

Full Length Research Paper

Innovation dynamics in cassava production systems in Uganda

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Traditional knowledge has made appreciable contributions to people's sustenance and livelihoods. Its contribution to science and technology is however not recorded, codified, stored or systematized to spur knowledge sharing and science and technology development. It continues to be ordinary, couched and associated with low prestige rural life. An innovation systems framework was used to study the dynamics and mechanism for product, process and organizational innovations in the cassava production systems. The research study revealed that though some traditional knowledge driven innovations may be risky to health and environment; many made a positive contribution to people's sustenance and livelihoods through production of innovative goods and services, improved livelihoods, sustenance, food safety and wholesomeness. The main argument in this study was that innovation strategies rooted in the traditional knowledge systems were socially inclusive and augurs sustainable development. The study underscored the value of creating systemic linkages useful in integrating traditional and modern knowledge systems to develop crop production systems.

Key words: Cassava production systems, rural livelihoods, social inclusion, systems linkages, traditional knowledge.

INTRODUCTION

There has been an obsession with external sources of innovation embodied in imported technologies (Hall and Nahdy, 1999) and machinery as a panacea to development problems; as is reflected in the strategy documents such as the Plan for Modernization of Agriculture (PMA) (MAAIF, 2000; MAAIF and MoFPED,

2000) and the National Agriculture Advisory Services (NAADS, 2001). Top-down innovation processes have dominated development efforts to fix social, economic problems such as food security (Bolwig et al., 2004), health (Buyinza, 2008) and environment degradation (Buyinza, 2010), and agricultural productivity with varying

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levels of success (Friis-Hansen, 2005; Friis-Hansen et al, 2004; Bibangambah, 2002). The main argument in this paper is that a lot of innovation activity occurs within the traditional systems that should be identified and nurtured to benefit the wider community and also for policy development. The paper is organized as follows: the introduction setting the agenda; description of the research methodology used to study the traditional innovation systems; description of results and findings and; conclusion.

At onset we argue that ignorance of innovation activities within the traditional knowledge systems constitute missed opportunities for intensive social, cultural and economic transformation. It is further shown that subsistence agricultural production systems draw on traditional knowledge during production activities and have made significant contribution to community sustenance and livelihood, and even thrived. This is based on the premise that the prosperity of any production system depends on its productivity and value created, and that innovation plays a central role in productivity enhancement and value creation. This means that innovation occurs in subsistence agricultural production systems. What is puzzling is why these innovations are depicted as ordinary, couched and associated with low prestige rural life, and are portrayed as inferior. It is suggested that one of the reasons for this is the unobtrusive profile of traditional STI which impacts their utility and affects knowledge sharing and development.

This state of affairs should not continue to be overlooked. In order to understand the dynamics of innovation in the traditional knowledge systems therefore, a holistic approach is essential. The major issue of contention is that traditional innovation systems are a neglected yet critical part of the innovation system that despite disregard has been blooming and hold potential for cultural, social and economic transformation. In order to support the argument, this paper reviews the innovation dynamics in the cassava production systems highlighting novel practices that could be enhanced and replicated elsewhere and used as foundation for policy development which is an organic outcome of the social economic milieu.

The agenda for discussion of this concept has just been set. Next is a presentation of the innovation systems framework as a holistic framework useful for texturing the profile of traditional STI.

The innovation systems framework

The innovation systems framework identifies the factors enabling knowledge transactions in the innovation processes. An innovation system is defined by the International Bank for Reconstruction, (The World Bank,

2006) as a network of organizations, enterprises, and individuals focused on bringing new products, new processes, and new forms of organization into economic use, together with the institutions and policies that affect their behavior and performance. The innovation systems concept embraces not only the science suppliers but the totality and interaction of actors involved in innovation. It extends beyond the creation of knowledge to encompass the factors affecting demand for and use of knowledge in novel and useful ways. The innovative performance depends not only on how the individual institutions (e.g. organizations, research institutions, universities) perform in isolation, but on how they interact with each other as elements of a communal system of knowledge creation and use, and on their interplay with social institutions e.g., values, norms, and legal frameworks.

Any attempt to bridge the two systems should look at the actors, the processes of knowledge creation and interaction, and the knowledge itself, which is the essence of an innovation systems framework (Bell, 2006). The innovation systems framework therefore provides us with an analytical framework to examine types of relations (Hall and Yoganand, 2004); the network of relationships among firms and the broader institutional setting that supports their innovative activities. The dynamic and cumulative nature of the innovative process is emphasized, since it is based on tracing the flows of knowledge among institutions constituting the system (Wolfe, 2000 in Adam and Wolfe, 2000 Eds.), and analyzing civic uniqueness in the innovation process in a wider economy (Sharif, 2005).

Applying the innovation systems framework, a textured description of the organization and patterns of activity that contribute to innovative behavior is done. Institutions and actors who play decisive roles in the innovation processes would be identified. Yet various factors affect choice of production possibilities (Gans and Stern, 2003; Nataro et al., 2011), including the social, economic, cultural setting of the community, physical environment, land use knowledge systems (Mikkelsen and Langohr, 2004); and technological innovation capacity^a (Sharif, 2005; Asheim, 2007; Borrás, 2011; Nataro et al., 2011).

Several factors affect conversion of knowledge into innovation as discussed conclusively by Furman et al. (2002) Gans and Stern (2003), and Nataro et al. (2011). Mikkelsen and Langohr (2004) moreover argued that the traditional sustainable approach takes great care of the

^a National innovative capacity is a country's potential—as both a political and economic entity—to produce a stream of commercially relevant innovations. This capacity is not simply the realized level of innovation but also reflects the fundamental conditions, investments, and policy choices that create the environment for innovation in a particular location or nation. National innovative capacity depends in part on the technological sophistication and the size of the scientific and technical labor force in a given economy, and it also reflects the array of investments and policy choices of the government and private sector that affect the incentives for and the productivity of a country's research and development activities (Porter and Stern, 2001).

particular needs of plants and animals and is closely adapted to an instable shifting physical environment. Therefore, the actors, the processes of knowledge creation and interaction, and the knowledge itself (Bell, 2006) have to be examined by tracing the flows of knowledge among institutions constituting the system (Wolfe, 2000 in Adam and Wolfe, 2000 Eds.), and analyzing civic uniqueness in the innovation process in a wider economy (Sharif, 2005) using an intensive approach, which will be discussed later.

The above definition of innovation systems framework shows that in order to understand and prove their worth therefore, information is required to demonstrate the value of traditional STI and constraints, and shed light on how to integrate traditional and modern knowledge for the benefit of marginalized communities; and get answers to the following questions. How the traditional knowledge is applied upon natural and social phenomena for sustenance and livelihoods? What opportunities exist for integration with modern knowledge? What linkages should be established and how this should be done? The information presented in this paper was obtained through case study of cassava production systems in Arua district of Uganda.

Background and justification

Despite a lot of investment in biotechnology to increase its productivity (Abele et al. 2007; NARO, 2000), cassava production activities have continued to thrive on knowledge transactions within traditional knowledge systems. Using an innovation systems framework, the innovation processes are reviewed in this article. Innovation is the key to development through production of goods and services (Watkins and Ehst Eds.) with increasing scientific and technological content, which transcend local confines into national, regional and even global frontiers (Furman et al., 2002; Gans and Stern, 2003; Nataro et al., 2011).

Furman et al. (2002) discussed determinants of national innovative capacity into three categories: the common pool of institutions, resource commitments, and policies that support innovation across the economy; the particular innovation environment in the nation's industrial clusters; and the linkages between them. Nataro et al. (2011) defined it as the real and potential capabilities of a system to convert knowledge into innovation. It is based on scientific knowledge base.

This capacity is determined by several factors discussed conclusively by Furman et al. (2002); Gans and Stern (2003), and Nataro et al. (2011). In order to understand the dynamics of innovation in the traditional knowledge systems therefore, a holistic approach is essential. The holistic approach is precisely described by the innovation systems framework.

The innovation systems framework aims to identify the factors enabling knowledge transactions in the innovation processes. In this article, information was obtained through case study of cassava production systems in Arua district of Uganda as discussed later. Next is a discussion of the methodology for generating the information.

METHODOLOGY

The study was done to identify innovations and dynamics of innovation in the traditional knowledge systems using an innovation systems framework. A multistage methodology was used involving literature search, key informant interviews, questionnaire, focus group discussions, and observation. Information was collected in the frontier district of Arua which was selected due to its closeness to regional markets and hence demand opportunities, and poverty and vulnerability issues.

The district leaders and key informants were interviewed using a questionnaire and information generated from them used to develop a sampling frame (Figure 1). The district leaders including the District Chairperson or Chairperson of Local Council Five^b (LCV), Chief Administrative Officer (CAO), Production Officer, Resident District Commissioner^c (RDC), and any other government officers or political leaders referred by them were interviewed using a questionnaire. The sampling frame was developed as summarized (Figure 1).

This methodology generated background information to establish the context, identify innovation spots, innovators and production activities. The district leaders or key informants identified innovation spots by sub-county or village, and innovators by name. In this way a list of names and innovations which constituted the sampling frame was developed from which a sample was selected for interview. The decision on which product to study was then taken as discussed in the next paragraph.

Selection of product to study

A product was selected out of fifteen identified product categories for in-depth study using a checklist. The criteria for selection of products for case study was: social, cultural factors such as gender issues, potential for sustenance and livelihood, and environment issues; opportunities provided by trade and availability of natural resources; prospects for deepening value chains (opening way for other uses); available technological capability; strategies to exploit new opportunities, and the professional orientation of the MSc. student to carry out the scientific aspects of the case study. The product category of cassava production and processing using heap fermentation technique was selected because it is a critical income generating activity in the area, which is typically rooted in the traditional agricultural systems focusing on ensuring both food security and livelihoods sustainability. This category fulfilled all the requirements stipulated in the above criteria.

A case study approach was then used to get in depth information about modes of knowledge generation and determine how the communities innovate through product, process, organizational changes and services for their sustainability and trade. Previously, methodology used to generate information is described, and followed by presentation and discussion of the findings of the study.

^b The District Chairperson also known as the Local Council Five Chairperson is the district political head

^c The Resident District Commissioner is a government or presidential representative in the district

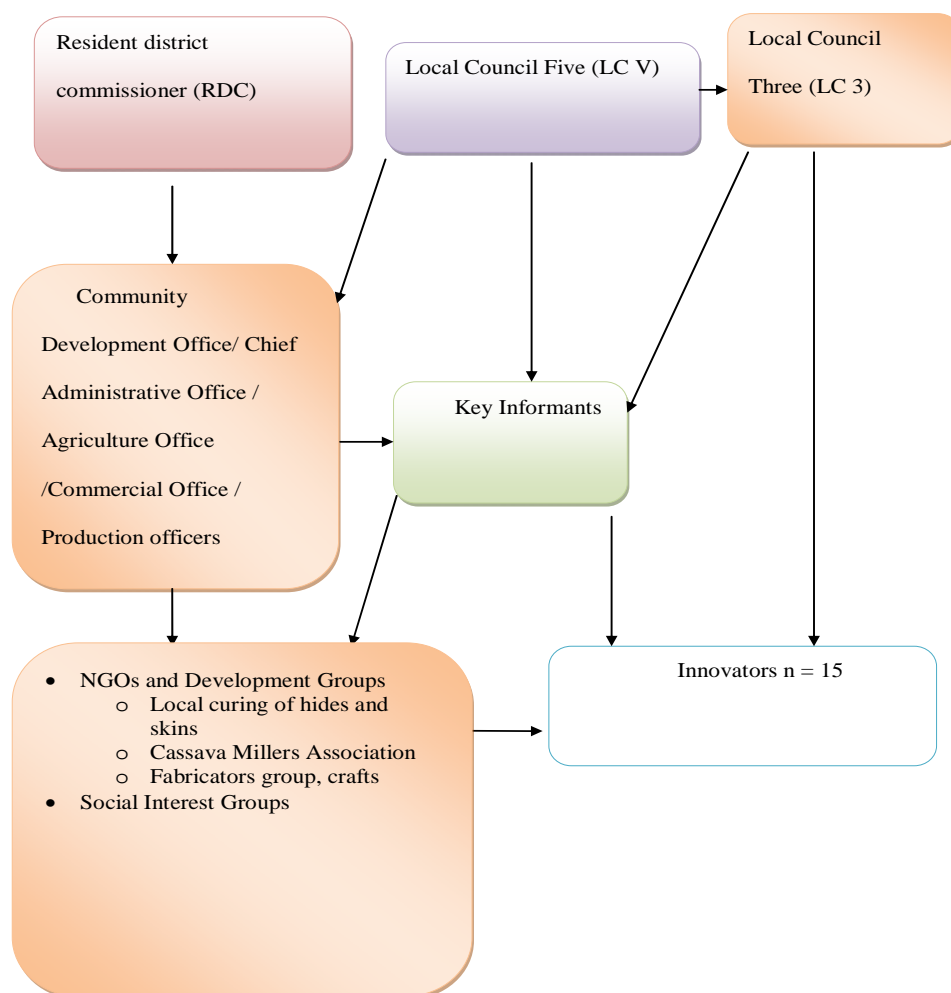


Figure 1. Sampling frame.

RESULTS AND DISCUSSION

Here we report and discuss the findings of the study that was implemented to assess the traditional knowledge systems and identify innovations in the cassava production systems in Arua district of Uganda. It was found out that despite a lot of investment in biotechnology to increase productivity of cassava production systems (Abele et al. 2007; NARO, 2000) cassava production activities have continued to thrive on knowledge transactions within traditional knowledge system as further revealed in this research.

The findings are discussed under two themes starting with activities within the formal or modern innovation systems which are guided by government policy. The innovations in the traditional systems are further discussed, and in all scenarios highlighting benefits, novel attributes of the identified innovations, constraints and risks. The activities within the formal innovation

systems are discussed as well.

Activities within the formal innovation routes guided by the government

Information regarding the formal innovation systems was collected using literature search and key informant interviews. It was found out that innovation occurring in the formal system is planned (Friis-Hansen E, 2005; Friis-Hansen et al, 2004), structured to be responsive to macroeconomic conditions as devised by the policy makers at national level (Hakiza et al., 2004) as laid down in the strategy documents including the poverty eradication action plan (PEAP), plan for modernization of agriculture (PMA), and national agricultural advisory services (NAADS). The activities in cassava production are mainly driven by the National Agricultural Research Organization (NARO), an agency composed of highly

trained and skilled personnel, and high tech infrastructure in Namulonge Agricultural Research Institute (NAARI). The main focus is on developing high yielding, quick maturing, and disease resistant sweet cassava varieties in order to fight disease, increase productivity; and deliver food security to the growing Ugandan population (Otim-Nape et al., 1994; NARO, 2000). The high yielding, disease resistant cassava sweet varieties must be harvested at maturity because they get spoilt when left for long in the soil. NARO capitalized upon this market oriented characteristic to enhance adoption and discouraged the growing of '*unimproved*^d' varieties arguing that it causes problems of phyto-contamination (Otim-Nape et al., 1994). The national agricultural advisory services (NAADS) promoted sweet cassava as a way of increasing productivity, an objective that was *technically*^e realized during the initial years of this program (Abele et al. 2007; NARO, 2000).

It was envisaged that increased production would lead to higher household incomes since farmers have plenty of sweet cassava that they had to market. It was reported (NARO, 2000) that there were plenty of cassava crops during the initial years of the biotechnology program, which report was also corroborated by the farmers during the research study. Due to the varietal attribute, however, the cassava had to be harvested at once and flooded the market. Increased total output led to very low prices (up to 50 shillings per kilogram in some areas! Bibangambah, 2002). This was complicated by the fact that the market for cassava changes with consumer income or availability of substitutes. Fresh cassava is only consumed as an inferior subsistence food for low income earners. Sweet cassava is moreover only eaten as a snack by some ethnic groups such as those in Arua, and has few alternative uses both locally and nationally. The local people claim that the sweet varieties do not make good fermented products, so do not fit in with their food preparation methods, and the local market requirements. Efforts to link production to manufacturing are dulled by the weak manufacturing base since there are few industries using cassava as their raw material.

At factory level moreover, processors decry the low volumes and high bulking cost in the context of small subsistence producers and few supplier Associations (Nkonya, 2002). It is still hard for farmers to access the market offered by the few factories. The farmers thus realize a lot of post-harvest loss (Mukadasi and Lusiba, 2006) and their aspirations for sustenance and improved livelihoods were thwarted. The years following the initial boom were bleak and cassava production plummeted (Otim-Nape et al., 1994). At that very time the innovation

system was battling the cassava diseases such as the cassava mosaic disease which complicated the scene. Next is a discussion of the approach used by NARO to combat the cassava mosaic.

Institutional and organizational response to cassava mosaic disease

Cassava mosaic disease epidemics have been reported since the 1920s and government intervened through research and development of improved varieties (Otim-Nape et al., 1994). The biotechnological approach has been followed since then. In the formal line, the seed in form of vegetative cuttings are distributed through producer groups which were developed following prompting by NAADS. The groups were required to pay a '*nominal*' fee by NARO which '*progressive farmers*' and politicians for electoral campaign purpose embraced to an appreciable extent.

In 1950s, a bye-law was passed where it was "*...mandatory for farmers to uproot all infected and susceptible local varieties and replace them with new resistant ones*" (Otim-Nape et al., 1994). Furthermore in the year 2009, government imposed a ban on movement of vegetative materials across districts. Success in eradication of the disease has however been elusive (Legg et al., 2002) for various reasons as reviewed by Otim-Nape et al. (1994) and Oleru et al. (2005).

It was found out that due to the structured nature of access to cuttings within the NARO program, coupled with need to buy them, and complicated by poverty and habits of access through familiar channels, farmers responded through parallel interventions applying traditional knowledge and other social economic arrangements. These arrangements have not been acknowledged before, yet they have been central to ensuring people's livelihoods.

In essence, traditional knowledge has assuaged social, economic, science and technology development problems as will be discussed next. We have discussed the approaches used in the modern innovation systems to manage cassava production and the outcome of these strategies on people's livelihoods and productivity, the producers in traditional knowledge systems in Arua district of Uganda developed innovations based on inherited experience gained over many generations and passed on verbally from generation to generation. These innovation processes are also discussed in this study.

Innovations based on traditional knowledge

It has been revealed in the previous discussion that innovation within the formal sector is structured and responsive to macroeconomic conditions as devised by

^d Emphasis ours

^e In technical terms there was increased cassava yield and more produce that was recorded and even observed in the markets, but farmers got a raw deal. Other reports show that this was due to increased use of more land not on increased per unit production ()

the policy makers at national level. It requires high outlay of inputs and often undertaken within research institutions that are removed from the mainstream network both in geographical and structural or institutional terms veiling them with an aura of superiority alien to the common person thus rendering them inaccessible. The innovation trail occurring in the informal system is spontaneous through selection of strains that are observed to possess required attributes, occurring within familiar context, and responsive to market needs and social, economic and cultural milieu.

In the traditional systems, seeds are distributed through family where an individual can enter the garden of a relative and pick cuttings in some cases even without prior consent. Clan linkages and neighborhood alliances transcend borders and legal frameworks; and are often not through the monetary economy but bartering systems to the extent of exchanging different types of seeds.

This study reveals that while operating under tension of restrictive bye-laws, local people have achieved major breakthrough. In some cases, even accessing the international market and purposively seeking knowledge from the formal sector, showing that the system is viable. Next is an exemplification of the viable innovations that have been developed within the traditional innovations systems that could be nurtured.

Selection of a mixture of cassava varieties

It was found out that regardless of the fact that NARO promotes sweet cassava varieties, local people continued to access bitter varieties even going as far as Congo to get them. A producer will plant a variety with its use and even ecological properties in mind.

It is believed that different varieties react differently to weather changes, soil conditions and cropping patterns even intercrop biotic factors. Seven '*varieties*' (which technical people referred to as strains of mainly three varieties) of bitter cassava each having its unique attributes were identified. These included varieties known by the following local names: *abiria*, *arua*, *omi*, *tongolo*, *mabulu*, *basimenge* and *mbazia*. The bitter varieties are preferred for fermentation. The variety locally called *abiria* can be dried in the shade. The producers say it is because it has high starch content, is hard and has low water content. If dried in the sun, it takes long to ferment and the product will not be good due to contaminants. When the cassava is matured, local people then select what to process into each specific product. The sweet varieties are preferred for cooking to eat as snack and as feed to domestic animals like pigs and goats.

Control of cropping patterns

The NARO required that improved varieties should be

planted on single stands to avoid phyto-contamination by the already infected local varieties. Producers' innovations take into consideration the varying ecological conditions in this rain fed agricultural system where farmers have little control and have learnt to adapt their cropping systems to weather and existing social economic and cultural needs. Local people continued to intercrop and all varieties of cassava are grown on same plot. The farmer plants cassava staggered all year round and harvesting is also done all year round. Where weeds become a problem, the varieties that form a canopy are grown to choke the weed. Intercropping is a main attribute of the farming system, whereby different varieties of cassava and other crops like ground nuts, beans, peas, maize, simsim, millet and sorghum are grown and each cassava variety serves a different purpose and occupies a specific niche in the ecological system. The bitter varieties are also planted at the fringes of the garden as a barrier to prevent domestic animals from browsing on the leaves of the more susceptible sweet varieties.

Organizational innovations

Organizational innovations aimed at enhancing the productivity, marketing and ensuring food security were developed through social, economic and technological arrangements rooted in traditional STI and blended with modern approaches. Bitter cassava cuttings are sourced by the local people from neighboring regions, even Democratic Republic of Congo (DRC). A local producer organization known as the West Nile Cassava Millers Association (The Association) established according to the NAADS requirements, trains processors in improved processing methods, recruits suppliers, packages the flour and labels it for bulk transport.

The Association helps to develop products, standardize, and market them. The interesting finding is that, in order to ensure consistent product quality, the Association identified farmers and taught them how to ferment and dry the product; use racks or plastic sheets to spread out to dry on soil free surface and provided carpets for drying; wash with water instead of scrapping off the black spores with knives after fermentation is complete. The varieties that are preferred are the bitter ones since they fit in with the local food habits, food preparation and presentation.

It was also found out that market (effective demand) is a critical driver of uptake of new and improved technology. Through the Ministry of Disaster Preparedness in collaboration with the World Food Programme (WFP) of the World Bank and the NAADS, an initiative to get food from local suppliers to people in Karamoja region of Uganda who were affected by famine started. It is significant to note that the Association

competed for and was awarded a contract to supply 250 tons of cassava flour. They also succeeded in servicing that contract through supply of cassava flour; which is a marketing innovation based on local bitter cassava detoxification technology. Through the incentive motivated by the market and skills acquired, the Association also got other outlets in Kampala; the product range includes: Anyafura or cassava flour composed of 50/50 fermented cassava and millet; millet flour; and gari porridge. A standard for the cassava flour was developed in collaboration with the Uganda National Bureau of Standards (UNBS). The Association even took samples of their products to Kampala (a distance of 500 kms away) for analysis at Makerere University then Department of Food Science and Technology to demonstrate quality, thus fulfilling the regulatory and trade requirement.

The producers are given a price which is less by 20% of the one offered by the buyer. This has benefitted not only individual farmers and households as a group of women respondents asserted that "...one can always get market for the product whether with the Association, Schools or individual consumers..." but has also benefitted the government agencies like UNBS, technology generating institutions like Makerere University. Farmers as individuals and in groups are engaged in cassava growing and selling business. They sell to schools, restaurants, cafeteria, millers - the West Nile Cassava Millers Association (the Association) - and to individual consumers. This finding is fertile learning ground for policy and strategies for modernization of agriculture.

The range of product innovations

Cassava is processed into several products for different markets. The popular products currently made out of cassava include starch, animal feed; heat gelatinized cassava gum, ethanol, and cassava flour either from fermented or unfermented cassava (Graffham et al., 2000).

The bitter cassava varieties are traditionally detoxified either through soaking, drying or aided spontaneous heap fermentation (Essers, 1996). Fermented cassava is a product with high demand in local urban centers. When the quality of the product became critical in terms of safety and standardization, particular skills and forms of knowledge were required to ensure high quality products^f and test methods to demonstrate safety from aflatoxins^f as a trade and regulatory requirement. Producers sourced bitter cassava cuttings from neighboring regions. Quality in terms of consistence and safety in terms of aflatoxin content remain issues of concern. Thus, the experience of the Association is very informative.

Response to biotic and environment factors

Producers carry out holistic innovations across a production system value chain. Innovative adaptations are made in the farming system. Where weeds become a problem, the varieties that form a canopy are grown to choke the weed, which has reduce the need and cost of weeding. The cropping system is adjusted to exploit varietal features relative to microenvironment, and adapt cropping pattern to weather patterns. A producer will plant a variety with its use in mind. With increase in population and density on arable land, and also competition for different uses, that is, tobacco and cassava, soil quality is affected due to heavy and continuous use. Depleted soils seem to support growth of certain weeds and neither favor cassava sweet varieties nor cereals.

Bitter cassava varieties often give equitable yields on depleted soils. It was also observed that after tobacco is harvested the soils have high nitrogen, phosphorus and potassium (NPK) fertilizer content; sweet varieties may become bitter and will rot very fast in such high salinity soils (Yang et al., 2011); an issue of biological significance. Accumulation of nitrogen in form of bitter substances called cyanogenic glycosides may be part of the nitrogen cycle in the ecosystem that plants use efficiently for other ecological needs like stress resistance and protection against pests and diseases. The cassava producers said that when the soils become depleted, they change the varieties often replacing sweet varieties, possibly because they require a more balanced soil profile, with the bitter ones. What is not clear is whether this shift is good for the soil; and why in two apparently dissimilar circumstances; when there is too much NPK and when the soils are depleted, cassava plants seem to respond similarly by accumulating bitter substances.

Response to economic factors, sustenance and livelihoods

A dual strategic course is being followed by the local community. The NARO are implementing the biotechnology strategy to increase productivity. The farmers adopted the NARO varieties and also continued to plant the local varieties and developed innovative processing technologies, looked for new markets, added value to their products through standardization and UNBS underwriting. The Association managers looked for the required information.

The NARO strategy to increase productivity was deemed successful by national standards because there was a lot of cassava on the market and prices were low to consumers hence delivering food security. The low

^f Aflatoxins are toxin produced by some molds in crops, especially peanuts and also fermented cassava

Cassava heap fermentation technique

According to the European Commission (2007), the global market for bio-based products is estimated to grow to \$ 250 billion by 2020. This knowledge led to selection of fermented cassava as a product for in-depth study. It was found out that detoxification of bitter cassava through aided spontaneous heap fermentation starts with harvesting the roots, which are peeled and sundried for one to three days depending on sun intensity. The producers gauge the dryness of the cassava by breaking several pieces, and based on skill determine the right stage to initiate the fermentation stage. It is known that adequate drying is necessary to avoid growth of spoilage microbes some of which are aflatoxin formers. Spontaneous inoculation occurs as a result of handling which includes peeling without washing and drying on the ground. After sun drying, the cassava is heaped in a corner usually in a hut and covered with sack cloth or dried banana leaves. Microorganisms will grow on it for a period of three to four days. The producer will determine the right stage to stop this process when she observes black/pink spores of moulds on the roots and also tests by pressing several roots between the thumb and middle fingers for softness. When ready, the roots crumble when pressed. The spores are then scrapped off using a knife. The roots are then sun dried and milled into flour. The roots can also be kept as sun dried chips until required for food or sale.

Box 1. Cassava heap fermentation technique.

prices that ensued in response to market forces however meant that farmer's expectations were thwarted. The farmers became prey to national success. Due to the varietal attributes of the improved varieties, producers had no control over the crop and the market was small. There were no alternative outlets since the sweet cassava value chain is shallow in Uganda. Attempts to find alternative uses were not fruitful. The farmers resorted to their traditional varieties and processing technologies (Box 1), which later were boosted by the WFP market. However, this posed a demand for specifications of the product for which the farmers could not provide the necessary information. At this point, they needed more skill and knowledge to solve the technological and business related problems. The UNBS intervened to develop standards for the products. The extent of this intervention was only at the level of documentation, the Association played the role of technology development and product description. The Association managers looked for the required information. There is an opportunity for intervention through collaborative linkages with a research and development agency to give the required information for improved inoculums for use as starter cultures to enhance colonization of the mass before contaminants have chance to grow; and developing a diagnostic recipe for aflatoxin in locally processed fermented cyanogenic cassava flour, which issues are being studied.

Social and cultural factors e.g. gender, community organization and relationships

The NAADS organized groups for development initiatives. Value chains are being developed by the Association through organizing individual farmers into processor suppliers. They are trained and skilled in quality assurance concepts. The availability of innovations for all to use, and continuous improvement is the essential characteristic of knowledge diffusion. In traditional systems, the users of such knowledge pay a form of royalty like direct payment by bartering with products, such as giving back some of the harvest later or bailing the person out when they are also in need. The cost depends on how close the relationship or friendship or the assumed value of the knowledge, product or innovation.

Nutrition innovations and benefits

Fermentation technology can prolong shelf life and ensure food security and safety of the bitter cassava products. The product must be thoroughly processed. If not well done incidents of poisoning are not rare. The local people said that sweet varieties are not good for fermentation because the product can easily be contaminated with aflatoxin forming molds with black

charcoal like spores which cause vomiting, headache and diarrhea when consumed. It is not clear whether presence of cyanogenic glycosides has an effect on the aflatoxin formers and what this effect is. It was further reported that the handling methods can lead to too many stones in the product and cases of appendicitis are many in the area.

The heap fermentation technology

Farmers detoxify the bitter cassava by a heap fermentation process (Box 1). It is not clear where and who developed the heap fermentation technology. The heap fermentation technique improves nutritional and commercial value but it is not efficient. It requires a long time to completely detoxify the cassava, which is limiting during periods of food shortage. Since it is not standardized, it leads to products of variable quality and safety.

These improvements are however not enough to ensure a safe product of consistently high quality. The people training also lacked information on the biological aspects of the process. There was argument regarding signs of good quality such as which type of mold was the best—the pink or the black spores mold? Some processors argued that it is the process conditions that determine which type of spores are produced, but the best product is when spores are black. This observation is in tandem with known biology of some of the molds that occur in more than one morphological form (Perkins and Turner, 1988; Dettman et al., 2001). The need for improved product quality prompted a research study to develop a starter culture as an appropriate value addition technology to enhance quality of the product and later develop a process. With this as entry point other improvements such as formulation of composite flour for baking industry will be made. The innovations, benefits, novel attributes of the identified innovations, constraints and risks within both modern and traditional innovation systems that were identified have been previously defined. The findings have demonstrated that rooting innovation, technology development and industrial development in the traditional systems is inherently valuable and strategically pragmatic. When managed and coordinated, the bottom up and inclusive development process for long hyped will be achieved. Conclusions were drawn from the findings and synthesis.

CONCLUSIONS AND RECOMMENDATIONS

Familiar contexts for integration of traditional innovation systems into the modern systems

This paper describes novel contexts for development that is rooted in the traditional STI centered on knowledge

and skills which originate in different bodies of knowledge and representations. A combination of practices, with biological and physical processes, social and economic contexts interacting at every level creates innovation. The need to reach beyond the biotic factors (e.g., mycological) and conservation approaches to integrate traditional innovation into agriculture, forestry, manufacturing and other land management practices, poverty reduction initiatives and development strategies is indicated. Ignorance of innovation activities within the traditional knowledge systems constitutes missed opportunities for intensive social and economic transformation. Subsistence agricultural production, processing and manufacturing systems draw on traditional knowledge during production activities and have made significant contribution to food security and livelihood.

The paper further reveals critical entry points for knowledge transactions for example variable product quality due to un-standardized and uncontrolled process conditions and safety risk due to aflatoxins are issues that require collaborative efforts. Likewise, critical stage for stopping the fermentation and techniques of process control needs to be developed. To demonstrate safety from aflatoxins, moreover, a simple diagnostic recipe is required as a trade and regulatory aid to show compliance to standards. The example of organizational innovations and how local people adopted new technologies within familiar contexts clearly shows how modernization of agriculture and industrial growth and development is possible starting at local level.

Critical policy and procedural issues were also isolated including: disjointed top down interventions that are not targeted to local people's needs and perception; top down research agenda setting that is not demand driven and fails to address community needs. It shows that improved productivity is not only key driver of modernization of agriculture, raising income and food security but a medley of factors and resources systematically structured synchronized in tandem. It also demonstrated that sustainable income from agriculture or other sources is necessary for food security and improved livelihoods which can only be assured if there is effective demand.

It is finally concluded that linkages between the modern and traditional knowledge systems should be enabling and based on mutual benefit and not intrusive and exclusive.

Conflict of Interest

The authors have not declared any conflict of interest.

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