THE IMPACT OF CLIMATE CHANGE ON COFFEE IN UGANDA

Lessons from a case study in the Rwenzori Mountains

LAURENCE JASSOGNE
PETER LÄDERACH
PIET VAN ASTEN

A coffee farmer in the Rwenzori Mountains Photo: ©Tanzanite

EXECUTIVE SUMMARY

Coffee is a major cash crop in Uganda accounting for about 20–30% of foreign exchange earnings. Smallholder farmers whose average farm sizes range from 0.5 to 2.5 ha produce 90% of Uganda's coffee. The livelihoods of these smallholder coffee farmers are very vulnerable and studies have shown that climate change can increase this vulnerability even further.

This project aims at understanding the potential impact of climate change on coffee-based livelihoods. We focused this study on Arabica coffee (*Coffea Arabica*), since this requires a rather cool tropical climate that is only found in high altitude areas. In Uganda, Arabica is predominantly found above 1400 m and this altitude threshold would move up hundreds of meters if temperatures rise.

First, the suitability for Arabica coffee in Uganda was mapped together with a projection of areas suitable for Arabica in 2030 and 2050. Then, a study of farmers' perceptions was carried out in Kasese (western Uganda) where farmers from two sites were interviewed individually and in groups. The sites were selected based on altitude following the climate analogues principle. The idea of a climate analogue is that you can understand the future climate and adaptation requirements of a site by moving down the slope where temperatures are higher. Travelling down the slope is then like travelling into future climates.

The climate change mapping showed that areas suitable for growing Arabica coffee will reduce drastically in the future. Future production losses induced by climate change are estimated to reach tens of millions of US$ annually. Adaptation strategies will be necessary if coffee is still to be grown in the areas where suitability has declined. The lower altitude areas (<1300m) appear completely unsuitable in the future under the current practices (i.e., using current varieties and with limited use of water conservation and shade technologies).

Farmers in Kasese perceived that droughts were becoming longer, rainfall during the rainy season was becoming more erratic, and that the rains were shorter. This impacted the coffee at flowering stage (i.e., abortion of flowers); at the filling of the berries stage (i.e., poor filling); and therefore negatively impacted coffee yield in general. Furthermore, certain pests and diseases (e.g. leaf miners, coffee berry borers, mealy bugs, and leaf rust) seem to be increasing. Leaf rust also seems to be more present in the lower site, suggesting that its incidence will increase at higher altitudes as climate changes.

An adaptation strategy that is already locally used by farmers is adding shade in the coffee systems. Shade can reduce temperatures in the coffee canopy by up to 2°C. Shade trees or shade crops like bananas have benefits both in the long term for farmers as they help to adapt the systems to increasing temperatures. At the same time, they also give short-term benefits to farmers by providing additional food and income. For an adaptation strategy to be adopted by smallholder farmers, such short-term benefits are a prerequisite.

However, a downside is that adding shade or shade crops to a coffee system increases competition among the different plants for water, nutrients, and light. This competition needs to be managed by using good agronomic practices (e.g. integration of fertilizers and organic nutrient inputs, soil and water conservation practices) in order to adapt successfully to climate change.

We conclude with some considerations and recommendations that could be taken up by the Ugandan coffee sector in order to go some way to adapting coffee production to climate change. Without adaptation, the financial impacts on Uganda's economy as temperatures rise will mount up; and in particular, large numbers of relatively poor smallholder farmers, who very much depend on coffee for their livelihoods, will suffer disproportionate impacts and risk falling further into poverty.

ACKNOWLEDGEMENTS

This study was funded by OXFAM in Uganda and supported and executed by IITA-Uganda.

The suitability mapping was done in collaboration with CIAT-Colombia, with thanks to Peter Läderach's research team. The collaboration between IITA and CIAT on climate change and coffee production systems received support from the CGIAR program on Climate Change, Agriculture, and Food Security (CCAFS). It is within this context that national partners from across East Africa (i.e., from Ethiopia down to Zimbabwe) contributed data needed to derive the algorithms for the Arabica coffee suitability mapping.

Contributions to the report structure and content were received with thanks from our Oxfam colleagues Anthony Wolimbwa (CAN-U), Charlie Kabanga, Marten Mylius, and John Magrath.

Oxfam further organized a critical but very constructive review of the science presented in this report by Reading University in the UK – thanks to Josh Hooker for his invaluable comments. Oxfam organized the media team from Tanzanite Visual Media to turn the key findings of this report into a short video documentary.

We would also like to acknowledge Brian McDonald and Brenda Onyutta for joining during field visits and surveys, which would make this study relevant for the general public and policy makers.

The results of this report were discussed and presented to several Uganda coffee stakeholders. Thanks to Dr Africano Kangire and his team at COREC for their contributions. We would also like to acknowledge the input from the Neumann Stiftung (HNRS) and Café Africa.

Finally, our sincere appreciation to Ibrahim Wanyama, David Mukasa, and Daniel Ikaaba from IITA for their assistance in organizing the field data collection with support from UCDA's Robert Ssekasala. We would also like to thank David Senyojo and Masereka Ezekel from HNRS' Kasese Program.

INTRODUCTION

Many studies have predicted that climate change will have a massive impact on the coffee-growing regions of Uganda (AFCA, 2012). As coffee is Uganda's largest export product, generating approximately 20% of the foreign exchange earnings, climate change will result in a negative impact on the national economy (UCDA, 2012). The foreign exchange value of coffee in Uganda has risen from over US$250m in 2010 to an estimated US$480m in 2012.

Approximately 40% of the coffee export value is generated by Arabica but significant inter-annual variations occur depending on crop yields and price fluctuations. Next to coffee being so important for the national economy, its production also relies on smallholder farmers; a population group that has been identified as the most vulnerable to climate change (Morton, 2007).

In Uganda there are officially 500 000 smallholder coffee farmers, 90% of whose average farm size ranges from less than 0.5 ha to 2.5 ha. The coffee industry employs over 3.5 million families through coffee-related activities (UCDA, 2012).

The famine early warning systems network (FEWSNET) (2012) showed in a study on climate change in Uganda that both spring and summer rains had decreased during the past 25 years. Cropping regions in the west and northwest appeared most affected by the observed changes in climate. Furthermore, rainfall decline in the west and northwest threatened Uganda's future food production prospects. The warming temperatures could be already adversely affecting coffee production, and rapid population growth and the expansion of farming and pastoralism under a drier and warmer climate regime could dramatically increase the number of at-risk people in Uganda during the next 20 years.

The FEWSNET (2012) data indicate that farmer's perceptions are grounded in the reality of changing temperature and rainfall patterns. However, there are also differences between perceptions of climate change and climatic data, which have been studied by Osbahr et al. (2011) in southwest Uganda. It was found that although farmers perceived changes in seasonality, distribution, amount, intensity, and temperature, only temperature had a very clear signal in the climate record.

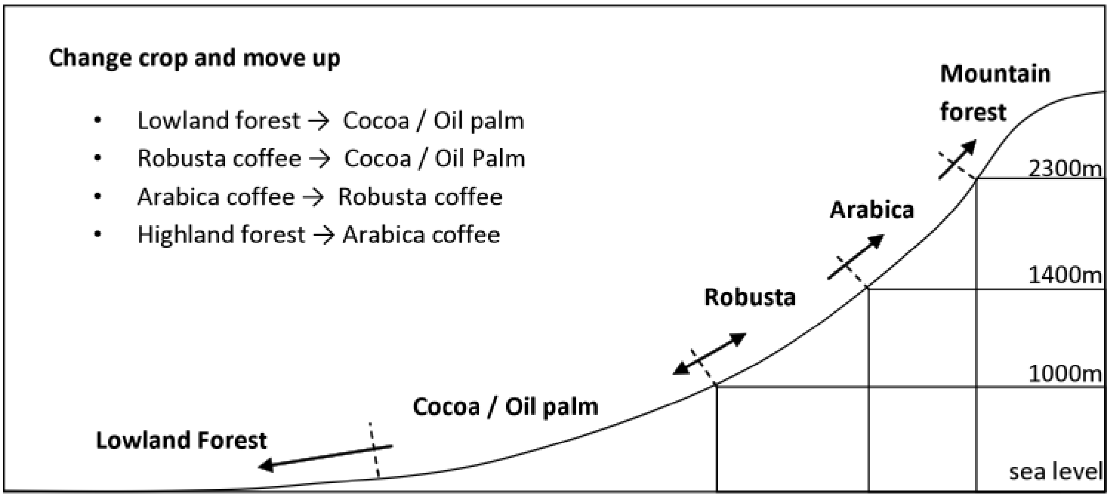
The climate record agreed to a lesser extent with farmers' views that the first rainy season (between March and May) had become more variable and less reliable than the second season (between September and December). This is in accordance with a climate study in Uganda by Mubiru et al. (2012), which showed that the onset of rains in the March–May season were delayed for as many as 30 days (with rains starting currently in mid-April). However, the timing of rainfall cessation had more or less stayed the same, regardless of the time of onset of rainfall.

Consequently, even when rains started late, withdrawal was timely, making the growing season shorter. In contrast, onset and cessation of the October–December season were less variable within stations and more uniformly distributed at most locations. At stations experiencing a unimodal rainfall regime, the average onset of rains was also quite stable.

On a monthly scale, there seemed to be a decreasing trend in the number of rainy days during the critical months of crop growth in the March–May season, making crops grown in this season prone to climatic risks; hence, in need of adaptation measures. The average daily maximum and minimum temperature trends revealed an increase in temperature over the 50-year period. However, the lower limits of the ranges of the daily maximum and minimum temperatures were increasing faster than the upper limits. So, day and night temperatures were becoming warmer overall.

Broadly, for coffee, if temperatures increase, areas suitable for coffee will be higher up in the landscape (Figure 1). This means that due to climate change, some areas will become more suitable for coffee; others will undergo a reduction of suitability; while much of the area becomes unsuitable (Läderach et al., 2011). Unfortunately, the areas that will become more suitable for coffee will compete with other crops or national nature reserves. In areas where the suitability for coffee will reduce, adaptation strategies will need to be undertaken in order to sustain its production.

Figure 1: Possible changes in land use and crops induced by climate change



In this study, the current suitability for Arabica coffee in Uganda is analyzed first, together with future suitability under climate change. After this, a case study on coffee production and the impact of climate change in the Rwenzori Mountains (Kasese) is presented. The results of this study are compared with other studies on climate change and coffee in Uganda and East Africa. Also, opportunities and constraints around local adaptation strategies are discussed. The report ends with conclusions and recommendations.

SUITABILITY OF ARABICA IN UGANDA

In Uganda, Arabica is grown in the highland areas on the slopes of Mount Elgon in the east; and Mt. Rwenzori and Mt. Muhabura in the southwestern and northwestern regions, respectively.

The current suitability of Arabica coffee in Uganda, together with suitability changes in the future (2030 and 2050) is shown in Figure 2 (adapted from Läderach and van Asten, 2012). The methodology is briefly explained in this section, although a more detailed description of the methodology can be found in Läderach et al. (2011).

The current climate was estimated using historical climate data from the WorldClim database (www.worldclim.org). WorldClim data were generated at a 30 arc-second spatial resolution (1 km) through an interpolation algorithm using long-term average monthly climate data from weather stations. The WorldClim database also includes 19 bioclimatic variables that are derived from monthly temperature and rainfall values to generate more biologically meaningful variables.

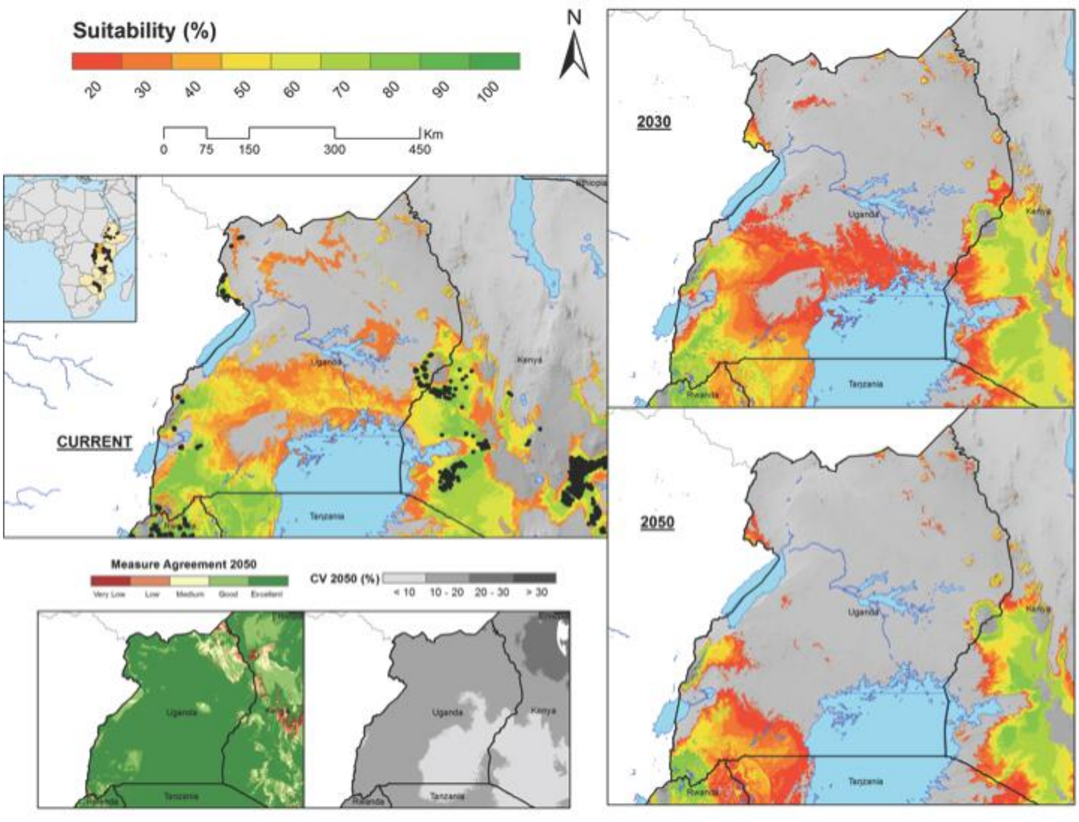
The future climate was estimated using the results of 21 global climate models (GCMs) developed by the Intergovernmental Panel on Climate Change (IPCC), data of which are partially available through the IPCC website (www.ipcc-data.org.ch). The IPCC scenario SRES-A2a (business as usual) was used. Future suitability predictions were then assessed through each of the GCM models via the software MAXENT and two measurements of uncertainty were computed: (1) the agreement among models calculated as percentage of models predicting changes in the same direction as the average of all models at a given location; and (2) the coefficient of variation (CV) among models.

Maximum entropy (MAXENT) is a general-purpose method for making predictions or inferences from incomplete information. This method was used to estimate the suitability of Arabica coffee in Uganda. The idea is to estimate a target probability distribution by finding the probability distribution of maximum entropy, subject to a set of constraints that represent (ones) incomplete information about the target distribution. The information available about the target distribution often presents itself as a set of real-valued variables, called features, and the constraints are that the expected value of each feature should match its empirical average (average value for a set of sample points taken from the target distribution).

Figure 2 was made by CIAT and IITA, with support from national partners in seven countries, using coordinates of coffee farms from all East Africa (Läderach and van Asten, 2012). Figure 3 focuses on the area of interest for this study, the Rwenzori Mountains. Figures 2 and 3 illustrate that if the same coffee production systems are kept with the same coffee varieties (this means that nothing changes and coffee production systems stay the way they are currently), then the areas suitable for Arabica coffee will drastically change and become less suitable. The green (more suitable) areas in the figure become smaller when looking at 2030 and 2050 compared with the map showing current suitability. The yellow, orange and red (less suitable) areas increase.

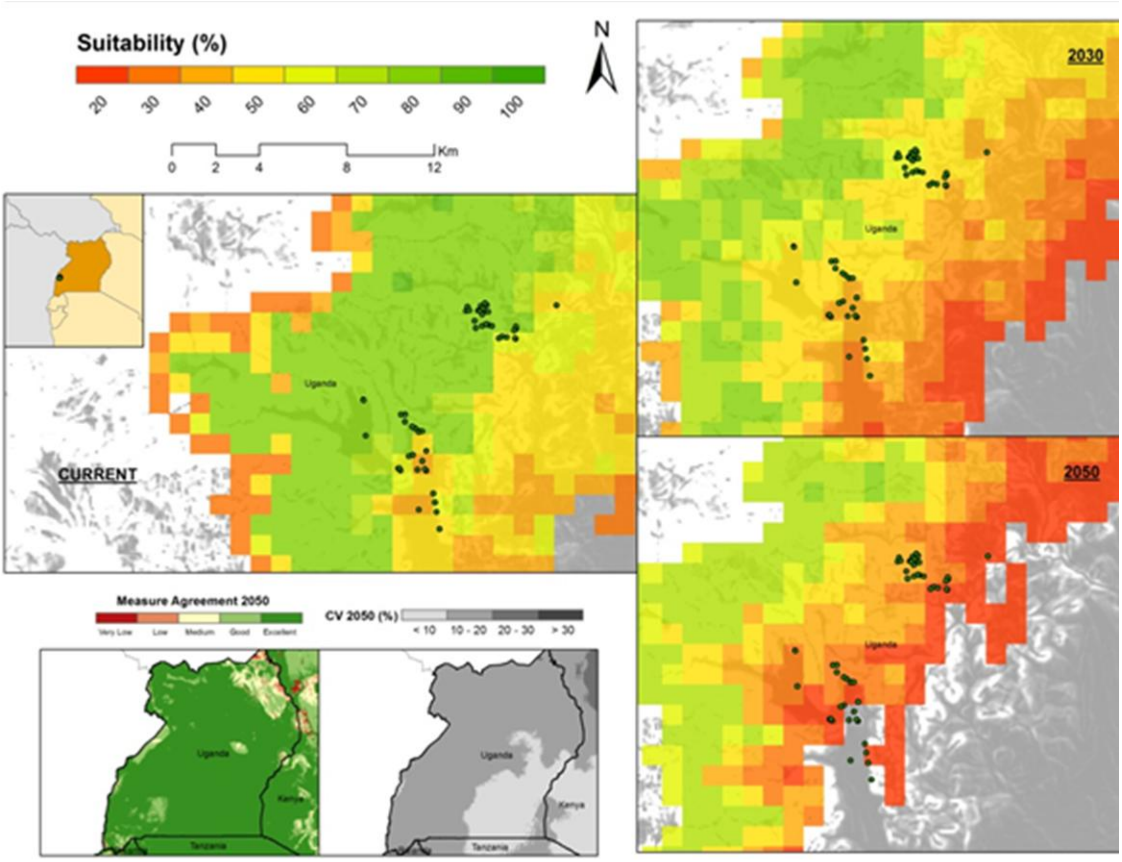
Smallholder coffee farmers are vulnerable because of various constraints negatively affecting their livelihoods (i.e., increasing pests and disease pressure, decreasing soil fertility, poor agronomic practices, postharvest challenges, poor market information and access, gender imbalances, poor extension services and challenges at institutional level). There is increasing consensus that to be undertaken, and to be successful, adaptation strategies need to address those challenges (e.g. improving food security of producers in the short term). Adaptation strategies are best based on indigenous knowledge and practices (FAO, 2008).

Figure 2: Predicted (according to MAXENT) suitability for coffee production in Arabica coffee-producing area in Uganda today, in 2030, and in 2050



The coefficient of variation (CV) and measure of agreement (ME) is shown for the study area with the points (black dots) representing the sampled *Coffea Arabica* farms (large map); adapted from Läderach and van Asten (2012).

Figure 3: Predicted (according to MAXENT) suitability for coffee production in Arabica coffee-producing area in the Rwenzori mountains today, in 2030, and in 2050



The coefficient of variation (CV) and measure of agreement (ME) for the study area with the points (black dots) representing the sampled *Coffea Arabica* farms (large map).

CLIMATE CHANGE AND COFFEE PRODUCTION

Predictions show that climate change will have an impact on the suitability of Arabica coffee in Uganda. Studies have shown that smallholder farmers are already adapting their system to climate change locally. A field survey was done in order to characterize the existing coffee systems and examine the coping mechanisms smallholder farmers use.

First, two participatory rural appraisals (PRA) were organized to select farmers at high altitude and low altitude. During these PRAs, general questions were asked about the coffee systems of the area and the influence of climate. This helped in setting up a general characterization of the coffee systems in the region. The site at high altitude was Kithoma and the PRA was attended by 41 participants (32 men and 9 women). The site at low altitude was Maliba and 38 participants (25 men and 13 women) attended the PRA. The farmers were then asked to rank the most important cash crops and food crops. In both locations, coffee was ranked as the most important cash crop. In Kithoma and Maliba, cassava and banana were the most important food crops, respectively (Table 1).

Table 1: Ranking of most important cash and food crops in the selected lower altitude site and higher altitude site in the Rwenzori region

Maliba – lower site		**Kithoma – higher altitude**	
Cash	**Food**	**Cash**	**Food**
1. Coffee	1. Banana	1. Coffee	1. Cassava
2. Cotton	2. Beans	2. Cotton – low areas	2. Beans
3. Banana	3. Cassava	3. Beans	3. Banana
4. Cassava	4. Sweet potatoes	4. Maize	4. Maize
5. Beans	5. Groundnuts	5. Cassava	5. Irish potatoes

Farmers explained during the group discussions that in both locations, coffee had been the most important cash crop for the past 10 years, even if prices for coffee in the past were lower than the current price. In Maliba, people used to eat a lot of cocoyam in the past. However, yams require swamp areas to grow, which have slowly dried out or have been turned into national parks. Furthermore, swamps are now being more used to grow trees (Eucalyptus).

Today, farmers grow more fruit trees than in the past. Farmers explained that volumes of harvested crops have reduced in the last few years. Before, there used to be enough surplus for selling on the market but now, almost nothing is left for sale. In Kithoma, beans used to be more important than cassava because they were promoted by a seed company. Now, cassava is more important but is being threatened by the brown streak virus.

After the two PRA's, individual interviews were organized for 54 farmers. They were asked about their household situation, coffee production system with existing opportunities, and constraints about the climate. In the end, 23 farmers living above 1400m were interviewed and were defined as the high altitude farmers while 31 farmers interviewed below 1400 m were defined as the low altitude farmers.

Climate change could affect Arabica coffee production directly and indirectly; directly because climate affects the flowering of coffee and the bean filling, and indirectly due to the appearance or increasing incidence of certain pests and diseases (while others disappear or decrease).

Farmers interviewed explained that seasonal changes have occurred over the past decade. Last year (2011) had an exceptional prolonged dry season. Most farmers explained that there were less rains during the wet season compared with the past but rains were heavier, creating mudslides. Table 2 summarizes climatic changes perceived by farmers. It should be noted that perceptions could be influenced by what happened last year, when all farmers endured a prolonged dry season that made most crops collapse.

Table 2: Summary of climatic changes perceived by farmers at above and below 1400m altitude

Perceived climatic change	**Above 1400 m**	**Below 1400 m**
Prolonged drought	97%	94%
Heavier rains	4%	39%
Rains not well distributed	57%	81%
Less rains in wet season	74%	68%

Arabica needs distinct dry and wet seasons. After the dry season, during the first rains, flowering occurs. When rains are not well distributed throughout the season, flowering can happen continuously. If that happens, farmers have to harvest coffee throughout the year and not at distinct periods. After flowering, bean filling can be affected negatively by too much sunshine. This will lead to cherries that are of low weight; hence, low quality. This will also affect the labor burden of the coffee farmers and the quality of coffee as farmers will not take the time all year round to pick only red cherries. The perceived impact of climate on coffee is described in Table 3.

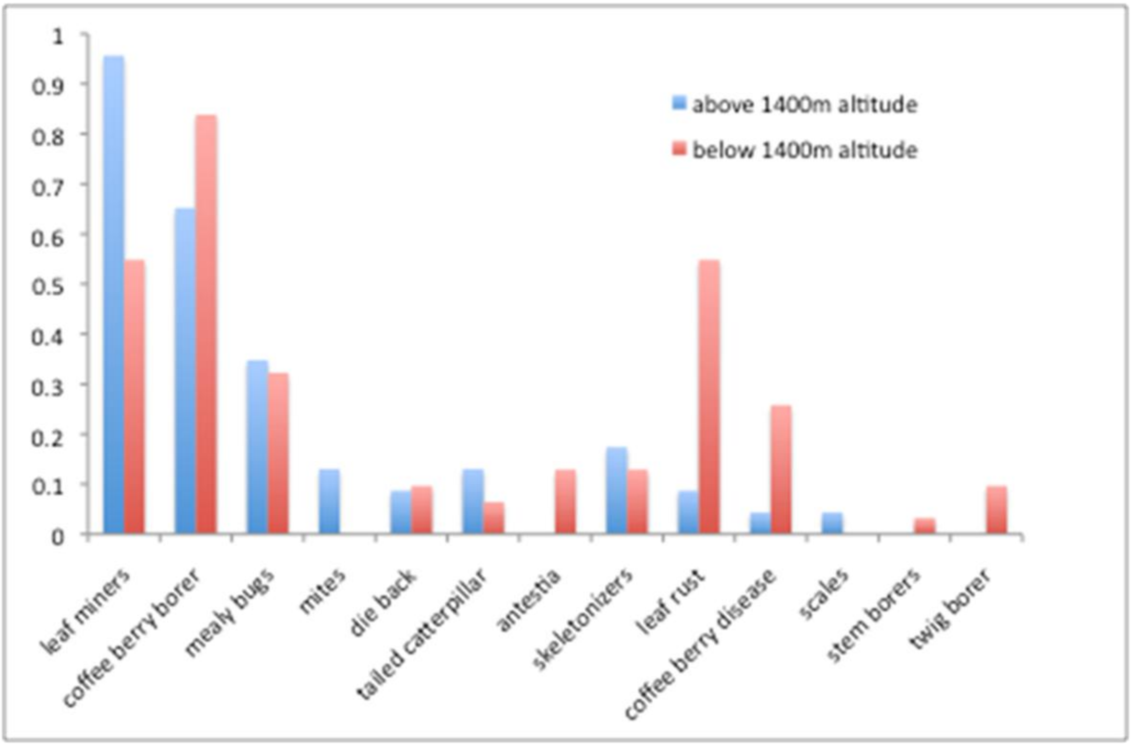
Table 3: Direct impact of changing climate on coffee production as perceived by farmers

Impact on coffee production	Above 1400 m	Below 1400 m
Affects bean filling	49%	29%
Affects flowering	26%	52%
Decreases yields in general	23%	19%

All but one of the farmers interviewed dry-processed their harvested coffee. This meant that they dried their coffee on the farm and brought it to the milling factory before selling it. Two farmers wet-processed part of their harvested coffee. About 55% of the farmers wanted to wet-process their coffee but did not have the facilities and tools to do this. One farmer who wet-processed some of his coffee explained that he would have liked to switch from dry processing to wet processing because the prices of parchment were much higher. However, this would only be possible if the coffee ripened at the same time, which seems to be the opposite of what would happen with climate change.

Next to the direct effect of climate on coffee, the incidence and severity of certain pests and diseases will also be affected by climate change. Figure 4 describes the proportion of farmers having to cope with certain pests and diseases.

Figure 4: Proportion of surveyed farms with presence of certain coffee pest or disease; farms were divided in a group above and a group below 1400 m altitude



The four most prevalent pests above 1400 m in the surveyed farms are leaf miners, coffee berry borer, mealy bugs, and skeletonizers while those below 1400 m are coffee berry borers, leaf miners, leaf rust, and mealy bugs. Figures 5 and 6 show the incidence (% of plants affected in the plot), severity (impact on yield of affected plant), and seasonality and trend of the four most prevalent pests and diseases above and below 1400m from the surveyed farms.

Farmers associated the incidence of leaf miners with drought. Although a national survey led by IITA, together with the National Agricultural Research Organization (NARO) and the Wageningen University and Research Centre (WUR), showed a decrease of the incidence of leaf miners with altitude, our study showed that leaf miners were more present at higher altitude in the surveyed farms in Kasese. Leaf skeletonizers were also found at lower altitudes in the national survey.

Figure 5: Incidence, severity, seasonality, and trend of leaf miners, coffee berry borer, mealy bugs, and skeletonizers at plot level in the surveyed farms above 1400m

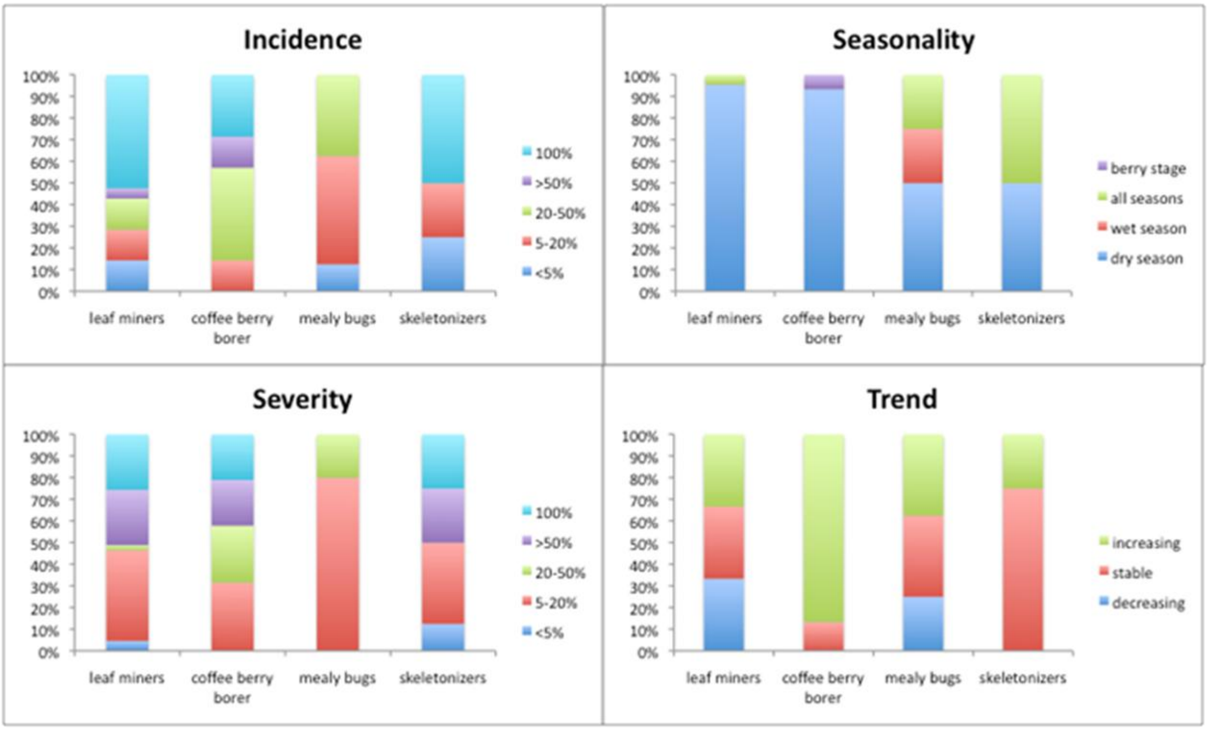
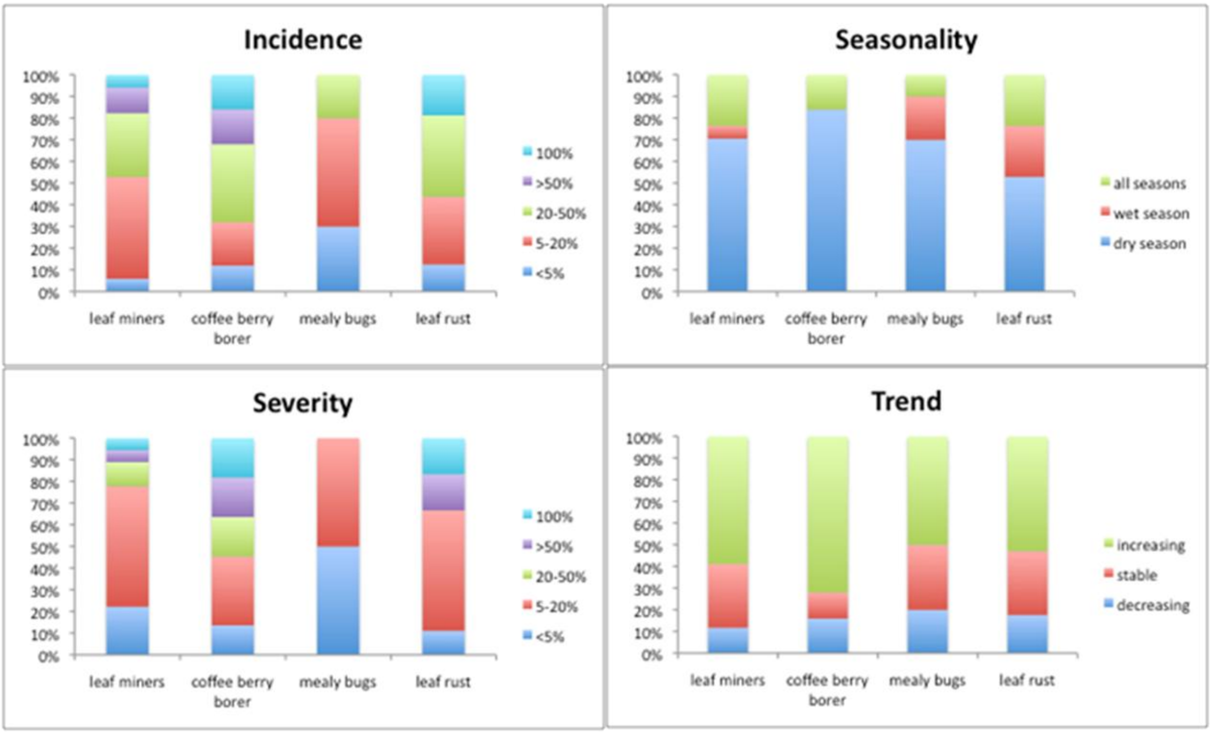


Figure 6: Incidence, severity, seasonality, and trend of leaf miners, coffee berry borer, mealy bugs, and skeletonizers at plot level in the surveyed farms below 1400m



During the surveys, farmers above and below 1400 m explained that coffee berry borer only appeared a few years ago and that it was becoming worse. This is in accordance with a study done by Jaramillo et al. (2009), which finds that the incidence and severity of coffee berry borer will increase in East Africa.

The size of coffee farms in our survey varied enormously. The ‘average’ size of coffee farm in our survey was 1.87 ha above 1400 m and 1.96 below 1400 m. However, this was within a range of +- 1.25 ha and 1.33 ha respectively. The average size of the coffee plots was measured with a GPS and was 0.29±0.15 ha above 1400 m and 0.23±0.16 ha below 1400 m. About 57% of the farmers had only one coffee plot, while 21% owned two coffee plots. The maximum amount of coffee plots a farmer owned was four (by two farmers only).

The reported average yield by farmers also varied hugely. The reported average yield above 1400 m was 897 kg/ha but within a range of 335 kg/ha plus or minus. Similarly the average yield below 1400 m was 932 kg/ha but within a range of +- 516 kg/ha. These figures are in the same range as with another survey done by IITA in the region. The high standard deviation shows that yields are highly variable between farms.

We asked the farmers the four most limiting factors for coffee production (Table 4). Taking into account the ranking of all limiting factors, drought was the most cited one. The most cited first limiting factor was ‘poor agronomic practices’.

Table 4: Perceived yield constraints for coffee production

Ranking	Perceived limiting factor
1	Drought
2	Poor agronomic practices
3	Pests and diseases
4	Declining soil fertility
5	Old trees

As shown in Table 4, drought is the dominant constraint perceived by farmers. This is particularly understandable as farmers endured a prolonged drought last cropping season. Farmers also put emphasis on good management practices, and pests and diseases. As explained earlier, pest and disease incidence and severity have been changing in recent years. However, we cannot state from our data to what extent this might be due to climate change.

THE ECONOMICS

At the time of the survey (June 2012), farmers sold their coffee in different forms depending on the urgency at which money was needed. Most farmers dry-processed their coffee, which means that for 1 kg of FAQ (fair average coffee) after milling, the average price would be 7480shs, although the price varied widely between 10500shs and 5000shs. FAQ is clean coffee, and essentially means that the coffee will be representative of the average quality of the crop but there is no defined standard for this.

Two farmers wet-processed their coffee and would get a higher price of 9000–9500shs per kg. Because it takes some time between harvesting and selling the coffee as FAQ, some farmers prefer to sell the coffee as *kiboko*, which is a less processed form of coffee that is only dried; or sell it even as red cherries, or as flowers. For *kiboko*, the average price per kg would be 4000shs (3500–6000shs) and for 1kg of red cherries, 650shs (450–900shs). The prices for coffee are also highly variable within the season. Although interviewed farmers used *kiboko* for naturally dried Arabica, the official name is *drugar*.

Farmers were asked what the yield would be in a good year and a bad year. On the average, yields in a good year were three times as high as yields in a bad year. Some individual farmers could also have yields five times higher in a good year compared with a bad year. When asked what would cause a good year for coffee, the farmers replied well-balanced wet and dry seasons, and good management practices. On the other hand, farmers cited prolonged dry season, bad management practices, and presence of pests and diseases as main reasons for having bad years.

The high variability of the yield among the farmers suggests that some farmers in the same agro-ecological conditions can obtain much higher yields than others. Understanding why some farmers get higher yields would help develop simple techniques and technologies to improve the coffee yield of smallholder farmers more generally.

The income generated by coffee was mostly used for children's education, medical expenses, and for the usual household needs. Because income is directed in these ways, and because of low and variable prices for their coffee, most farmers do not have enough capital to reinvest in their coffee production; and if they do re-invest, then it would be in casual labor for weeding and harvesting. Only one of the surveyed farmers invested in fertilizer; none of the other farmers would invest in inputs.

ADAPTATION TECHNOLOGIES

There is a variety of smallholder coffee systems in Uganda and each of these systems is adapted to the livelihood of the smallholder farmer; at least, to the best of his or her possibilities and priorities. Without climate change, smallholder coffee farmers are already vulnerable due to a lack of capital, declining soil fertility, and increasing pests and diseases. Climate change only adds to the pressure a smallholder farmer already feels. Even though several studies have shown that climate change is already happening – as explained in the introduction – a smallholder farmer is very unlikely to adopt any adaptation strategy or technology unless it has a short-term positive impact on his or her livelihood.

Smallholder coffee farmers are generally very vulnerable and try to survive from day-to-day. Investments that only pay off in the further future (>1 yr) are, therefore, of little or no interest to smallholders who struggle with cash flow problems on a daily basis.

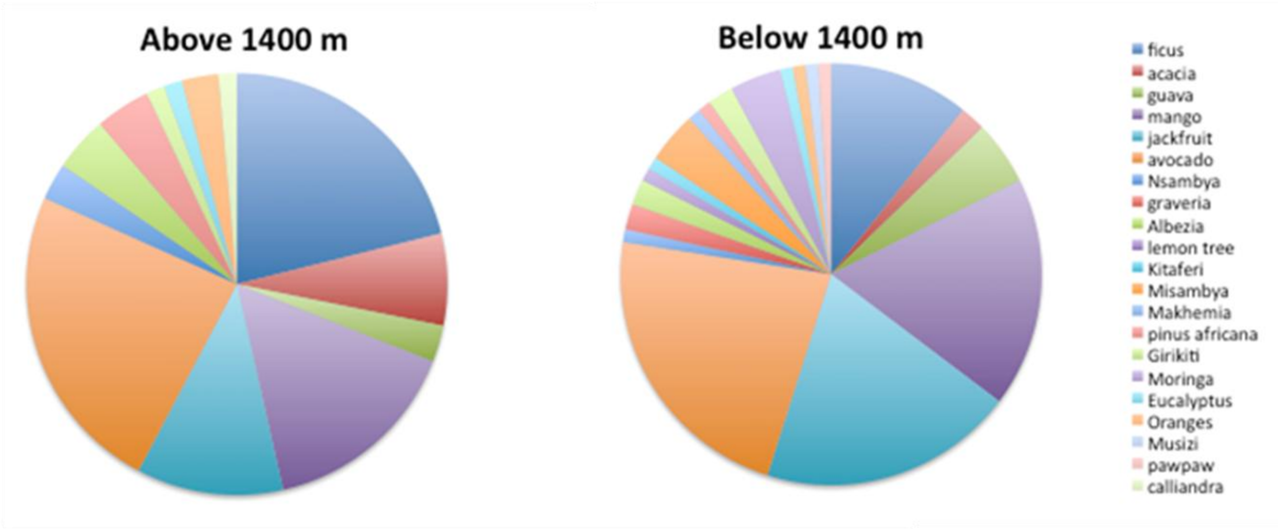
Adding shade to a coffee garden is, however, an adaptation strategy that some farmers are already applying. Shade trees can reduce temperatures in the coffee canopy by 2–3°C (Vaast el al., 2006) and can even buffer high and low temperature extremes by up to 5°C. Furthermore, shading decreases evapotranspiration compared with coffee growing in full sun. From the PRAs, 55% of the farmers in Maliba and 57% of the farmers in Kithoma were using shade trees in their coffee gardens. Of the 54 farmers who were interviewed individually, 93% had shade in their coffee garden. The intensity of shade was estimated during the survey and can be found in Table 5 for farms above and below 1400m.

Table 5: Proportion of shaded farms with low, medium, and high shade intensity

Shade intensity	Above 1400m	Below 1400m
≤ 10%	53 %	65 %
10–40 %	40 %	10 %
≥ 40 %	7 %	25 %

The type of shade tree was also recorded and their incidence is illustrated in Figure 6. A lot of farmers explained that some trees were already in the plot before they planted coffee, or the trees would grow by themselves probably due to household residues. When farmers plant a tree deliberately, the tree would be for a definite purpose other than shade (e.g. fruit trees or timber trees). Nonetheless, most farmers agreed that shade has a positive impact on coffee.

Figure 6: Proportion of incidence of shade trees in the shaded coffee farms



The farmers explained the benefits and limitations of shade trees in their coffee systems (Table 6). Farmers also explained that certain shade trees were less interesting for growing with coffee than others. For example, farmers explained that Ficus is a very good shade tree while Acacia is not because it competes a lot for water. These findings are in line with other (unpublished) studies in the region that confirm that coffee performs well under Ficus.

Table 6: Benefits and constraints of shading in coffee systems and percentage citation

	Benefits		**Constraints**	
1.	Shade is good for coffee	65%	Competition	32%
2.	Fruits from fruit trees for eating	58%	Falling branches damaging coffee	14%
3.	Nutrient cycling	54%	Hosts pests	7%
4.	Fruits from fruit trees for selling	40%	Compacts soils	4%
5.	Trees for fire wood	39%		
6.	Mulching	23%		
7.	Wind breakers	19%		
8.	Wood for timber	7%		
9.	Bigger beans for better quality	7%		
10.	Fodder	2%		

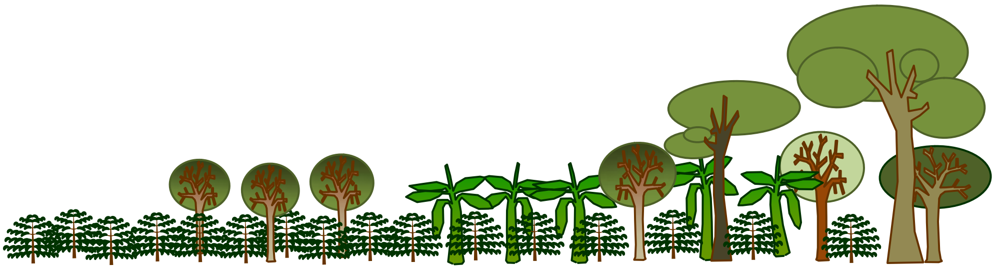
Farmers also intercrop their coffee with banana or annuals. Only 19% of the farmers did not practice intercropping and only had shade trees in their coffee plots. Banana is the most common crop grown with coffee. Farmers intercrop with banana because this system provides food and cash from the same piece of land. At the same time, bananas provide shade and *in-situ* mulch.

When farmers manage one of the crops, the other crops also benefit. This increases labor use efficiency. This was also shown in a study by Jassogne et al. (2012). Some farmers used to intercrop coffee and banana but the banana got wiped out either due to competition for water and nutrients, or because of banana bacterial wilt. Farmers also grow beans with coffee. They recognize that when coffee is interplanted with beans, it benefits from the improved soil fertility thanks to N-fixation. However, some farmers explained that if the coffee was too densely planted, and that the canopy was becoming too thick, then intercropping with annuals would not be possible because of lack of light.

The most important reason for farmers to intercrop annuals with coffee was food security. Most of the time, crops that deliver a large amount of cash would be managed by the husband, while food crops would often be decided by the wife. For example, when coffee and banana are interplanted, the husband would often have decided on this system. When beans were grown in between the coffee plants, or pumpkin, then the wife would often have decided.

The relation between plot level functions and coffee systems are illustrated in Figure 7. It is clear that diversified systems offer the lower risks with highest food and income diversification while monocropped coffee systems can offer the highest yields, if well managed.

Figure 7: Illustration of trade-offs at farm/plot level in coffee systems



Plot level functions	Full sun monocrop	Shade tree monocrop	Banana/food intercrop	Polyculture system	Forest system
Yield quantity					
Yield quality					
External input use					
Nutrient recycling					
Production risks					
Plantation life					
Food security					

Light colour = low → dark colour = high

Good management practices that reduce soil erosion (e.g. cover crops and contour bunds) and increase water retention (mulching, shade) will further help adapt to climate change and retain the more fertile topsoil.

CONCLUSIONS AND RECOMMENDATIONS

- Climate change will have an impact on the suitability of Arabica coffee growing areas in Uganda, including the Rwenzori Mountains. Most areas will become less suitable, and particularly those at lower altitudes (1500m) will be severely affected.
- The annual export value for Arabica in the year 2010/2011 was US$154,284,625. For the unfinished year 2011/2012, Uganda is already at US$161,676,750 (Uganda Coffee Development Authority (UCDA, 2012). If climate-induced yield losses occur in the order of 10–50%, as reported by AFCA, these will affect Uganda's foreign exchange revenue potentially in the range of US$15–80m per year.
- Lower areas that are currently still suitable for Arabica coffee require adaptation strategies in order to sustain the livelihood of farmers depending on Arabica coffee. The lowest Arabica growing areas (<1300m) are likely to become completely unsuitable and farmers may have to switch crops. On the other hand, areas that are currently often considered too cool (>2100m) will see suitability improvements in the decades to come. Unfortunately, this area is limited in size, soils are often stony, and a substantial part of the area is under nature conservation.
- Climate change will affect the crop physiology. It will have an impact on the flowering stage and fruit filling stage of Arabica coffee. The unpredictable rains will cause coffee to flower at various times throughout the year, causing the farmers to harvest small quantities continuously. This is opposed to distinct wet and dry seasons that lead to the preferred harvest of large quantities during a short (± 2 months) harvest season. Prolonged droughts can cause flower abortion. Increased temperatures and sunshine can cause premature ripening of the beans, which will have a direct negative impact on the quality of the coffee and yield quantities.
- Climate change is anticipated to have a strong impact on the incidence and severity of certain pests and diseases. For example, farmers explained that the incidence of leaf miners has increased over recent years. They associate their increased incidence with drought. Coffee berry borer is another pest that appeared recently and is expanding fast. Likewise, coffee leaf rust is associated with warmer temperatures and is recorded to be moving up the mountain slopes.
- Adaptation strategies have to consider the resource constraints and risk-adverse behavior of coffee smallholders. This means that any adaptation technology promoted needs to provide the farmer with short-term livelihood improvements, without further increasing their vulnerability. Gender has to be taken into consideration, as coffee is a traditional cash crop managed by men. Care has to be taken that the labor burden of women does not increase when introducing new technologies. Furthermore, efforts can be made to promote joint decision making at the household level.
- Planting shade trees can be an adaptation strategy to climate change. Fruit trees can increase food security and income diversity while timber trees can diversify income. At the current reported yield levels, modest shading (<40%) does not appear to have any negative impact on yield.
- Intercrops like banana can also be used as they provide cash and food from the same piece of land and offer shade. Such benefits can be achieved within two years after planting, as opposed to trees that often require 5–10 years lag time before returns to investment are noted. Bananas also offer a significant amount of *in situ* mulch. Care has to be taken by the farmer to control water, light, and nutrient competition.
- Good management practices that reduce soil erosion (e.g. cover crops and contour bunds) and increase water retention (mulching, shade) will further help farmers adapt to climate change and retain the more fertile topsoil.
- Whereas the adaptation practices require investments (labor, planting material, nutrients, pesticides), only a small number of farmers actually re-invest part of their revenue back into their coffee field at present. This is because the income from coffee has to be spent on more urgent priorities like school fees, food products, and medical expenses. Helping farmers out

of this poverty trap with more wide-ranging measures will help them better adapt their livelihoods to climate change.

REFERENCES

AFCA. 2012. 7th African Scientific Workshop, Addis Ababa, Ethiopia (http://www.eafca.org/events/scientificconference.asp).

FAO. 2008. Climate change and food security: A framework document. Food and Agriculture Organization of the United Nations (http://www.fao.org/forestry/15538-079b31d45081fe9c3dbc6ff34de4807e4.pdf).

FEWSNET.2012. http://pubs.usgs.gov/fs/2012/3062/FS2012-3062.pdf.

Jaramillo, J., A. Chabi-Olaye, C. Kamonjo, A. Jaramillo, F.E. Vega, et al. 2009. Thermal tolerance of the coffee berry borer *Hypothenemus hampei*: Predictions of climate change impact on a tropical insect pest. PLoS ONE 4(8): e6487. doi:10.1371/journal.pone.0006487.

Jassogne, L., P. van Asten, I. Wanyama, and P.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.

Läderach, P., M. Lundy, A. Jarvis, J. Ramirez, E. Prez-Portilla, K. Schepp, and A. Eitzinger. 2011. Predicted impact of climate change on coffee supply chains. The economic. social and political elements of climate change. Part 4, 703–723.

Läderach, P. and P. van Asten. 2012. Coffee and climate change, coffee suitability in East Africa. 9th African Fine Coffee Conference and Exhibition, Addis Ababa, Ethiopia.

Morton, J.P. 2007. The impact of climate change on smallholder and subsistence agriculture. Proceedings of the National Academy of Sciences of the United States of America. 104, 19680–19685.

Mubiru, D.N., E. Komutunga, A. Agona, A. Apok, and T. Ngara. 2012. Characterizing agrometeorological climate risks and uncertainties: Crop production in Uganda. S Afr J Sci. 2012:108(3/4), Art. #470, 11 pages (http:// dx.doi.org/10.4102/sajs. v108i3/4.470).

Osbahr, H., P. Dorward, R. Sterns, and S. Cooper. 2011. Supporting agricultural innovation in Uganda to respond to climate risk: Linking climate change and variability with farmer perceptions. Experimental Agriculture 47, 293–316.

UCDA. 2012. http://www.ugandacoffee.org/. Monthly reports.

For more information, or to comment on this report, email AWolimbwa@oxfam.org.uk or research@oxfam.org.uk

Published by Oxfam GB under ISBN 978-1-78077-262-2 in March 2013. Oxfam GB, Oxfam House, John Smith Drive, Cowley, Oxford, OX4 2JY, UK. Oxfam GB is a member of Oxfam International, a confederation of 17 organizations networked together in 94 countries as part of a global movement for change, to build a future free from injustice and poverty. www.oxfam.org