Understanding and exploring the evolution of coffee-banana farming systems in Uganda

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Abstract

In Uganda, coffee accounts for approximately 20% of total export revenue. For smallholder farmers coffee is a main source of income, extremely important to cover large costs such as school-fees for the children. A substantial proportion of the coffee farmers (37-88%) intercrop coffee with banana, which is one of Uganda's primary staple food crops. This practice is the result of local innovation.

Farmers' main reasons for intercropping coffee and banana are that (I) intercropping provides both food and cash from the same plot of land, (II) banana provides in-situ mulch and shade for the coffee, and (III) because land scarcity 'forces' farmers to intercrop. Recent research findings showed that coffee yields per hectare per year are not significantly affected by the coffee-banana intercrop system. Hence, incorporating banana in the coffee fields seems to improve food availability without jeopardizing the coffee revenues.

A trend-analysis of coffee-farming systems in Eastern Uganda suggests that the ratio of intercropping has been increasing the past 5 years with currently more than 85% of the farmers having at least one plot with coffee- banana intercropped. Analysis at plot level indicates that almost 50% of former coffee mono-plots changed into coffee-banana intercrop plots in the same period. Despite these trends, around half of the coffee farmers in Central and Western Uganda still practice monocropping. In neighbors Rwanda and Burundi, the intercrop practice is generally discouraged by the local authorities. Although the advantages of intercropping seem obvious from an agronomic point of view, there may be socio-economic barriers to adoption at the farmer, extension and policy level.

We will present a research framework to identify and understand the past evolution in the farming systems of the East African coffee producing regions with the aim to explore opportunities and barriers of future development pathways for coffee smallholders.

1. Introduction

Coffee is one of the most important export products in the East African Great Lakes Region, contributing respectivey 20%, 25% and 60% of total export revenues in Uganda, Burundi and Rwanda (UN-Comtrade, 2010). Uganda exports both *Coffea canephora* (Robusta coffee) and *Coffea arabic*a (Arabica coffee), of which 90% is produced by smallholder coffee farmers. Rwandan and Burundian smallholders produce Arabica coffee. Next to its importance at national level, coffee plays a vital role in household income.

There are two main smallholder coffee production systems in the East African Great Lakes Region: coffee intercropping and coffee monocropping. In Uganda coffee is mostly intercropped with banana, and it can

also be intercropped with annuals and trees. Banana is one of the primary staple foods in Uganda, and it provides a small continuos income throughout the year. Banana is also an important crop in smallholder farms in Rwanda and Burundi. However, in these countries coffee and banana are both dominantly cultivated in monocultures and the rate of intercropping is very low (Jassogne et al., 2011).

In this study we focus on the coffee monocropping systems and the coffee-banana intercropping systems of Uganda. These production systems have different results in terms of food availability, income and sustainability.

In general, coffee intercropping systems offer more agronomic benefits to smallholder farmers than coffee monocropping systems, with an increase in organic matter/nutrient recycling, soil conservation, productivity life cycle of coffee plants and higher biodiversity values (Moguel & Toledo, 1999 ; Diaz, 2012). Due to these advantages, there is less need for external inputs in the intercropping system.

More specifically, incorporating banana in the coffee fields seems to improve food availability and household income. Van Asten et al. (2011) have analyzed the agronomic and economic benefits of coffee-banana intercropping in Uganda, showing that coffee yields per hectare per year are not significantly affected by intercropping coffee and banana. However, the total annual revenues per hectare increase tremendously when coffee and banana are mixed in a plot (see Figure 1, van Asten, 2011).

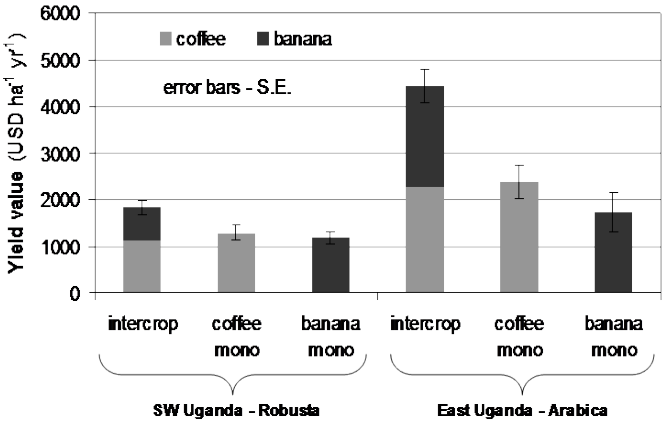

Figure 1. Profit per hectare for different coffee systems in Uganda. (van Asten, 2011)

While in Uganda, Rwanda and Burundi both coffee and banana are very important, the production systems in these countries are different. Even within Uganda there are differences in the systems and the evolution within these systems. This is because farming systems are highly dynamic, co-evolving with their social, economic, ecological and political contexts (Norman et al., 1994 ; Collinson, 2000 ; Dixon et al., 2001). Farming systems analysis includes understanding farmers' decision-making which are the driving forces behind changes within systems (Keating & McCown, 2001). And there are many factors influencing farmers' decision-making. In order to understand and explore opportunities to enhance coffee-based farming systems we need to identify the influencing factors in farmers' decision-making and the related evolution within farming systems. This requires a research approach going beyond the agronomic, political and institutional analysis of coffee production currently predominant in the East African Great Lakes Region.

In this paper we will present a research framework aiming to identify and understand the influencing factors in household decision-making and changes within the systems. The research framework will be

illustrated by general changes in coffee-banana intercrop systems in Uganda. The broader aim of the framework is to facilitate the identification of intervention points to improve food availability, income and sustainability of coffee smallholder farmers in the East African Great Lakes region.

2. Methodology

This paper is based on field observations, informal discussions and several databases of information collected in Uganda between 2006 and 2012 concerning coffee and banana field performances.

Results presented are based on a study carried out by IITA with financial support from LEAD-USAID including 26 districts over 5 regions. Herein structured interviews were held with 250 households and 26 Participatory Rural Appraisal (PRA) meetings were done in the different districts.

We also refer to a study done in South, West and East Uganda by van Asten et al. (2011) with Agricultural Productivity Enhancement Program (APEP). During this study, 152 coffee plots were surveyed. The data was collected through structured interviews, field measurements and observations. The study assessed the profitability of intercropped coffee-banana systems compared to monocropped coffee and banana systems in the different regions of Uganda.

Furthermore data has been collected for an impact assessment of APEP, the APEP follow-up study. Structured interviews and field visits were done in August 2011 and January 2012 in seven districts in the East and Southern regions of Uganda. A total of 210 households were included and 11 PRA meetings.

To characterize perceptions on coffee-banana intercropping and monocropping, data is used from Deraeck (2011) and Jassogne et al., (Manuscript Draft). Within this study, in-depth semi-structured interviews were held in Uganda (40) and Rwanda (46) and field measurements and observations were recorded. Interviews were done with managers, extension workers and smallholder coffee farmers.

The presented research framework is guided by decisions systems theory (Öhlmér et al., 1998 ; Fountas et al., 2006) through providing 'an interpretation of the decision-making process used by farming families' (Farmar-Bowers, 2010 p. 148).

3. Results and Discussion

3.1 Coffee-based farming systems

There are different coffee-based farming systems in the East African Great Lakes Region with different evolution pathways. In general we can identify six main evolution pathways of coffee production systems in farmers' fields in Uganda, Rwanda and Burundi. The occurrence of the systems and their general evolution pathways differ much between the countries (Table 1).

1- Coffee is planted in a monocrop system and remains a monocrop system.
2- Coffee is planted in an intercrop system with banana. While the coffee is maturing the banana can already be harvested. In the long term banana provides a steady income throughout the year and coffee provides bulk income at harvest season. The aim is to maintain a coffee-banana intercropped system.
3- Coffee is planted in an intercrop system with banana. While the coffee is maturing the banana can already be harvested. When coffee starts producing, less management is put on banana and eventually the system becomes a coffee monocrop system.
4- Coffee is planted in an intercrop system with annuals. While the coffee is maturing the annual crops can already be harvested. When the coffee is mature and producing, annuals can no longer

grow because of the negative impact of the shade of the coffee plants on annuals. A coffee monocrop system remains.

5- Coffee is planted in an intercrop system with shade trees. The shade trees provide the necessary shade for the coffee and preferably some fruits for consumption or cash. The aim is to remain with a shaded coffee system.

6- Coffee is planted in an intercrop system with shade trees, annuals, and banana. While the coffee is maturing the annuals and banana can already be harvested. When the coffee is mature the coffee, banana, shade trees and few annual crops remain, being a coffee-homegarden.

Coffee System	Uganda	Rwanda	Burundi
1 - Coffee monocrop	Common	Dominant	Dominant
2 - Coffee-Banana intercrop	Common	Not common	Not common
3 - Coffee-Banana to Coffee monocrop	Common	None	None
4 - Coffee-annuals	Not common	Occasional	Occasional
5 - Coffee-shade trees	Dominant	Not common	Not common
6 - Coffee-homegarden	Common	Not common	Not common

Table 1. Occurrence of the coffee-development pathways and current coffee systems in Uganda, Rwanda and Burundi.
(None- Not common- Occasional- Common- Dominant)

3.2 General changes in coffee-based farming systems in Uganda

When we focus on coffee-banana intercropping systems in Uganda, specific trends of change can be identified. Analysis in the Eastern and Southern regions of Uganda suggests that the ratio of intercropping systems has been increasing the past five years with currently more than 75% of the farmers having at least one field of coffee-banana intercropped. However, around half of the coffee farmers in Central and Western Uganda, and the majority of the coffee farmers in Rwanda and Burundi still practice coffee monocropping. When we analyze individual plots, we see that almost 50% of former monocropped coffee plots transformed into coffee-banana plots between 2006 and 2012 in Eastern Uganda. In Southern Uganda this is only 12.5%. In the Southern region almost 18% of the former coffee-banana intercrop plots became coffee monocropped fields over the same time-period, while in the East this is only 10% of the former intercrop plots.

Aiming to understand the general trends in existence of the coffee-banana systems in Uganda we look at studies of Jassogne et al. (Manuscript Draft) and Deraeck (2011) which reveal three major locally identified factors influencing the decision to intercrop coffee and banana. These are 1) intercropping provides cash and food from the same piece of land and increases income, 2) banana's provide shade and in-situ mulch for coffee, 3) land scarcity 'forces' people to intercrop. Another study of Bongers et al. (2012) reveal the same influencing factors for intercropping. There are no differences in factors between different regions.

Other research results show that the coffee-banana intercrop system is more profitable per hectare than having a monocrop field (van Asten et al., 2011). This corresponds to the local identified factor influencing intercropping in order to increase income. Also, corresponding to the factor of in-situ mulch from banana, the mulch layer in coffee-banana intercrop fields is significantly larger than in the monocropped coffee fields (Wanyama, 2012). However, when analyzing baseline data of coffee smallholders, there is no

significant difference between cropping systems and amount of land (Jassogne, 2012). Moreover, when asking farmers what they would do when they would have enough land, taking away the influencing factor of land scarcity, about half of the farmers would still opt for intercropping (Bongers et al., 2012). This indicates that the third major factor influencing intercropping (land scarcity) does not match with measurements, and that intercropping is a dynamic process very sensitive to influencing factors. Understanding the general changes in the occurrence of coffee monocropping systems and coffee-banana intercropping systems in Uganda requires a detailed analysis of these influencing factors in farmers decision-making processes. We therefore developed a research framework with which the influencing factors in decision-making processes can be identified.

3.3 Research framework to identify influencing factors in decision-making

There are many different factors at different levels influencing farmers' decision-making processes. According to Dixon et al (2001, p15) there are five main categories of factors influencing farming systems which are often beyond the household setting, including 1) the natural resources and climate, 2) science and technology, 3) trade liberalization and market development, 4) policies, institutions and public goods and 5) information and human capital. Woodward et al (2008) also state that many factors influencing a farming system are beyond the households' ability to control or manage. Norman et al. (1994) divide the main influencing factors in technical and human ones, with the latter containing both endogenous and exogenous factors. Endogenous factors are embedded in households, like land, labour and capital, while exogenous factors comprise the social environment including community structures, institutions, markets and demographic factors like population density and location (Norman et al., 1994).

Going more in depth in influencing factors embedded within households, de Bruijn and van Dijk (2004) argue that it is important to emphasize the diversity in socio-economic conditions and changes in the local interpretation and use of the environment between households. Farmar-Bowers (2010) stresses the influence of the households' and individuals' objectives, interpretation of opportunities and perspectives. These aspects deepen the endogenous factors of Norman et al. (1994) by including individuals' perceptions and skills.

As we aim to analyse and understand why farmers actually 'do what they do' within the farm system and the specific factors that influence farmers' decision-making, we have developed a research framework guided by decision systems theory. We partly adopt the conceptual model of Öhlmér et al. (1998) of the decision-making process including four main phases: the problem detection, problem definition, analysis and choice, and implementation. Moreover, these steps of decision-making processes within a farm family can be at the strategic, tactical and operational level (Sharifi & van Keulen, 1994 ; de Koeijer et al., 2003). Decisions taken at the strategic level are directly related to the long-term objectives of the farming household (e.g. being a coffee farmer), decisions at the tactical level focus on the activities at medium long-term scale guiding activities at seasonal level (e.g. applying fertilizers), and operational decisions results in day-to-day activities.

Important aspects within a decision making model are the influencing factors, the decision-making processes, the management actions and the performance indicators. The research framework presented in Figure 2 highlights these main components and their interlinkages triggering change within coffee-based farming systems.

- The influencing factors are the components both within and outside the farming household which guide directly or indirectly the decision-making process within a farming system

- The decision-making process consists of the problem detection, the problem definition and the analysis of possible solutions considered and analysed by the farming household resulting in a specific choice guiding the management actions within the farming systems.
- The management actions are the activities done within the farming system concerning inputs, crops, livestock, labour and other cash- and natural- resource investments. Allocation of labour (whom, when, what, how) and inputs (what, where, when, how much) are important.
- The performance indicators are the actual results of the management actions within a farming system in terms of resource use efficiency for food availability, income and sustainability of the system.

Changes within farming systems occur mainly as the result of an adaptation in management decisions under influence of internal and external influencing factors, as well as under influence of current and former allocation of management practices and the performance indicators of the system in terms of food availability, income and sustainability.

- Internal factors are intrinsic within a household (de Bruijn & van Dijk, 2004 ; Farmar-Bowers, 2010). We categorize the internal factors according to the five livelihood capitals from the sustainable livelihoods approach, which include the human, physical, financial, natural and social capitals (DFID, 1999). A livelihood is based on a combination of these capitals which partly determine the actual manifestation of a farming system. Household objectives and aspirations are an important element within these internal factors.
- External factors are outside or beyond control of the household (Dixon et al., 2001 ; Woodward et al., 2008).

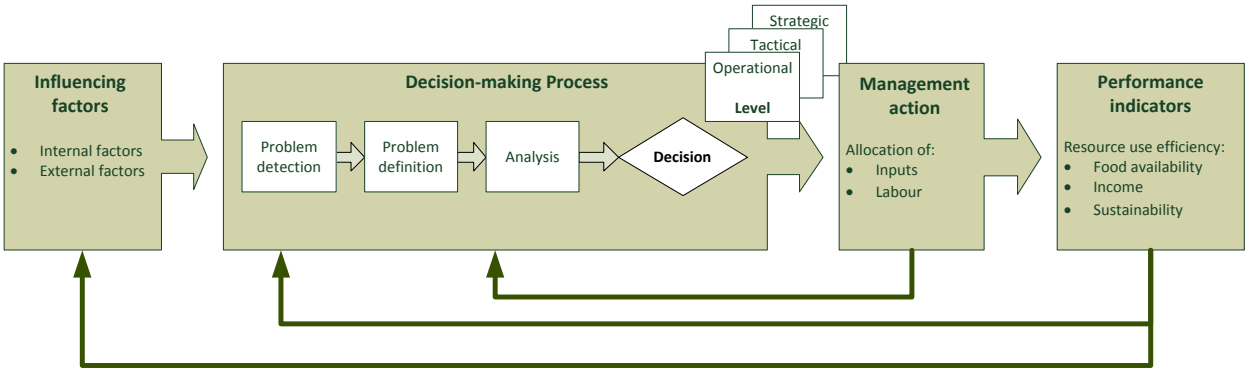

Figure 2. Research Framework.

3.4 Decision-making processes and evolution in coffee-based farming systems in Uganda

To illustrate the research framework, we use preliminary findings of field research in Uganda to deepen out the decision-making processes contributing to the change of occurrence of the coffee-banana systems described above (section 3.2). From the initial stage of a coffee-banana intercrop system we have identified three main decision-making processes at the tactical level which have transformed the system into coffee monocropping or reinforced the maintenance of coffee-banana intercrop system. We focus on specific farmers' household level where different decision-making processes resulting in certain activities within the individual farming system.

- A crisis occurs (external factor). A disease is found in either the coffee- or banana- population (problem detection). Information on the disease is gathered: the coffee disease is defined as

Coffee Wilt Disease (CWD), the banana disease is defined as Banana Bacterial Wilt (BXW) (problem definition). Analysis of options: (i) cure the disease, (ii) leave the disease there, and (iii) remove the infected crop (analysis). Decision is often to remove the infected crop: resulting in a monocrop coffee- or a monocrop banana- system.

- The desired objective of increased food availability and income is not met (performance indicator). The banana and coffee are not producing enough (problem detection). Source of the problem is defined as poor soil fertility constraining a good production of both crops (problem definition). Analysis of options: (i) reduce the spacing between the two crops, (ii) remove the bananas, and (iii) remove the coffee. Decision is often to remove the banana which is perceived as the most vulnerable crop: resulting in a coffee monocrop system.
- There is a lack of labour (internal factor). Yields of coffee and banana are low due to limited management practices (problem detection). There is not enough labour to allocate management practices on different plots for the benefit of the crops (problem definition). Analysis of options: (i) hire labour, (ii) buy chemicals that reduce the required weeding-labour like herbicides, (iii) allocate labour efficiently to a certain field to obtain minimum required food and cash, and (iv) allocate labour to a certain crop to obtain minimum required food and cash. Decision is often to allocate labour to the coffee-banana field. Therein banana provides in situ-mulch which results in less time needed for mulching activities and it suppresses weed-growth. This results in specific maintenance of the coffee-banana intercrop system.

4. Conclusion

As we have seen there are many agronomic benefits to intercropping coffee with banana, and also local perceptions identify many advantages of this practice. Food availability, income and sustainability of the farming systems generally increase in the coffee-banana intercrop system. However, we see that the existence of the coffee-banana system is not everywhere adopted and it is neither a stable system. The presented illustrations show that there are many factors influencing the existence of coffee-banana intercropping systems, and thereby the food availability, income and sustainability of coffee-based farming systems. We propose that, in order to be able to successfully identify intervention points to promote coffee-banana systems to improve coffee-based livelihoods, a step-wise and detailed analysis of decision-making is required.

However, while modelling decision-making processes in farming systems is identified as highly suitable for guiding innovations for agricultural development (Woodward et al., 2008), it seems to have achieved little impact so far. Woodward et al (2008) and Jakku and Thorburn (2010), among others, argue that one of the main reasons for this lack of impact is the little participation of stakeholders in the definition of the problem, the development and testing of the hypotheses and monitoring and evaluation of intervention oriented research and developed policies. We therefore stress the point that it is important to analyze the factors influencing farmers' decision-making processes in close cooperation with the coffee stakeholders.

We believe that the presented research framework facilitates participatory and step-wise mapping of the decision-making processes in farming systems, and will thereby improve insights in the constraints and opportunities for adopting different farming practices. Application of the research framework to the coffee-banana intercropping systems in Uganda will enhance the identification of intervention points to improve food availability, income and sustainability of the coffee-based farming systems in the East African Great Lakes Region.

References

Bongers, G., Mukasa, D. & van Asten, P. J. A. (2012). APEP follow-up study. Work-in-progress. Uganda. Personal Communication: 27-2-2012

Collinson, M., Ed. (2000). A history of Farming Systems Research. Rome/London, Food and Agricultural Organization of the United Nations and CAB International.

de Bruijn, M. & van Dijk, H. (2004). The Importance of Socio-Cultural Differences and of Pathway Analysis for Understanding Local Actors' Responses. In: The Impact of Climate Change on Drylands: With a Focus on West-Africa. A. J. Dietz, R. Ruben and A. Verhagen, Kluwer Academic Publishers**:** 341-362.

de Koeijer, T. J., Wossink, G. A. A., Smit, A. B., Janssens, S. R. M., Renkema, J. A. & Struik, P. C. (2003). Assessment of the quality of farmers' environmental management and its effects on resource use efficiency: a Dutch case study. Agricultural Systems(78): 85-103.

Deraeck, J. (2011). Le potentiel de l'association banane - café au Rwanda: une analyse systémique. MSc. Thesis. Belgium, Université Catholique de Louvain-la-Neuve,

DFID (1999). Sustainable Livelihood Guidance Sheets. United Kingdom, Department for International Development.

Diaz, M. (2012). Improving coffee quality: a strategy for small growers. 7th-African-Scientific-Coffee-Conference. Addis Abeba, Ethiopia. Personal Communication: 14-2-2012

Dixon, J. A., Gibbon, D. P. & Gulliver, A. (2001). Farming systems and poverty: improving farmers' livelihoods in a changing world, Fao Inter-Departmental Working Group.

Farmar-Bowers, Q. (2010). Understanding the strategic decisions women make in farming families. Journal of Rural Studies 26(2): 141-151.

Fountas, S., Wulfsohn, D., Blackmore, B., Jacobsen, H. & Pedersen, S. M. (2006). A model of decision-making and information flows for information-intensive agriculture. Agricultural Systems 87(2): 192-210.

Jakku, E. & Thorburn, P. J. (2010). A conceptual framework for guiding the participatory development of agricultural decision support systems. Agricultural Systems 103(9): 675-682.

Jassogne, L. (2012). Analysis LEAD data and APEP data. Kampala, Uganda. Personal Communication: 27-2-2012

Jassogne, L., Asten, P. v., Wanyama, I. & Baret, P. (Manuscript Draft). Perceptions and outlook on intercropping coffee with banana as opportunity for smallholder coffee farmers in Uganda. 31.

Jassogne, L., Nibasumba, A., Wairegi, L., Baret, P. V., Deraeck, J., Mukasa, D., Wanyama, I., Bongers, G. & Asten, P. v. (2011). Coffee-banana intercropping as an opportunity for smallholder farmers in Uganda. CIALCA conference, Kigali, Rwanda.

Keating, B. A. & McCown, R. L. (2001). Advances in farming systems analysis and intervention. Agricultural Systems 70(2-3): 555-579.

Moguel, P. & Toledo, V. M. (1999). Biodiversity Conservation in Traditional Coffee Systems of Mexico Conservation Biology 13(1): 11-21.

Norman, D. W., Siebert, J. D., E.Modiakgota & Worman, F. D. (1994). Some key concepts important in farming systems research. In: Farming Systems Research Approach: A primer for Eastern and Southern Africa. D. W. Norman, J. D. Siebert, E.Modiakgota and F. D. Worman, Food and Agricultural Organization**:** 18-26.

Öhlmér, B., Olson, K. & Brehmer, B. (1998). Understanding farmers' decision making processes and improving managerial assistance. Agricultural Economics 18(3): 273-290.

Sharifi, M. A. & van Keulen, H. (1994). A Decision Support System for Land Use Planning at Farm Enterprise Level. Agricultural Systems(45): 239-257.

UN-Comtrade. (2010). 2010 International Trade Statistics Yearbook. United Nations International Merchandise Trade Statistics. United Nations Statistics Division/ Department of Economic and Social Affairs Retrieved 23-12-2011. Available at http://comtrade.un.org/pb/CountryPagesNew.aspx?y=2010

van Asten, P. (2011). CIALCA's effort in farming systems r4d. CIALCA-conference. Kigali, Rwanda. Personal Communication: 24-10-2011

van Asten, P. J. A., Wairegi, L. W. I., Mukasa, D. & Uringi, N. O. (2011). Agronomic and economic benefits of coffee–banana intercropping in Uganda's smallholder farming systems. Agricultural Systems 104(4): 326-334.

Wanyama, I. (2012). Analysis LEAD data. Kampala, Uganda. Personal Communication: 29-2-2012

Woodward, S. J. R., Romera, A. J., Beskow, W. B. & Lovatt, S. J. (2008). Better simulation modelling to support farming systems innovation: review and synthesis. New Zealand Journal of Agricultural Research 51(3): 235-252.