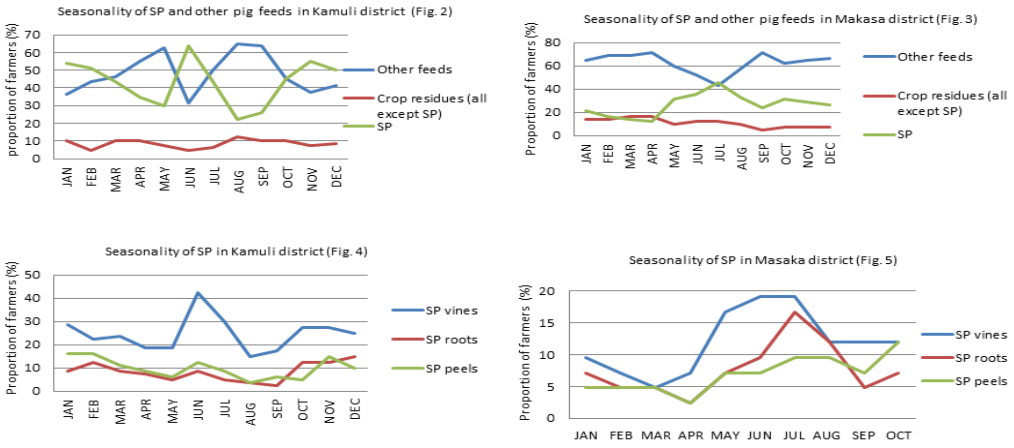

Figure 2: SP and other feeds availability along the year in Masaka and Kamuli

Awareness of SPS technology and feeding by men, women and youth is low in Kamuli (practiced by only one farmer) and absent in Masaka as compared to the dairy feed value chain. The idea was eagerly accepted during the field study because of perceived saving of labor and time for women and youth in the preparation and feeding fresh SP vines and roots to pigs.

MARKET DEMAND FOR PRODUCTS DERIVED FROM THE INNOVATION

Products derived from the innovation are the silage for pig feeding and live pigs for sale. Silage will address the constraints of low access and availability of pig feeds during the dry season, as well as offering an opportunity as a business for marginalized groups especially youth and women. In addition, improved profitability of the pig enterprise will generate new employment along the SP pig value chain and generate income for smallholder farmers.

The price of commercial feeds being high (compared to the silage), provide an opportunity for willingness to pay for the silage that is relatively cheaper compared to the commercial feeds. In pig production, farmers strive to feed using the cheapest feeds available, which is the advantage of silage, which is 2 times and 3 times cheaper than commercial feeds in Kamuli and Masaka districts respectively. This drives the demand for the use silage as a pig feed.

Uganda has the highest per capita pork consumption in Africa (3.4 kg/year) and the demand for pork will continue to grow with the growing population. The consumption of pork in Uganda has been rapidly increasing due to population growth, rising income, changing preferences and urbanization. A more formal meat marketing sector is emerging as proved

by the development of brands such as Fresh cuts, Quality cuts and Mychoice. This presents an opportunity for the pig sector to supply the required quantities of pork as proposed by the business model through increased pig production based on availability of silage for pigs feeding.

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