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International Journal of Agricultural Sustainability

Publication details, including instructions for authors and subscription information:

<http://www.tandfonline.com/loi/tags20>

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Version of record first published: 28 Aug 2012

To cite this article: Laurence Jassogne, Piet J.A. van Asten, Ibrahim Wanyama & Philippe V. Baret (2012): Perceptions and outlook on intercropping coffee with banana as an opportunity for smallholder coffee farmers in Uganda, *International Journal of Agricultural Sustainability*, DOI: 10.1080/14735903.2012.714576

To link to this article: <http://dx.doi.org/10.1080/14735903.2012.714576>



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Perceptions and outlook on intercropping coffee with banana as an opportunity for smallholder coffee farmers in Uganda

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Coffee and banana are important cash and food crops in Uganda and the surrounding East African highland region. Production is dominated by smallholders that have limited arable land and often coffee and banana are intercropped. No significant research and development efforts have been undertaken over the last few decades on this coffee/banana intercropping system. Because recent studies suggest that this system could be a practice with high benefits to the farmers, we decided to study the perceptions of stakeholders along the coffee value chain starting with farmers. Perception analysis based on open-ended interviews following interview guides revealed that a major limitation for the sustainability of this system was poor soil fertility conditions. Perceptions on the benefits of intercropping differed little among coffee actors; that is, banana intercropping provides additional food and income from smallholders' limited land and helps farmers reduce risks related to drought, pest/disease attacks and coffee price volatility. However, farmers' desire to minimize risks does not match the objective of stakeholders higher up the coffee value chain to maximize coffee production. Furthermore, research by public institutes, both national and international, is primarily organized for single crops and not systems. We conclude that the institutional setting of the coffee sector hampers the promotion of intercropping, despite the benefits for the farmer.

Keywords: farming system; coffee; banana; innovation; perception analysis; food security; institutional settings

1. Introduction

Coffee and banana are primary cash and food crops in Uganda and the surrounding East African highland countries. In Uganda, coffee constitutes 20–30% of the foreign exchange earnings (UCDA 2011) and banana is its primary staple crop (Edmeades 2006). According to FAOSTAT (2010), banana (*Musa* spp.) is estimated to meet >10% of the dietary energy requirements in Uganda, Rwanda and Burundi. Both crops are predominantly grown by smallholders with farm size <2 ha (Ponte 2002) and can be found on the same farm on separate or as intercropped plots. In Uganda, 80% of the coffee grown is Robusta (*Coffea canafora*) and 20% is Arabica coffee (*Coffea arabica*) (UCDA 2011). Robusta coffee is grown at altitudes up to 1500 m while Arabica coffee is dominant above this altitude.

The coffee/banana intercropping system has been described as a traditional system in Uganda in both Robusta and Arabica growing regions (Oduol and Aluma 1990). When the colonial powers

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introduced coffee at a large scale in the first half of the 20th century, farmers traditionally intercropped bananas at planting, but found it challenging to keep both crops productive over time (Thomas 1940a, 1940b). Later, Mitchell (1963) observed negative effects of banana intercropping on coffee yields in a trial in Bukoba, Tanzania. After 4 years, coffee yield decreased by 35% when intercropped. He concluded that intercropping could not be recommended, but based this conclusion solely on coffee revenue, without including the banana revenue generated from the same plot. Despite the doubts raised on the productivity and sustainability of coffee/banana intercrop systems, recent studies suggest that intercropping potentially provides numerous advantages to the smallholder farmer. First, it offers higher returns per unit land compared with coffee that is monocropped, even if coffee yields decrease (Chipungahelo *et al.* 2004, van Asten *et al.* 2011). Ouma (2009) suggested that farmers increasingly revert to intercropping due to declining farm sizes in an effort to reduce risks related to income and food security. If one crop is attacked, there will be the harvest from the other crop for food or cash. The one-dimensional focus on coffee yield in the intercrop study by Mitchell (1963) was probably perceived acceptable at that time, since coffee was one of the few export products that generated substantial foreign revenue for the East African countries. Assuring high and reliable yields was, and still is, of key importance for Uganda and its neighbours.

Besides the socio-economic advantages of intercropping coffee with bananas, there are numerous beneficial biophysical interactions. Banana offers a continuous ground cover keeping erosion rates low (Lufafa *et al.* 2003) in coffee fields. Furthermore, bananas can provide shade for coffee and shade has been shown to be advantageous for coffee production, especially in suboptimal growth conditions (DaMatta 2004). Shade can in some instances stabilize or increase coffee yield quantity, but also quality (Beer 1987). Coffee prices for farmers increasingly depend on coffee quality (Ponte 2002). This was already the case for Arabica, but quality norms are now being developed for Robusta coffee by the Ugandan Coffee Development Agency (USAID-LEAD 2010).

The limitation at farm level for a sustainable intercrop system is resource competition. Balancing this competition for light, water and nutrients between the crops is essential to optimize revenues for the smallholder farmer. Developing recommendations for sustainable intercropped systems has been identified as a major challenge in Uganda (Oduol and Aluma 1990). Despite the identified need for these recommendations, no research-based guidelines for banana/coffee intercropping exist to date in the East African highland region. Moreover, even if we further improve the knowledge on the socio-economic and biophysical advantages of intercropping coffee with banana, there are numerous studies (e.g. Adesina and Baidu-Forson 1995, Röling 2004) that have shown that successful adoption of 'improved' agricultural technologies is only feasible if perceptions of farmers and other stakeholders on perceived benefits and constraints are taken into account. Hence, developing improved site-specific guidelines for sustainable intercropping based on economic and biophysical indicators may not be enough. Farmers' subjective preferences for characteristics of new agricultural technologies are important determinants of adoption behaviour (Adesina and Baidu-Forson 1995). Farmers can expand their production by innovating autonomously but the right conditions need to be created at higher scales to extend these innovations, underlining the importance of including all stakeholders in research projects (Röling 2004). A significant advantage of the coffee/banana intercropping system is that it is based on indigenous knowledge and local coping strategies, which is beneficial for adoption (FAO 2008). In this study, we explored the conditions from farm to institutional level to see whether this technology can be improved and disseminated to help farmers in Uganda and beyond.

Our objective is to capture and analyse the perceptions of various coffee stakeholders in Uganda on the benefits and constraints of coffee/banana intercropping. In order to describe and compare perceptions of the different actors, we conducted in-depth interviews following an

interview guideline. We particularly wished to study if there are conflicts of interests or perceptions between different actors in the coffee value chain, since the successful development and deployment of improved recommendations will strongly depend on the support and institutional arrangements of all actors along this value chain (Röling 2004).

2. Materials and methods

2.1. Selection of managers

Managers were defined as actors higher up in the coffee value chain and belonging to the public, private or non-profit sector. These organizations were active at the level of the smallholder farmer, the cooperatives and the washing stations/coffee warehouses (Figure 1). Managers belonging to the Ugandan Coffee Development Authority (UCDA) were also interviewed. The UCDA was established in 1991 after the liberalization of coffee. Its main role is to promote and oversee the deployment of the entire coffee subsector through support to research, propagation of clean planting materials, quality assurance, value addition and timely provision of market information to stakeholders. Coffee research is done by National Crops Resource Research Institute (NaCRRI)–Coffee Research Centre (COREC). At the time of the study, several private sector and NGOs had projects at the grassroot level to ensure the stable provision of high-quality coffee to the international market, as coffee consumption within Uganda is negligible.

In this context, the first manager was selected at a coffee stakeholder workshop organized in Kampala, Uganda. Then, using the snowball method for sampling, the next manager to be interviewed was identified by the previously interviewed manager (Patton 2003). Interviews were stopped when perceptions were repeated and no additional key information was provided. Consequently, a total of eight managers were selected and interviewed using this method representing one coffee authority, three research, two NGO and two private sector stakeholders.

2.2. Selection of extension agents

In Uganda, extension for coffee by the public sector is primarily provided by the National Agricultural Advisory Services and by UCDA. Extension services can also be provided by the

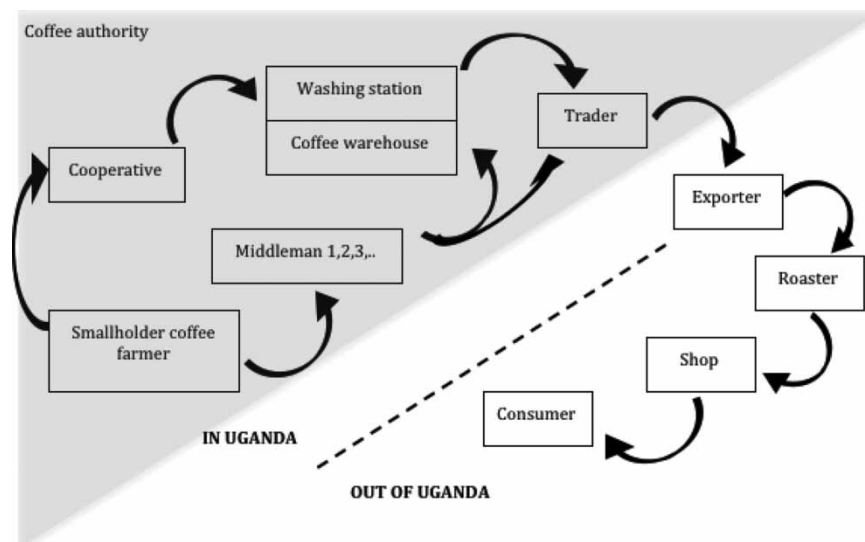


Figure 1. Illustration of the coffee value chain and main linkages between actors in Uganda.

private sector. In every site where farmers were interviewed, public (5) and private (3) extension agents that were active on the site were selected.

2.3. Selection of farmers

Farmers were selected in four sites from three main coffee regions in Uganda (Figure 2). The sites described below were selected because they were part of an ongoing survey organized by the International Institute of Tropical Agriculture (IITA) to characterize coffee/banana intercropping systems in the different agro-ecological zones of Uganda:

- (a) Luwero is situated in the central region of Uganda at a mean elevation of 1135 m (low altitude). Luwero is located approximately 75 km from Kampala. It is estimated that 85% of the district population is engaged in agriculture. Due to urbanization from the proximity of Kampala, there is an increased demand of food crops in the south. The main crops include bananas, cassava, potatoes, maize and pineapples. In this region, only Robusta coffee is grown (UCC 2011a).
- (b) Ibanda and Bushenyi are situated in West Uganda where both Arabica and Robusta coffee are grown at mid-altitudes with mean elevation of 1578 and 1550 m, respectively (UCDA 2011). In both districts, main crops grown next to coffee are banana, beans, maize and groundnuts (UCC 2011b, 2011c).
- (c) Kapchorwa is situated in East Uganda where only Arabica coffee is grown (mean elevation of 2022 m). Besides coffee, the main crops grown are millet, beans, potatoes, bananas and maize (UCC 2011d).

In each site, six farmers were selected, three practicing monocropping and three intercropping. They were randomly chosen among participants of participatory rural appraisals (PRA) organized in June–August 2010. Each PRA had 40–60 participants. During the PRA, general questions were asked about the coffee growing systems of the region, and their limitations and

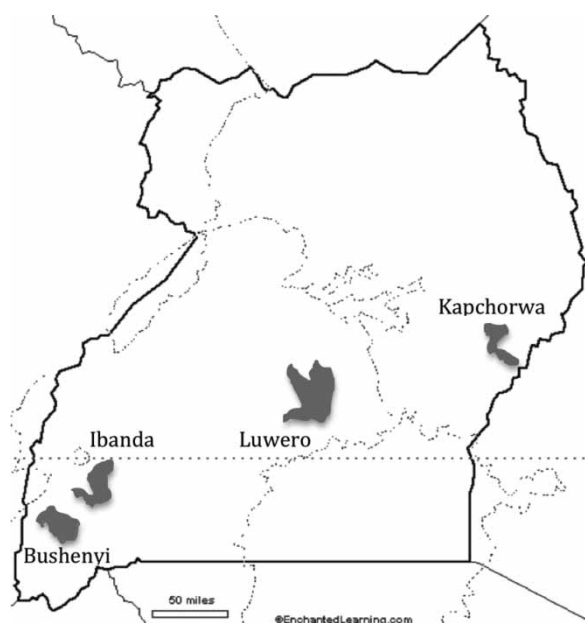


Figure 2. Selected districts for coffee farmer interviews in Uganda.

opportunities. At the end of each PRA, participants were asked to indicate (i.e. by raising their hands) whether they intercropped or monocropped coffee and banana. An overview of the selected stakeholders is given in Table 1.

2.4. Interviews

Each interview took between 1 h and 1 h 30 min and included a start in conversation style and a follow-up based on an interview guide (Patton 2003). To assess stakeholder perceptions, Huberman and Miles (2002) explained that in-depth analysis of a smaller number of long open-end interviews appeared more useful than a quantitative analysis of a larger number of short-structured interviews (e.g. questionnaires).

With managers and extension agents, the interview guide was developed in such a way that first, the general situation of the coffee sector at present was asked. Furthermore, the history of coffee and the importance of the coffee/banana intercropping system in the region were covered. Finally, the reasons why farmers would intercrop coffee and banana and the limitations and opportunities of this system were discussed.

With farmers, first, a general description of their farm was asked. Then they described the opportunities and limitations of their coffee system (monocrop or intercrop with banana) and ways to improve it. Finally, the interview went through the impact of coffee on their livelihood.

2.5. Analysis

All conducted interviews were transcribed into a text file and encoded using the software called R-based qualitative data analysis (RQDA) (Huang 2010). A list of codes or keywords was carefully chosen and those codes were then attributed to pieces of text in the transcribed interviews. When the encoding was finished, pieces of text from all interviews belonging to one particular code could be selected and analysed. Using this technique, incentives for intercropping and monocropping were identified. After identification, the citing frequency and citing order were calculated for intercropping and monocropping separately. The citing order was calculated as follows: (i) the incentive first mentioned would receive the highest score number that was equal to the total number of incentives; (ii) every subsequent incentive mentioned would be attributed a score number -1 from the previous; (iii) the average citing order was calculated by dividing the cumulated score by the number of respondent citing the incentive. The overall rating was calculated as citing frequency times the average citing order.

3. Results

3.1. General information

Results from the PRAs show that in Kapchorwa 73% of farmers intercrop. In Ibanda, 38% would intercrop, in Bushenyi 90% and in Luwero 47%. Care needs to be taken when interpreting these

Table 1. Overview of actors interviewed for this study.

	Luwero <i>Robusta</i>	Bushenyi <i>Robusta</i>	Ibanda <i>Arabica</i>	Kapchorwa <i>Arabica</i>
Managers	8			
Extension	2	3		3
Farmers	6	6	6	6

data, as farmers practicing intercropping would sometimes also have monocropped coffee plots. From the 24 farmers interviewed, 5 farmers grew coffee as a monocrop only. Out of these five farmers, one said he would be interested in applying coffee/banana intercropping the following year; he even started digging the planting holes.

3.2. *Incentives for intercropping*

In Table 2, the incentives for intercropping coffee with banana or for growing coffee monocropped are summarized together with the citation frequency, citing order and rating. We explain the perceptions on each incentive in the following sections.

3.2.1. *Cash and food from same piece of land/increased income and land scarcity*

Farmers explained that due to land pressure their farms were small, which compelled them to intercrop banana with coffee. This also allowed them to manage risks. If one crop would fail, they would still have the other crop. For example, a Robusta farmer explained that he lost most of his coffee due to coffee wilt disease (CWD). He was obliged to intercrop the remaining coffee with banana for food security to ensure some returns from his land if more coffee trees would get infected. In Uganda, 52% of Robusta trees were killed by CWD since 1993 (UCDA 2011).

Table 2. Incentives and importance ratings for coffee/banana intercropping and monocropping explained by farmers in Arabica and Robusta growing regions, extensionists and managers.

	Citing frequency and importance rating					Citing order	Rating
	Arabica (<i>n</i> = 12)	Robusta (<i>n</i> = 12)	Extension (<i>n</i> = 8)	Managers (<i>n</i> = 8)	Sum (<i>n</i> = 40)		
<i>Incentives for intercropping</i>							
Cash and food from same piece of land/ increased income	9	11	5	7	32	6.3	202
Banana provides shading for coffee	8	9	4	7	28	6.1	170
Land scarcity	5	5	4	5	19	5.2	98
Banana provides in situ mulching material for coffee	8	3	0	2	13	6.5	84
Motivation to manage coffee well	1	3	2	2	8	4.1	33
Coffee under shade gives thicker cherries	2	2	0	2	6	2.7	16
Feed animals with banana stems	2	0	0	0	2	5.5	11
<i>Incentives for monocropping</i>							
Unsuitability of soils – low soil fertility	2	2	8	8	20	5.2	103
Lack of training/recommendations	4	0	1	2	7	4.3	30
Unbelief through experience	2	2	1	0	5	2.6	13
Bananas damage coffee	0	2	0	0	2	5.0	10
Cultural traditions	0	1	0	0	1	4.0	4

Both farmers and extension agents indicated that coffee provides a cash boom twice a year, whereas bananas provide food and a modest income continuously. So, intercropping coffee would increase and diversify income of farmers from the same piece of land.

Farmers in all regions explained that intercropping coffee with banana was particularly advantageous for young coffee trees. Depending on the variety, it takes 3–5 years after planting for coffee to start yielding. Farmers generate no income from their coffee during that time. Intercropped bananas provide some food and income.

Higher and diversified income and food supply were also most cited by extensionists and managers. They explained that intercropping was more common in the Arabica regions where there was more pressure on land. In the Robusta regions, extension agents said that intercropping works best when coffee is young, and that bananas would generally be wiped out as the plantation matures, indicating a problem with sustainability.

3.2.2. *Banana provides shading for coffee*

Most farmers (17 of 24) explained that coffee required shade and that intercropped banana would provide this. Coffee under shade was perceived greener and less affected by drought. Some intercrop farmers explained that neighbouring monocrop farmers would ask them in dry periods why their coffee would still look green while theirs did not. Only four farmers mentioned that shade could adversely affect coffee yields, meaning higher yields when coffee is in full sun.

Managers and extension agents agreed with farmers that banana shade was beneficial for coffee. One extension agent and three managers stressed the importance of this benefit in the context of climate change. They indicated that Uganda's climate is predicted to become hotter with more erratic dry periods, making shade a necessity. One manager explained that Uganda's current attempt to expand coffee production in the north would also increase the necessity for shade, given the distinct dry season of the mono-modal rainfall pattern there.

Five farmers practising monocrop Arabica explained that they observed biennial yield variations; that is, good and bad coffee yields would alternate from one year to the next. Farmers did not mention this when banana was intercropped with coffee. The biennial variation was due to overbearing according to the extension agent; that is coffee, especially when young and unshaded, would exhaust all its resources to produce a lot of beans one year, only to produce a significantly inferior yield the next year.

3.2.3. *Banana provides mulching material in situ for coffee*

Interviewees indicated that a mulch cover on the soil helps preserve water, replenish nutrients, control run-off and erosion and suppress weeds. However, farmers and managers explained that application of external mulch in coffee plots is labour intensive. Intercropped bananas are perceived to provide mulch in situ. Furthermore, farmers indicated that weeds in intercropped coffee fields were softer and easier to remove, thanks to the banana mulch. Monocrop farmers would mostly either buy mulch or not mulch at all. They did not transfer residues from their banana field to their coffee field but would sometimes use some of their maize and bean residues. Mulch purchased off-farm was normally grass material. Scarcity of mulching material and subsequent high prices were perceived to be the major constraint for its application.

3.2.4. *Motivation to manage coffee well*

Farmers perceived the lack of returns from a young monocropped coffee field in the first 3–5 years to be a disincentive to invest in weeding, pruning, pest management and soil fertility

management. Farmers indicated that the food and cash generated from intercropped bananas motivated them to manage their coffee plot even when it was not yet producing coffee. Furthermore, farmers indicated that banana intercropping would continue to motivate them to manage mature coffee fields, as both crops would benefit from the same care. Extension agents and managers also cited this improved labour use efficiency (e.g. on weeding) as a significant advantage.

Most farmers explained that generally men and women jointly manage their coffee fields but men dominate the sale. Managers explained that even if most women also worked on the coffee monocropped fields, they would not see the money from coffee come back to the household and therefore would not be motivated to apply good agronomic practices on the coffee. Women would be more motivated to apply good agronomic practices on a plot where bananas were intercropped, because of its use for home consumption. Coffee would then indirectly benefit from this improved management.

3.2.5. *Coffee under shade gives thicker cherries*

Managers explained that coffee under shade produces thicker cherries that would therefore be of better quality for which farmers could get a higher price.

Farmers interviewed explained that the quality of coffee was important to get high prices; however, only two Arabica growing farmers and two Robusta growing farmers associated thicker cherries with shade-grown coffee.

3.2.6. *Feed animals with banana stems*

Land was scarce and farmers explained they did not have enough land to grow fodder crops to feed livestock. Two farmers in Kapchorwa mentioned that they did feed their animals with banana pseudostems that originated from intercropped coffee plots.

3.3. *Incentives for monocropping*

3.3.1. *Unsuitability of soils – soil fertility*

Four farmers (out of 24) explained that they could not intercrop coffee with banana because the soil in their coffee plot was unsuitable for banana plants due to poor soil fertility (two farmers in Luwero) or the stony nature of the soil (two farmers in Ibanda).

Managers and extension agents reported that soil fertility was a major constraint for coffee production and that intercropping coffee and banana without proper soil fertility management would not be sustainable, because it would increase soil nutrient depletion and bananas would be wiped out.

3.3.2. *Lack of training/recommendations*

All monocrop farmers except for one in Bushenyi explained they were never trained on how to practise intercropping. The one farmer in Bushenyi indicated that he was recently trained on intercropping and he now planned to start practising this, because of all the anticipated advantages.

The extension agent that provided intercrop training in Bushenyi explained that he was encouraged to do so through a new development project for which he worked. Several other extension officers explained that when farmers would ask for recommendations on intercropping, they provided recommendations based on their own experience.

Both extension agents and managers explained that the monocrop recommendation was a relic from the colonial past that some extension officers continued to preach and practise.

3.3.3. *Unbelief through experience*

Four monocrop farmers explained that they tried intercropping, but bananas were ‘wiped out’ as coffee matured. They did not believe that coffee and banana would be a good association.

One extension agent in Luwero explained that almost all farmers want to intercrop, but some farmers tried and failed. Consequently, these farmers would not be willing to practice this system again.

3.3.4. *Damaging coffee*

Two farmers explained bananas could fall and damage their coffee trees. This could happen at harvest or due to strong winds.

3.3.5. *Cultural traditions*

One farmer in Luwero attributed the choice for mono- or intercropping to cultural differences within central Uganda. Farmers belonging to ‘tribes’ that do not have banana as their primary staple crop would prefer monocropping coffee or intercrop coffee with other crops.

3.4. *Crop management for sustainable coffee/banana intercropping*

Three types of farmers could be distinguished: (i) farmers that monocrop coffee only, (ii) farmers that intercrop with banana when the coffee is young, and (iii) farmers that manage to intercrop coffee and banana permanently. For a coffee/banana intercropping system to be sustainable, all stakeholders explained that the prerequisite was good crop management practices. With sustainable, we mean that the farmer could maintain the coffee/banana intercropping system for a long period of time, that is also when coffee would be mature.

Table 3 gives a summary of activities perceived necessary to maintain coffee and banana intercropped in a sustainable way by farmers, extension agents and managers with their citing frequency.

All extension agents and six managers explained that competition between coffee and banana was the limiting factor for the sustainability of a coffee/banana intercropping system. Competition relates to inter-plant competition for nutrients, water and light. When coffee is young, it is perceived to compete less with banana. When the coffee matures, competition increases and

Table 3. Crop management activities for a sustainable coffee/banana intercropping system named by actors interviewed.

Crop management activities	Citing frequency			
	Arabica (<i>n</i> = 12)	Robusta (<i>n</i> = 12)	Extension (<i>n</i> = 8)	Managers (<i>n</i> = 8)
Competition/bananas wiped out	7	8	8	6
Density/spacing	6	1	8	6
Soil fertility management			3	5
Manure	8	7	3	3
Fertilizers	5	9	2	3
Mulching	5	4	1	4
Weeding	4	5		
Trenches	2	2	1	2
Pruning (coffee and banana leaves)	4	4		2
Right banana cultivar	1	1		1

Note: *n* is the number of interviewees.

the weakest crop (i.e. often perceived to be banana) is wiped out. This concurs with the explanation of 15 interviewed farmers (seven Arabica and eight Robusta). Farmers that could not sustain intercropping related this mainly to poor soil fertility and competition. All mentioned stakeholders explained that managing this competition was the key to a sustainable intercrop system. Several crop management factors were cited to manage competition.

The first factor was coffee and banana plant density. Six managers and all extension agents interviewed explained that correct densities are critical for successful intercropping. Correct densities would minimize crop resource competition and optimize production. The official recommended plant spacing for monocropped Robusta coffee is 3×3 m and monocropped Arabica is 2.4×2.4 m (NaCRRRI 2010). There was no consensus among extension agents on the appropriate spacing for intercropped coffee. Only six Arabica farmers and one Robusta farmer stressed the importance of spacing when intercropping coffee with banana; bananas have to be regularly desuckered to maintain their density. Although there was consensus among farmers that monocropped Arabica should be spaced at 2×2 m and Robusta at 3×3 m, there was no consensus on the appropriate banana spacing in coffee.

The second factor was soil fertility management. All extension agents and managers explained that lack of sufficient nutrient inputs (i.e. organic and inorganic) was a major constraint for coffee. Three extension agents and five managers explained that this was even more important when banana was intercropped. Farmers emphasized that adding enough manure, fertilizers and mulch was critical for sustaining intercropping. Out of the 24 interviewed farmers, 22 used manure to improve their coffee system. Sixteen farmers complained not having enough animals to produce sufficient manure. They would either want to buy more animals for manure or directly buy manure from other farmers. However, they noted that manure was scarce and often too expensive.

Five Arabica farmers and nine Robusta farmers said that mineral fertilizers would help them maintain the intercrop system. However, only eight had ever used small quantities of mineral fertilizers. None of the monocrop farmers currently used mineral fertilizers. Ten farmers explained that they wanted to try mineral fertilizers but it was either not accessible or they lacked the capital.

The third factor was mulching. Nine farmers explained that coffee/banana intercropping required extra mulching for nutrients and/or water conservation. Two of these farmers purchased mulch, while the others would get grass mulch from their land and roadsides, or they would use maize and beans residues. Perceptions were that mulching material was scarce and very expensive. High labour requirement for applying mulch was also considered a major constraint.

Other important crop management activities cited were weeding, establishing trenches and pruning coffee and banana (Table 3). For these activities, high labour requirements were considered a major constraint.

At last, two farmers and one manager explained that choosing the right banana cultivar was an important factor for the sustainability of a coffee/banana intercropping system. The right banana variety should be tall and have more erect leaves, while not being too nutrient demanding. One Arabica farmer had identified Yangambi-km5 as a suitable variety, while one Robusta farmer explained that the Pisang Awak variety (locally known as Kayinja) was a big scavenger and therefore not suited for intercropping.

3.5. *Perceptions on the way forward: access to credit and savings*

Managing competition between coffee and banana was perceived as the major condition for sustainable intercropping. Although nutrient input use is key, managers and extension agents explained that insufficient farmer capital prevented input purchase. Lack of farmer credit facilities and saving abilities were seen as the main reason for this lack of financial capital. Only seven

farmers accessed loan or saving facilities through their farmer organization. When coffee farmers need money, they mostly rely on middlemen providing quick money by selling their coffee pre- or post-harvest. Depending on the maturity stage of the coffee and the negotiation power of the farmer, the coffee revenue generated through pre-processed sale of coffee can be up to four times lower than the revenue generated when selling processed coffee through their farmer association or washing station. Some farmers explained that they would not sell through their organization because an organized sale would often delay payment. Hence, several farmers would still decide to sell their coffee partly or entirely to middlemen, even if this drastically reduced total income.

The overall perception of managers and extension agents was that farmers needed to change from subsistence to commercial agriculture before they would invest to increase coffee production.

3.6. Perceptions on extension activities and requirements

Extension agents explained that they relied on their own experience and judgement to come with intercrop recommendations. They had no knowledge or access to research results on coffee/banana intercropping in Uganda or the region. The extension material provided by the public sector only mentions intercropping as a possibility for young coffee.

During our interviews farmers repeatedly asked for information on banana/coffee intercropping. Farmers observed constraints and requested solutions. They explained that they never received training on intercropping, with the exception of farmers in Ibanda where a development project started to recommend it recently. A PRA in Ibanda in November 2010 showed that only 38% of coffee farmers intercropped to date, but a farmer explained they just got the training a year ago and were now planning to intercrop coffee and banana.

3.7. Perceptions on research activities and requirements

Managers from the public and non-profit sector explained that research should provide information and data to develop sound recommendations for the extension services so they can communicate it to farmers. They also explained that public research in Uganda did undertake agronomic experiments in 1993 to evaluate banana densities and fertilizer use in coffee/banana intercropping systems. Unfortunately, the results were based on a single on-station trial, considered inconclusive and therefore never published.

Uganda's public research and extension services are dominantly organized per crop, making it unclear as to who should undertake research on systems that entailed more than one crop. Managers belonging to the public sector explained that there exists very little collaboration between the different crop-specific and theme-specific research bodies within Uganda.

4. Discussion

The study revealed that perceived incentives for monocropping and intercropping were remarkably similar across stakeholders and regions. Citing frequency and order generally revealed the same trends, with the exception of citing order for incentives that were infrequently mentioned. As such, both citing frequency and citing order methods appear to bring out the importance of issues mentioned by the interviewees, provided that interview numbers are large enough (>30).

4.1. Sustainability of coffee/banana intercropping

Farmer interviews revealed that minimizing risks seems more important than ensuring maximum productivity as observed by Oduol and Aluma (1990). In the situation where farm sizes are

decreasing, the most cited advantage of intercropping is cash and food from the same piece of land. Increase of income per unit area and diversifying income contributes to increasing farmers' resilience in case of emergencies (van Asten *et al.* 2011). Population pressure will continue to increase in the medium-to-long term, further decreasing farm sizes and increasing farmers' desire to mix several crops in a single field. Managers explained that productivity of smallholder coffee farms in Uganda could be sustained and increased if better management practices were used. However, according to farmers, managing coffee better demands hiring labour, which requires financial resources they do not have. Similarly, managers and extension agents promoted a larger use of inputs to increase productivity, but, here again, farmers explained they lacked capital to buy these inputs. Although the profitability of fertilizer use on coffee is very high (value/cost >10) and far exceeds that of major staple crops, fertilizer use in the region is among the lowest in the world (Wairegi and van Asten 2011). If farmers could maintain coffee/banana intercropping at the early stages, then increased income could also help them acquire necessary inputs to continue the system in a more sustainable way. The extra income farmers get from the bananas that are intercropped with coffee (van Asten *et al.* 2011) could be returned to coffee management, so that the cash boom from coffee could increase overall revenues. However, farmers intercropping said they had difficulty maintaining the crops together because they could not afford the inputs to start with.

In general, interviews revealed that coffee smallholder farmers do not have enough assets, have restricted access to credit facilities and have to take uninsured risks. The required costs associated with sustaining coffee/banana intercropping exceed their asset stocks and therefore, the intercropping option becomes not viable long term. Initial conditions are fundamental for livelihood choices (Barrett 2008). Smallholders earn a living by combining their labour power with natural assets embodied in renewable natural resources (Barrett 2008). The main constraints perceived in this study for a farmer to sustain the productivity of a coffee/banana intercropping system at plot level were low soil fertility and increased competition for soil nutrients. If soil fertility is not replenished, then natural resources will be deteriorating and farmers will remain in a 'poverty trap' (Barrett 2008). Inputs used by farmers to manage soil fertility were mostly manure, mulch and even mineral inputs. In this context, integrated soil fertility management could promote the maximum use of locally available resources and the combined application of organic and mineral inputs to optimize production in an economically and socially acceptable way (Vanlauwe *et al.* 2004). Most farmers cited that adding manure would ensure the sustainability of intercropping coffee and banana. Studies, however, have shown that nutrient cycling through livestock could increase nutrient losses in the system but that livestock is very attractive to farmers due to its additional function next to providing manure (Giller *et al.* 2011). In terms of mulching, the COREC recommends a mulch layer of at least 10 cm (NaCRRI 2010). This would correspond to approximately 50 ton/ha of dry matter (Bizimana, personal communication), an amount that cannot be applied and maintained by the average farmer. Therefore, the advantages of intercropping coffee and banana that banana would provide mulch material in situ appears again more efficient and sustainable. In situ mulching would alleviate the labour required, reduce erosion, retain moisture and improve nutrient cycling (Snoeck *et al.* 1994).

Next to the benefit of increasing resilience of coffee farmers systems, intercropping of coffee and banana could improve coffee yield quality and reduce temporal variability. Increasing coffee quality leads to higher prices. This strategy seems to be in accordance with perceptions of managers and extension agents. It is well researched that coffee quality can be improved by shade (e.g. DaMatta 2004) and interviewees said that coffee benefited from shade of banana in an intercropped system. However, too much shade can negatively affect coffee yield (DaMatta 2004). A study done in Mexico showed that shade tree covers between 23–38% have positive effects on yield (Soto-Pinto *et al.* 2000). The benefits of shade increase as the environment

becomes less favourable to coffee production (DaMatta 2004). When coffee is in full sun, unless optimal management conditions are used, it will suffer from overbearing which exhausts the tree's reserves and limits both production and retention of leaves, leading to poor crop the next year (DaMatta 2004). Monocrop farmers confirmed experiencing this biennial variability, but none of the farmers mentioned it for intercropped coffee. Coffee under shade will survive setbacks such as temporary abandonment when coffee prices are low far better than monocultures of these crops (Beer 1987). Farmers seldom related coffee quality with shade even if they mentioned that coffee berries were thicker under shade. This is in contrast with managers, for whom thicker berry sizes are a direct indicator for the much-desired better coffee quality. To farmers, the advantage of banana shade is that their coffee suffers less from drought periods, which is interesting when looking at resilience of coffee systems in a changing climate. The Ugandan coffee sector would like to increase coffee production and one of their strategies is to expand the coffee-growing area to north Uganda. There, climate is unimodal with a more pronounced dry season during which shade will be particularly important. There is already evidence that more shade trees are present in coffee gardens in the north (Wanyama and Mukasa, personal communication) than in the Central and South where rainfall is bimodal.

4.2. Development and research requirements

It seems that farmers adapt autonomously to the changing climate, facilitated by their own social capital and resources (Adger *et al.* 2003). Focusing on how policy can support the adaptive capacity and resilience of vulnerable communities is primordial (Adger *et al.* 2003). At the moment, there seem to be inherent limiting conditions through the coffee value chain to stimulate farmers to practice the coffee/banana system in a sustainable way. As explained earlier, farmers lack capital for labour and inputs, and inputs are poorly accessible. For agricultural development to be effective, enabling conditions should be created at an institutional level to promote new technologies that are adapted to farmers' needs (Röling 2004). For example, the input market could be linked to the output market for coffee, which seems by far the most organized agricultural market in Uganda. Furthermore, extension agents did not have knowledge of any research done for recommendations on agricultural practices for intercropping coffee and banana. One example is that there was no consensus between interviewees about the densities at which coffee and banana should be planted when intercropped even if they all agreed that densities should be adjusted compared with monocropping. Enabling conditions need to be created at public research and policy level to come up with sound recommendations and training facilities on the intercrop systems. At the moment, research and extension facilities are organized by crop, and interviewees explained that there was little collaboration between different research entities. Systems like coffee/banana intercropping are subsequently left unattended by either research groups.

5. Conclusions

Stakeholders along the coffee value chain all perceived coffee/banana intercropping as a beneficial system for smallholder farmers. However, the primary driver of farmers to minimize risks does not match the objective of stakeholders higher up the coffee value chain to maximize farm productivity. Furthermore, poor soil fertility and limited access to nutrient inputs hampers many farmers to practice coffee/banana intercropping sustainably. Institutional changes need to be created in the coffee sector and intercrop research needs to be prioritized to develop and disseminate good agronomic practices that fit with smallholder production constraints and objectives. Recommendations to increase the sustainability of coffee intercrop systems are

particularly lacking due to poor institutional arrangements and support. If farmers can address soil fertility constraints through improved access to nutrient inputs, then farmers can escape from the 'poverty trap' and productivity, profitability, and food security can increase over time. All actors are present to escape from the poverty trap, but escaping requires better (institutional) linkages between input dealers, farmer organizations, micro-credit providers and coffee exporters. These linkages can be encouraged through appropriate (policy) support from the public sector. Besides minimizing short-term risks in terms of food and income security, coffee–banana intercrop systems appear to have a strong potential in terms of climate change adaptation. This merits more attention, particularly for Arabica coffee, which is limited to high (> 1500 m) altitudes.

Acknowledgements

The authors thank David Mukasa for all the help organizing the field work of this study. They are also grateful for the time all stakeholders made for the interviews. The funding for this paper was made available by DGDC funded CIALCA project, USAID-LEAD and IITA.

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