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Food insecurity as a supply chain problem. Evidence and lessons from the production and supply of bananas in Uganda

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ABSTRACT

Despite agriculture being the main economic activity in Uganda, increasing food prices within the country point to the growing challenge of food insecurity. In 2016, food shortage was reported in some parts of Uganda (mainly in Karamoja sub-region and parts of Serere) and government resorted to temporary relief distribution of food from other regions of the country. The acute food shortage in one part of the country while another part, a few hundred kilometers away, has excess farm output calls into question the efficiency of the supply chain of some agro-commodities.

This research attempts to examine the challenges faced in the production and supply of bananas in Uganda and how the supply chain perspective can help us address these challenges better. We juxtapose the supply chain approach against the value chain perspective and argue that the supply chain perspective offers a much deeper understanding of market-based challenges, which affect livelihoods of smallholders who often sell their products at rock-bottom prices.

A cross sectional survey of various banana production and consumptions points in Uganda was conducted. The findings show that losses in the supply chain accounted for about 29% of banana production – a figure slightly lower than that 40% previously reported in the literature. In addition, the farmers did not benefit from increased food prices due to inadequate market information at their disposal despite banana value chains having recently received significant development attention. We also found that infrastructural bottlenecks and limited collaboration and coordination among smallholders heavily affected the supply of bananas in the country. This is arguably a key factor that strongly explains the food insecurity problem in Uganda. We conclude that the findings point to a different problem, which is that of a dysfunctional supply chain structure of bananas from the rural areas to urban centres in Kampala.

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Introduction

Improving smallholders' access to markets is a leading policy objective of most governments in Sub-Saharan Africa [1,4,17]. This policy option does not only increase smallholder income and helps to alleviate poverty but ensures that areas facing food shortages are able to get adequate food supply. In part, it also helps to stabilize food prices across various parts of these countries.

Uganda is no exception. According to Ribbink et al. [37] up to 90% of Uganda's population live in rural areas. Based on this fact, Uganda could be described as a rural economy. Rural in this case is defined as areas that have relatively lower population densities than cities and in the Ugandan context, where agriculture and related activities usually dominate the local economy [30]. With Uganda's climate comes excellent conditions for agricultural production. Indeed a large population of the labour force is involved in agriculture. According to a FAO [16], report, Agriculture is by far Uganda's biggest employer accounting for about 72% of the total labour force of 10 million in a country of 41 million people.

Incidentally, despite the size of the labour force, agriculture contributes only 36.3% to GDP [17]. This partly because production and supply of agricultural output is generally inefficient. Smallholder famers struggle with poor farming techniques coupled with poor infrastructure, lack of market information and the volatile weather patterns [40,43]. These huddles are part of what this paper describes as supply chain inhibitions or bottlenecks. The supply chain inhibitions have no doubt contributed to increased food prices hence food shortages in many parts of Uganda.

The increase in food prices can partly be attributed to low productivity and for the most part supply chain inhibitions, which as we shall argue here, are partly responsible for the food insecurity problems faced in Uganda today. Some studies (e.g. [19]) agree with this argument. Yet despite this challenge, we know so little about the impact of supply chain inhibitions in the supply of farm output. Only a few studies (e.g. [5,42]) have considered the supply chain perspective to assess the actual impact of these inhibitions and more especially in the supply of bananas in an African context.

This paper therefore attempts to contribute towards a better understanding of the supply chain inhibitions in the supply of bananas in Uganda. Particularly we measure the pricing and loss of output at each stage of the supply chain from farm to market to get a better understanding of the loss of banana output in the entire value chain. Finally, we propose interventions, which if instituted within the supply chain will not only address the loss of banana product in the supply chain but also increase the smallholders' income. To do this, we propose model that places farmers at the centre of the banana value chain, and propose ways how the Government of Uganda policies can be targeted to help smallholders move up the value chain as actors rather than spectators in the supply chain. This will help improve their bargaining power and at the same time make the banana supply chain less erratic.

Food insecurity as a Ugandan and African problem

According to Slipsbury [39] as cited by Rubaihayo [38], bananas exist in four major types based on their purpose i.e. cooking, brewing, roasting and dessert types. In Uganda, the East African highland banana cooking type dominates banana production [13]. In this paper, we shall focus on cooking banana type, which contributes 90% of all bananas produced in Uganda as reported by the Uganda Bureau of Statistics (UBOS) in the National House hold Survey of 1999/2000 [44].

Bananas are regarded as a dietary staple to hundreds of millions of people in the world. For example a typical person in Uganda, Rwanda and Burundi consumes more than 550 pounds of bananas in a year. In Uganda, bananas commonly known as *matooke* are the most valued staple with 10 million tonnes produced each year. However, it is estimated that 40% of these bananas harvested go to rot and are wasted each year for various reasons that we shall explore later on in this paper [15]. So responding to market and value chain opportunities by smallholder producers is a key challenge to the commercialization of agriculture in Uganda [28,43].

In this paper, we argue that the systemic farm-to-market losses of agricultural produce including bananas largely explain the food insecurity problems that many African countries like Uganda faces [28]. At present, a significant number of Africans still face widespread hunger and malnutrition because of acute food insecurity [12,21].

In Uganda alone, in mid-2016, food shortage in the parts of North and North Eastern part of the country approached crisis levels and government resorted to immediate relief distribution [41]. In a country with sufficient labor force, pleasant climate, agricultural farm output should certainly be high under normal circumstances. Agricultural output should be sufficient to offset possible starvation in areas where farm output is less. However, this is not often the case in Uganda [20].

A number of studies (e.g. [8,21,45]) attribute the food insecurity problem to poor agricultural policies, low agricultural productivity, poor infrastructure thus high transport costs, poor marketing strategies, frequent extreme weather events, high disease burden with weak support systems and political conflict. Almond and Hainworth [2] point to poor infrastructure, limited market access and weak linkages between producers and consumers as the cause of the food crisis in many developing countries.

In Uganda, food prices have more than doubled since the start of 2010 [32]. These are partly attributed to high transport costs, while the limited access to market have been attributed to poor infrastructure. Milner et al. [34] ranked poor infrastructure as the number one constraint limiting market development in the majority of rural areas in Uganda. Transport, transport costs are highest in Sub-Saharan Africa compared any other part of the world [17]. As such, farmers struggle to get agro-produce to markets due to high transport costs [28]. Most rural roads in Uganda are still impassible especially in rainy seasons. This hinders the transportation of food to urban areas and further complicates the food insecurity in the country.

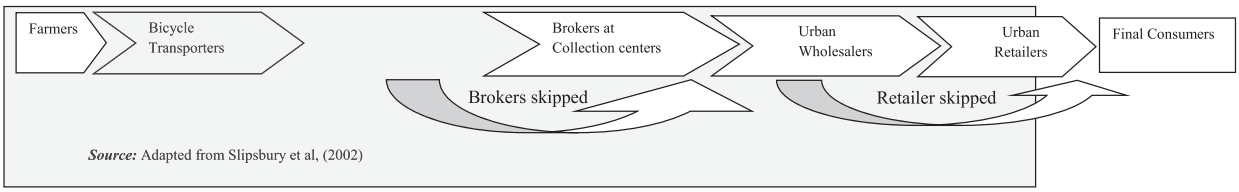

Fig. 1. A typical banana supply chain in Uganda.

In addition, food insecurity can be explained by the decreasing role of government as a player in the agricultural sector [11]. The structural adjustment programs instituted in Uganda in the 1990s saw government support towards farming communities drop significantly. Investments in rural infrastructure such as roads, input subsidies, marketing schemes and extension services and research have since declined yet most smallholder farmers who need these services most live in remote areas of the country.

The supply chain of bananas in Uganda

Supply chains in developing countries, not to mention for agro-commodities, are a long and complex [9]. Slipsbury et al. [39], attempted to map the banana supply chain in Uganda and showed that smallholders produce and sell banana bunches to bicycles traders at farm gate prices based on finger and bunch size, banana type and variety.

Bicycle transporters sell the bananas to brokers at collection centres located within the producing areas. The main producing area of bananas is the western part of Uganda, which contributes up to 61% of all bananas produced in the entire country [39]. At collection centres, bicycle traders have less negotiation power as they cannot store bananas or preserve them for future sale since bananas are by nature a perishable product. The brokers, operating at collection centres purchase large amounts of bananas in order to fill-up trucks destined for urban centres such as Kampala – Uganda's capital city which is the biggest market for that produce.

The brokers sell the bananas to wholesalers in various areas in the city. Brokers are often in regular contact with farmers, bicycle transporters, truck drivers and wholesalers and hence have good unit price information from urban centres. The small number of brokers and the market information available to them gives brokers significant amount of power to control and influence product price. In addition, the cost of hiring trucks is prohibitive and therefore acts as a barrier of entry for people who want to join this business.

The city based wholesalers purchase bananas from brokers and sell them in bunches to urban retailers or sometimes directly to consumers. Wholesalers occasionally fail the supply chain by hiring trucks themselves and buying bananas from collection centres. They are an estimated 200 wholesalers around Kampala alone: most are spread around the city markets including Nakasero, St Balikuddembe, Nakawa, Wandegeya, Kalerwe, Nankulabye and Kasubi.

Urban retailers sell their product alongside roads and major highways and within markets directly to the final consumers. In principle, forces of demand and supply determine the price. However, given the inadequacy of storage facilities, urban retailers have limited negotiation power because of the need to sell the bananas as fast as possible. The sale of bananas to the final consumer completes this rather long supply chain as shown in Fig. 1.

The studies of Basheka et al. [9] and Batt [10] show that supply chains of agricultural products especially in developing countries are long and often involve a large number of players. Citing Mendoza and Rosegrant [33], Batt [10] suggests that the market of agriculture produce involves many small and widely dispersed farmers growing perishable crops hence a highly atomistic production side and an oligopolistic demand side with just a few powerful traders. The powerful traders are able to extract value at the expense of poor farmers who are information deficient [24]. This is akin to the traditional supply chain where the balance of power problem common and often linked to the lack of timely information which in this case affects farmers [24,43].

Besides, bananas are perishable by nature [29]. Therefore, the time to market should be short. However, the nature of this supply chain involves quite a number of actors. At each exchange point in the supply chain, the product quality deteriorates. This is further worsened by the inadequate packaging and handling facilities [11,43]. For example, these bananas are loaded as whole bunches and handled manually to transport trucks. Therefore, the damage and chippings, coupled with theft of actual produce are a common problem. In the end, the ultimate consumer pays for 'not-so-fresh' bananas, or in most cases not good quality.

Supply chain inhibitions

Several studies (e.g. [1,2,35,43]) paint a picture of smallholders that are poor, operate independently and on small scale. They have little bargaining power compared to market savvy traders who have access to market and price specific information. This according to Clark and Hobbs [11] is a major hindrance for farmers to negotiate better prices in the market. So [2], propose that if farmers organized themselves into cooperatives, their capacity to pool resources for collective action would

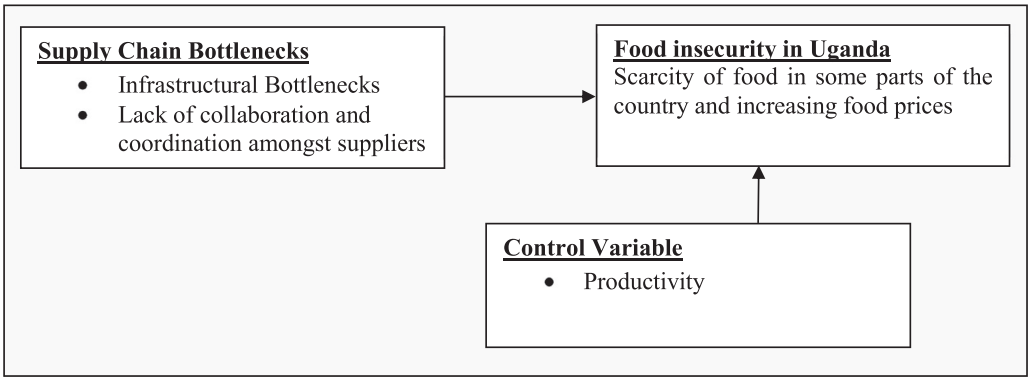

Fig. 2. Conceptual framework.

be significant in the achievement of economies of scale. Cooperatives have the potential to tackle problems of handling, distribution and marketing of agricultural output [28,43]. The lack of organized cooperatives deprives farmers access to market information which means they know little about the worth of their produce and how much would be earned if they opted to transport their product to the nearest town rather than sell it to traders at their gardens.

In addition, most farmers have a limited understanding of the market and what happens to their product once it's sold [35]. They lack sufficient production and market information of 'when to produce' and 'when to market'. Access to market information enables farmers to plan their production in line with market demand. This would allow them schedule their harvests at the most profitable times and decide to which markets they should send their produce [11,24]. The lack of market information increases the risk of failure in the distribution channels of agricultural output [28]. With sufficient market information, farmers can reap between 5% and 15% higher farm gate prices, hold onto the product until prices are high enough or sell in a different market where the price is relatively higher [36]. However, we need to note that the management of market information can be costly bearing in mind the undeveloped transport network infrastructure and language challenges due to the semi-illiterate rural labor force.

Moreover, the most affected regions with food problems appear to be those with populations living in remote and geographically hard to access areas. They have limited storage facilities hence high-post harvest losses due to the perishable nature of the product [3,11,21]. Bad roads especially in the rainy season and lack of own transport trucks further complicate the situation. As a result, access to agricultural inputs like seeds and fertilizers also becomes a costly activity for the smallholders [43].

The identified challenges in banana supply chain above can be categorized into two: (i) those that are policy related and (ii) those that relate to the structural bottlenecks in the supply chain. While policy related issues could be solved politically [4], the supply chain bottlenecks have no defined solution hence a huge challenge. This paper focuses on supply chain challenges, which can be summarized as high variability in supply, asymmetric information flow, low balance of power between smallholders and intermediate buyers, and quality related issues. These are compounded by category (i) or policy related challenges such as infrastructure problems.

This implies that even when the farm output is in sufficient quantities, smallholders will not benefit economically. They are forced in many cases to sell their produce at farm gate prices rather than market prices or alternatively sell to the most available buyer because of infrastructure bottlenecks and fear of additional losses beyond the farm [11]. Moreover, the inability of smallholder to explore opportunities outside their vicinity creates a situation of sufficient supply of farm output in one area of the country and near-starvation in another, a few hundred kilometers away.

In this paper therefore, we advance the need for an in-depth analysis of the current supply chain of bananas, through which actors are identified and categorized, relationships among them understood, bottlenecks identified and actions for overcoming them advanced. This research attempts to focus only on the interventions that can be instituted within banana supply chain in order for the smallholders to generate economic benefits, stabilize food prices while at the sometime help to avert food insecurity in Uganda.

Basing on the foregoing literature review, a conceptual framework in Fig. 2 is developed and is reinforced with the subsequent hypotheses.

Research hypotheses

As indicated earlier, the supply chain inhibitions in the production and supply of bananas are numerous in the reviewed literature. In this research, we specifically study the impact of infrastructural bottlenecks and lack of collaboration and coordination among the banana producers on the food insecurity in Uganda. The literature (e.g. [3,18,28]) is unequivocal: smallholders are faced with inhibitions at every stage of the supply chain including poor infrastructure and inefficient transport system and lack of explicit support services. Many of the banana producers are in the most rural parts of the country

supplied by a very poor road network and rough terrain. This in no doubt affects supply of bananas at collection centres and eventually to the market. We postulate therefore that infrastructural bottlenecks play a significant role in the food insecurity problem in the country and by focusing on the banana production and supply, we hypothesize thus:

H1. *Infrastructural bottlenecks in the supply chain for bananas are responsible for the food insecurity problem in Uganda.*

The literature (e.g. [4,22,31,43]) reported the lack of collaboration and distrustful relationships among players in the food supply chains. This is not different in banana supply chain in Uganda. Consequently, supply chain actors are often reluctant to share information on where bananas are bought and sold. The lack of quality information in the banana supply chain has led to absence of customer focus and difficulties in matching products to market requirements [23]. Closer relationships would in fact enable the participating parties to achieve better economic terms and revenue as well as flexibility in dealing with supply and demand uncertainties. We hence hypothesize thus:

H2. *Lack of collaboration and coordination amongst supply chain players is responsible for food crisis in Uganda*

Methodology

A cross- sectional survey was conducted amongst smallholder banana farmers in Western and Eastern part of Uganda. These two areas in addition to production from the central part of Uganda contribute to nearly the total production in the country. According to UBOS National Household Survey statistics (2002), the western part of Uganda produced 61% of all total production of bananas in the country. Convenience-based sampling was adopted in order to gather information from difficult to locate and semi-literate farmers: most of whom seemed uninterested in the study.

In order to systematically minimize the exclusion of relevant subjects of the population as is common with all non-probability sampling methods [14], specific segments – samples of specific subgroups (high income and low farmers) were targeted and represented in the sample in an approximately the same proportions as they represented in the population.

Four research assistants were sent to rural parts of western and eastern Uganda after preliminary interviews with banana brokers, who indicated that Buwejju (Bushenyi district) and Bufumbo (Mbale district) areas were the major banana producing areas in western Uganda and eastern respectively. Given that population in these two areas is largely illiterate, the questions were translated into the local languages during the questionnaire administration.

First, we calculated the productivity per acreage. The productivity figure when compared to the national expected average, would enable us determine efficiency in land utilization and determine whether the experienced food insecurity situation was partly indicative of low productivity. Although, this was not one of our measurement variables, it was quite necessary to include it in our findings as it helps us understand the aggregate productivity level of bananas in the country.

We then determined the amount of loss in the supply chain by calculating the amount of bananas produced per household. We compared this amount with the sum of what was consumed domestically and what was actually sold. The difference between the two constituted the loss of bananas at farm gate. In addition to loss at farm gate, we added what the brokers estimated, as losses during transportation at collection centres to Kampala. An aggregate of the two, loss at farm level and loss during transportation constituted the total loss of bananas within the supply chain. We were unable to determine loss at the retail level. Our experience showed that at retail level, most bananas were sold overnight hence; loss at this stage of the supply chain is not as significant as earlier thought. However, we are also cognizant that if this loss at retail level were to be added, the final figure would ultimately increase the proportion of aggregate banana losses in the entire supply chain.

Findings

A total of 150 questionnaires were sent out to the field targeting varied groups including: banana growers, banana traders, truck owners, bicycle vendors, banana retailers and consumers in Kampala. 122 questionnaires were returned reflecting a response rate of about 81.3%

Productivity

In general, the smallholders' acreage for banana growing ranged from as little as 0.2 acres to 30 acres. The banana growers surveyed had a total acreage of 522.9 acres of which 282.2 acres were used for growing bananas constituting 54% land utilization for bananas only. The total banana production for the surveyed farmers were 25,355 bunches a year. This constituted an average annual yield of about 90 bunches per acre. According to the UBOS National Household Survey of 2000, it was estimated that annual production of bananas per hectares was about 359 bunches. This is equivalent to 143 bunches per acre. From our research 90 bunches were being produced per acre which is about 63% of the expected national average. There is no doubt that this is relatively low and if assessed based on national consumption figures (banana consumption per capita), it becomes easy to attribute food insecurity in the country. However, we did not pursue this argument further since it was outside the scope of this research.

Table 1
showing banana losses at farm level.

	Banana production	Banana sales	Domestic consumption	Total sales & domestic consumption	Calculated loss at farm level
Number of bunches	25,355	18,955	2,792	21,787	14%

Loss in the supply chain

Next, we looked at the loss at farm level. To calculate the loss at farm gate we used the formula below:

$$Loss\ at\ farm\ level = Total\ Bananas\ produced - (Total\ banana\ sales + Domestic\ Consumption).$$

Annual production amongst the sampled farmers were 25,355 bunches. Annual sales amongst sampled farmers was about 18,995 bunches. In addition it was estimated that domestic consumption was about 2792 bunches making a total of 21,787 bunches consumed domestically or sold to bicycle traders. This constituted a loss of 14% at farm level (Table 1).

In addition to the loss at farm level we interviewed brokers and how much they thought they lost in transportation of goods from the rural areas to Kampala. On average, intermediaries and traders claimed an average loss of about 15% mainly because of poor handling, theft and bananas ripening during transport. This brings the total loss in the supply chain to 29%. Khan et al. [27] estimated that 40% of bananas in the supply chain in Uganda are lost. Two issues could explain the difference in these two figures: (i) that Khan et al. [27], considered all types of bananas i.e. cooking bananas, brewing and dessert bananas. In this research, we focused on cooking bananas only: (ii), we did not collect empirical data on loss of bananas at retail level but relied on the brokers estimates. If these two factors had been considered, the two figures on loss in the supply chain i.e. 29% calculated in our research and that of 40% according to Khan et al. [27] would have been much closer.

Overall, our findings with regard to losses in the supply chain help us clearly understand the supply chain bottlenecks in the supply of bananas. One, they corroborate the extant literature which argues that supply chains of agricultural output are generally inefficient (see [43]). Two, they help us to go deeper to analyse the specific impediments in the supply chain and how these impediments influence the supply of bananas and ultimately food security in Uganda. Lastly, we ask if these impediments affect the over role income of the smallholder farmers. To come up with this information we shall need to compare price of bananas at the different levels of the supply chain.

Prices of banana along the supply chain

We assessed market prices of an average sized banana along the supply chain and the Table 2 shows the prices along the value chain. Prices at farm level are assessed in the survey area of Buwejju and the final consumer is in Kampala, which is about 320Kms away. The findings are shown in the Table 2.

The findings also point to a very low bargaining power amongst smallholder farmers as corroborated by Katende [26]. This can be noted in the Table 2. Bananas are purchased from farmers at farm gate of UShs3000 (US$0.8) on average. By the time the banana reaches urban centres (like Kampala), the cost would increase by 70%. The biggest change in price is seen between the brokers who buy the bananas at UShs6000 (US$1.6) and the urban consumer at UShs 25,000 (US$6.7) representing a price increase of about 76%. The cause of this price increase, as mentioned by the wholesalers, is the long distances, high cost of the transport to urban centres like Kampala, possible loss due to ripening, poor terrain and constant breakage of transport trucks while in transit.

These findings reflect the same line of analysis of Tinzaara et al. [43] which argues that banana farmers sell their produce to middlemen and do not benefit from the higher prices gained when bananas are sold in urban markets. For example, Bafana and Sawa [6,7] observed that a farmer may only earn 300 Ugandan shillings (US$0.15) when a bunch is sold in remote rural areas and yet the same bunch can fetch more than 10–20 times more at markets in the capital, Kampala.

Fundamentally, the variation in prices between smallholder farmers and the final consumers can be attributed to controllable and uncontrollable factors. This categorization is based on what the small holder farmers can do amongst themselves (controllable factors) and what they cannot do amongst themselves (uncontrollable factors). They will need support of government for uncontrollable factors but can mobilize themselves to solve the uncontrollable factors [4]. One of such uncontrollable factors are the infrastructural bottlenecks.

Table 2
Showing prices of a banana along the supply chain (July 2017).

Levels of the banana supply chain	The farmer	Bicycle transporter	Broker	Urban wholesaler	Urban retailer	Final consumer
Price of a medium size Banana (UShs)	3000	5000	6000	10,000	15,000	25,000

Table 3
Showing the correlation between infrastructural bottlenecks and food insecurity.

		Infrastructural bottlenecks	Food crisis
Infrastructural bottlenecks	Pearson Correlation	1	0.801(**)
	Sig. (2-tailed)		0.000
	N	122	122
Food crisis	Pearson Correlation	0.801(**)	1
	Sig. (2-tailed)	0.000	
	N	122	122

** Correlation is significant at the 0.01 level (2-tailed).

Infrastructural bottlenecks in the banana supply chain

In Uganda the quality and stock of infrastructure is still not good enough. Packing houses, cold rooms and refrigerated trucks, collection centres are inadequate while the road network especially in rural areas is not good. This partly explains the wastage and losses of agro-produce in the supply chain [43,11,18]. For instance, Uganda has a total road network of approximately 144,785 km including community access roads of which about 4% is paved. The rest is gravel or earth roads [25]. With this background, a correlation analysis was conducted to establish the statistical significance of the relationship between infrastructural bottlenecks in the supply chain and food insecurity. The hypothesis tested was:

H1. *Infrastructural bottlenecks in the supply chain for bananas are responsible for the food crisis in Uganda.*

We posited that with the right infrastructure in place, food shortages in specific places in the country would partly be minimised, especially in a well-functioning supply chain. From impassable roads especially in rainy sessions, to inadequate handling equipment, inappropriate storage facilities and lack of transportation trucks to collection centres, the food supply to consumption centres and markets was inhibited [28]. Nine (9) questions sought to establish the relationship between infrastructural bottlenecks and the supply chain for bananas as mentioned above and the food crisis in Uganda. The Pearson correlation result in Table 3 showed a high positive correlation ($r = 0.801$, $p < .01$) implying that infrastructural bottlenecks is highly correlated to food insecurity in Uganda.

The poor state of the transport infrastructure is in itself a major challenge. Over 60% of the road network in Uganda is not well maintained rendering some of it impassable in rainy seasons. This affects the transportation of goods and services to markets. This assertion is supported by Tinzaara et al. [43] who rank transport infrastructure problems as among the top constraints limiting market development in the majority of rural areas in Uganda.

The poor road infrastructure aside, basic harvesting and handling equipment in farms and collection centres lead to a lot of wastage. For example, in all parts of the surveyed regions, bananas were harvested using machetes. This resulted in chipping and loss of the banana fingers from falling to the ground. If this happens, which is quite often the case, such bananas would be lost and cannot be transported to the collection centre. Transporting of bananas on bicycles to collection centres also affects the quality of bananas. Six to eight bunches are tied to one bicycle and one-man pushes it to the collection centres. The bicycle men reported bananas falling off these bicycles that led to further deterioration of the quality of banana during transport.

At collection centres, there was lack of appropriate handling equipment. Just like at the farm, many chippings took place. If trucks were unable to pick the bananas in time, wastage due to ripening and rotting was inevitable. Such occurrences continued all the way to the final consumer thus significant losses at every level of the supply chain.

Collaboration and coordination

The infrastructural bottlenecks, which we earlier classified as uncontrollable factors, require significant government participation [4]. However, there are controllable factors that smallholder farmers can address themselves. This is collaboration and coordination. Banana farmers are generally disjointed: they need some level of collaboration and coordination in order to succeed [22,31]. We examined the relationship between coordination and collaboration among supply chain actors and the food crisis problem in the country using the following hypothesis;

H2. *Lack of collaboration and coordination amongst supply chain players is responsible for food crisis in Uganda*

H_2 bases on a premise that acting collectively helps correct supply chain imperfections such as high transaction costs and variations in demand across the supply chain. This would increase the smallholders' purchasing power and allow them gain more market knowledge. Ten (10) questions tested the role of collaboration amongst supply chain players and its impact of food shortages in some parts of the country. The asymmetric information flow about market prices and market opportunities was as a result of the limited collaboration and coordination among supply chain actors [35]. This typically explained the high prices, and 'high supply-in low demand' phenomenon at banana consuming centres particularly in the central parts of the country. A correlation analysis was conducted. The Pearson correlation result in Table 4 showed that collaboration and coordination amongst supply chain actors and food crisis were strongly correlated ($r = 0.579$, $p < .01$) implying that

Table 4
showing correlation values between collaboration and coordination on food insecurity in Uganda.

		Collaboration and coordination	Food crisis
Collaboration and coordination	Pearson Correlation	1	0.579(**)
	Sig. (2-tailed)		0.000
	N	122	122
Food Crisis	Pearson Correlation	0.579(**)	1
	Sig. (2-tailed)	0.000	
	N	122	122

** Correlation is significant at the 0.01 level (2-tailed).

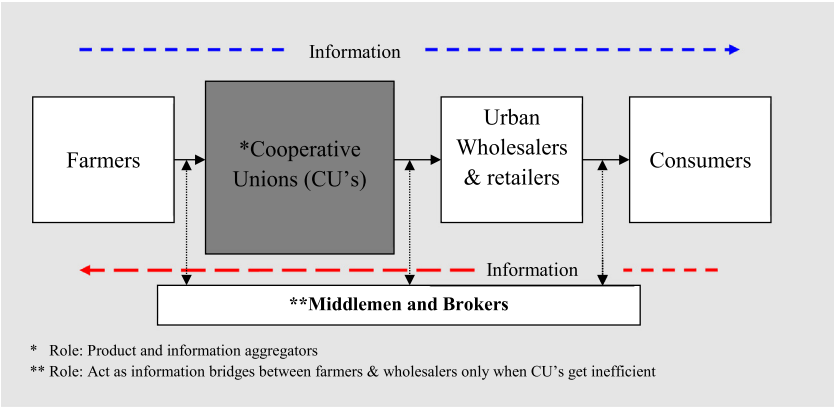

Fig. 3. Remodeled supply chain for bananas.

food shortages and sharp seasonal fluctuations in *matooke* prices exist due to lack of information and fragmented sales by uncoordinated smallholder groups

The lack of collaboration among supply chain actors was responsible for low smallholder participation, lack of market information, smallholder exploitation by intermediaries, and their inability to exploit existent market opportunities. These findings are in tandem with and who report that closer supply chain collaboration enabled supply chain actors to achieve cost reductions, and reduce losses as well as have better flexibility in dealing with supply and demand uncertainties. This is because actors share vital information on demand, production, inventory levels (excess, shortage), and processing capacities which can be useful to anticipate embedded problems in the supply chain.

Proposed interventions within the banana supply chain in Uganda

As we have demonstrated in this paper, a long and complex supply chain coupled with infrastructural impediments and weak collaboration and coordination among banana supply chain actors is central to understanding the food insecurity challenge in some parts of the Uganda. The supply chain has a number of players: smallholders, bicycle transporters, rural retailers, and brokers at roadside collection centres, wholesalers, truck transporters, urban traders, and urban consumers [28,39,43]. In order to simplify supply chain, there is need for small holders to augment their collective effort in order to stamp their presence in the supply chain through forming smallholder owned groups – as also proposed by Lev and Stevenson [31]. In our normative model in Fig. 3 we refer to these as smallholder owned groups as information aggregators or cooperative unions (CUs). CUs are important vehicles for increased smallholder participation in value chains and more power to the smallholder to control what they produce and how it is distributed in the supply chain.

CUs as aggregators in the supply chain

The current supply chain for bananas is very inefficient. Many disjointed small-scale farmers with uncoordinated production and limited bargaining power characterize it. The small holder has low bargaining power partly due to the product characteristics and partly due to low market information [28,39].

The remodelled supply chain in Fig. 3 integrates the role of transporters, brokers at collection centres and urban wholesalers into a single pro-farmer managed cooperative union. Why cooperative unions? By working together farmers can realize the scale economies of bundling resources and have a better understanding of markets. By pooling resources to invest in transport or processing facilities, they become more active participants in the marketing systems and therefore add better value to their production [31].

In the past, Uganda had a well-developed and a vibrant cooperatives environment within the coffee, tea, and cotton agro-commodities. Some of these included Bugisu cooperative union (Eastern Uganda) and Banyakore-kweterena (western

Uganda) for coffee and Nyakatonzi cotton growers (Western Uganda) for cotton produce. Currently only Bugisu cooperative union is presently active.

This proposal presents a shift away from the value chain approach to a supply chain perspective where the emphasis is consumer driven efficient supply and information processes rather than efficient production. As a result, we demonstrate that the supply chain perspective has the capacity to improve smallholder incomes if farmers understand how value is appropriated at every stage in the supply chain hence the emergent role of an aggregator (CUs). The aggregators have the capacity to organize smallholder groups better and offer benefits such as technical, information, business or financial support services about produce markets. They could also refocus on value chain development as many have proposed (see [43]). We believe that taking the value chain approach is often essential to successful economic development only if the agro-supply chains are developed and are efficient. Only then, can smallholder farmers benefit over the long term when the whole market is dynamic and competitive [28]

Needless to say, the government's role in providing critical infrastructure cannot be understated. Governments and local businesses have a key role to play to increase food security and improve smallholder incomes [4,17]. For example, government investments in rural infrastructure are profitable if aggregators (in this case CUs) also invest in increased production, local businesses invest in processing and distribution, service providers invest in new technology, and so on. If these complementary efforts are not well coordinated, supply chain failure will occur.

With such interventions, it's hoped that smallholder incomes will be improved due to the expected reduction in wastage through better packaging and processing of bananas for value addition. It is also important to point out that the long and complex supply chain will be shortened thus making the smallholders key actors in decision making rather than relying on individual buyers who dictate what, when, and how much to buy. Through CUs, it is possible to educate and train banana producers on in record keeping in order to effectively use information obtained externally. Moreover, smallholder owned organizations are known to play a key role of organizing economic activities beyond local boundaries [31]. They can build up relationships with other supply chain actors and create commitments from various actors to cooperate on mutually beneficial projects.

Conclusion and policy recommendations

In this paper, we examined the problem of food insecurity in Uganda by investigating the supply chain inhibitions in the production of bananas in Uganda. We purposely moved the food insecurity problem away from the ongoing value chain development narrative to a more business oriented supply chain narrative by arguing that the value chain approach is a production-oriented concept: it downplays the market orientation in which the supply chain strongly rooted.

Our findings suggest that smallholder banana producers lose on average 29% of the total production of bananas in the supply chain. The study further revealed that there is a positive correlation between infrastructural bottlenecks and food insecurity in Uganda. We believe that with the right infrastructure in place, food shortages in specific places in the country would partly be minimized, particularly when the supply chain is efficient. The infrastructural bottlenecks ranged from impassable roads (during rainy sessions), inadequate handling equipment, inappropriate storage facilities, high cost of transport to collection centres, food supply to buying centres and markets and so on.

In addition, the results showed that collaboration, coordination, and food insecurity are strongly correlated. We advance that limited supply chain collaboration was responsible for food shortages and sharp seasonal fluctuations in prices of bananas due to lack of good quality information and uncoordinated smallholder groups in the country.

While some of the bottlenecks which the study explored required government intervention, others required the major actors in supply chain to establish collective action in the areas of concern along the supply chain. The operational benefits inherent were presented and discussed. The biggest benefit was the shift of power from product intermediaries such as information brokers to smallholder farmers and their CUs. This, we argued, would drive economic development by increasing incomes to smallholder farmers. As a result, the impact on the banana value chains would increase significantly.

The implications drawn from the study highlights three (3) areas that should be of policy and managerial interest. Firstly, the *reduction of the total banana losses in the supply chain.* It is imperative that farmers organise themselves into cooperative unions to increase their synergy and reduce the time to market through a shortened supply chain thus shorter lead-times. Alternatively, CUs as aggregators could perform the bicycle transport role, which not only reduces the of number actors hence reducing waste, they would also help producers capture additional margins and give them better market information than it is currently.

Secondly, *legislate towards agricultural information as a public good*. Governments and specifically the government of Uganda should provide legislative and policy alternatives which open opportunities for CUs to control information in their various commodity domains. By playing a lead role in collection and distribution of information on banana production, marketing, pricing and distribution, CUs and therefore smallholders become active participants in the banana value chains. Regulated information conduits like CUs maybe linked to agricultural extension services of government, which presents opportunities to share production and marketing information across other commodity chains. In Uganda, for example, the lessons from banana production CUs would provide lessons to other smallholders and farmer groups through existing government legislated programs such as National Agricultural Advisory Services (NAADS), the Presidential Initiative on Banana Industrial Development (PIBID) and Operation Wealth Creation (OWC). The potential for this approach to shared learning across the entire agriculture sector is immense.

Thirdly and finally, *the need to invest in physical infrastructure to support post-harvest banana handling and transport.* Appraisal and investment in feeder and main roads by both central and local governments is necessary to reduce transport costs and ensure bananas can get to markets in time. During the rainy season when most community roads become impassable, we estimated that banana losses were highest. Investments in infrastructure would not only improve the banana supply chains alone, but would also enhance marketing of other commodities. Moreover there is need to develop a smallholder production response systems in order to quickly predict price variations as a way to increase smallholder incomes, improve consistency in annual market volumes and reduce consumer price peaks.

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Supplementary material

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