Facing higher vulnerability in coffee crops

Climate change impact on coffee value chain In Northern Honduras

According to the International Coffee Council, "Climatic variability is the main factor responsible for oscillations of the coffee grain yields all over the world. Some climatic factors can reduce the productivity; such as adverse air temperatures happened during different growth stages. Solar radiation and relative humidity influence many physiological processes of the coffee tree but are not generally thought to play an important role as thermal and rainfall conditions in defining potential yield or ecological limitations for this crop".

Different studies predict significant impacts of climate change on coffee in Central America. For example, Laderach et al. found that the optimal altitude for coffee will shift from 1,200 m to 1,400 m in 2020 and 1,600 m in 2050. Although smallholders at altitudes currently too high for speciality grade coffees could benefit from this shift, the vast majority of small producers at currently viable altitudes will be losers. And not only producers but also the rest of stakeholders in the value chain will be affected in their livelihoods unless adaptation pathways are identified for this value chain or diversification strategies into other high-value crops are implemented.

Climate model simulations are essential elements of any adaptation strategy, as they make better planning possible through the anticipation of future impacts. However, efforts are currently scattered and not many institutions are systematically applying climate modelling to productive systems. The impact of increasing climate variability and more frequent extreme weather events on agriculture, livestock, fisheries, agribusiness and food value chains is unknown in most regions of the world, making the recommendation of viable, practical adaptation paths even harder.

The Climate Research Foundation (Fundación para la Investigación del Clima, FIC) and the Institute for Hunger Studies (Instituto de Estudios del Hambre, IEH) have been working since 2009 on the application of robust climate simulations to enhance food security in rural areas in Central American and Central Asian countries. They have developed an innovative methodology (FIC/IEH methodology) designed to analyze climate change impacts on productive systems in order to make recommendations for strengthening the resilience of vulnerable populations.

fic fundación para la investigación del clima

IFAD Enabling poor rural people to overcome poverty

IEH Instituto de Estudios del Hambre

This methodology is based on the adaptation and application of a robust downscaling technique (FICLIMA), which has been shown to obtain excellent results in producing local climate change scenarios, and analysing their impact on productive systems.

This methodology has been already applied in development programmes funded by the European Commission, IFAD (International Fund for Agriculture Development) and bilateral donors. FIC/IEH methodology has the capacity for translating climate "scientific language" into the language used by technicians and smallholder farmers/fisherfolk. On the one hand, it fulfils the necessary requirements for the robust production of climate change scenarios using the most advanced climatic projections and downscaling tools. On the other hand, it uses a participatory approach, involving experts and smallholder farmers in the processes of defining the elements vulnerable to climate change and the formulation of indexes that will assess how climate change will influence a particular productive system or value chain.

The methodology applies the following steps:

1. Production of local future climate scenarios

2. Mapping the productive system or value chain and identifying the "critical elements" particularly vulnerable to climatic events

3. Analysis of the vulnerability of each of the critical elements identified and the effects of future climate on them

4. Making recommendations regarding each of the critical elements to minimize negative impacts and reinforce positive ones

This document summarises the implementation of the phases of FIC/IEH methodology in the Northern Horizons Project co-funded by IFAD in Honduras in the departments of Santa Barbara, Cortés and Atlántida

STEP 1: Production of local future scenarios

Previous to analyzing climate change, one of the first requirements (necessary to proceed with subsequent stages of the study) consists of adapting the downscaling technique FICLIMA to the local area under study, verifying and validating it.

The FICLIMA downscaling technique

Statistical downscaling techniques consist of establishing relationships between large-scale atmospheric fields (predictors) and high-resolution surface variables such as temperature and precipitation (predictands). The scenarios are built applying those relationships to the outputs (simulations of the predictors for the future) provided by the Climate Models (CMs).

The 'FICLIMA' downscaling technique, developed by FIC, has been successfully verified in several national and international projects and its application to climate change impact studies comply with the technical requirements needed to fulfill adaptation purposes: FICLIMA uses the newest Climate Models from CMIP5 (Coupled Model Intercomparison Project Phase 5), most of them are Earth System Models (ESM), and their results are used for IPCC AR5; it works on a daily scale and produces daily series of maximum and minimum temperatures, precipitation and other variables for each projection; it produces local information (for observatories and/or available grid points); uncertainties are considered and quantified by means of downscaling as many projections as possible (several CMs with several Representative Concentration Pathways –RCPs- each); and detailed verification and validation processes are undertaken for each variable, observatory or grid point and CM (see Figure 1).

After the verification and validation procedures, local future climate scenarios are produced by applying the downscaling technique to each of the projections.

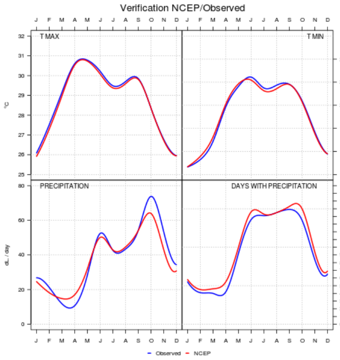


Figure 1. Results of the verification process for temperature and precipitation for the period 1951-2011 in the IFAD Northern Horizons Project

Top graphics represent monthly averages of maximum and minimum temperatures for all the stations studied, and bottom graphics represent precipitation (observed data in blue and simulations obtained downscaling predictands observations in red). Verification results (in this case for the Northern Horizons Project) are sound, especially for temperature. Validation results (not shown) are also satisfactory for most of the used Climate Models (CM)

After the verification and validation procedures, local future climate scenarios are produced by applying the downscaling technique to each of the projections available (one projection for each CM under each RCP).
More details about FICLIMA downscaling technique can be found at: www.ficlima.org/FICLIMA-statistical-downscaling-methodology.pdf

As a result of the changing climate in the study area over the coming decades, it is generally expected that the maximum and minimum temperatures increase gradually over the entire century for all RCP (emission scenarios). For mid-century the highest increases are expected in maximum temperature, with values up to 2ºC (on average for all the observatories and CMs) in the most extreme RCP, and 1ºC in the “coldest” RCP. The minimum temperature increases are expected to occur between 0.8°C and 1.7ºC for the same period.

Rainfall is expected to increase gradually over the whole century, reaching values by mid-century of about 0.25 mm/day (approx. 90 mm/year), which represents an increase of less than 10%. Figure 2 shows the temperature and precipitation changes, as an average of different stations, for several CMs and RCPs. This gives an idea of the overall change but, as has been emphasized before, FIC/IEH methodology is applied on a local scale because very different changes may appear at close points.

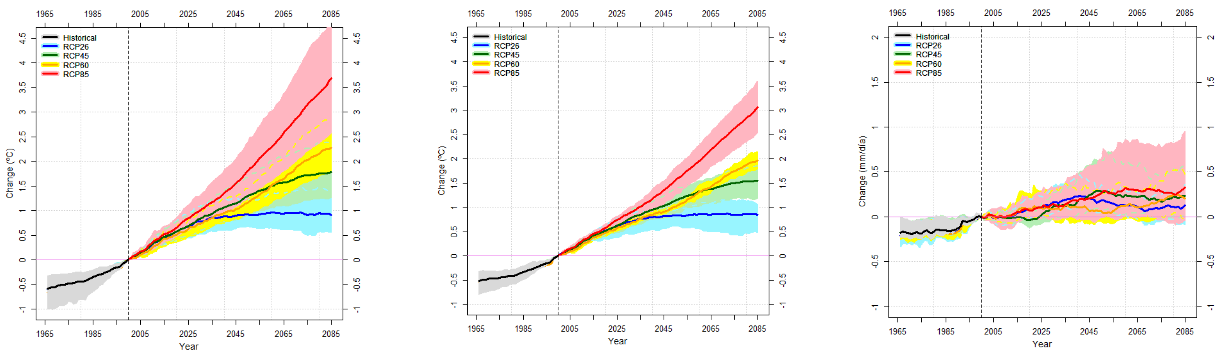


Figure 2. Changes in annual mean maximum temperature, minimum temperature and daily precipitation expected throughout the 21st century (30-year moving averages) in the IFAD Northern Horizons Project. Thick lines represent the average for all the stations and Climate Models. Shaded areas represent the interval between the 5th and 95th percentiles. Temperature changes in °C. Precipitation changes in mm/day.

STEP 2: Mapping coffee value chain and identifying the "critical elements" particularly vulnerable to climatic events

2.1 Coffee value chain steps and scheduling

The coffee value chain at Northern Honduras is particularly complex due to its diversity of activities, actors and channels through which the product is distributed. Many links in this chain are especially sensitive to climate events that affect the quantity produced, the quality achieved and the price obtained. Small-scale coffee growers form the biggest group of coffee producers, both in terms of cultivated area and production

They are also those most vulnerable to potential climate change negative impacts, due to their dependence on this crop, scarce financial capacity and limited resilience to adverse climatic events. The central link of the value chain is composed by the activities related to the physical handling of the product, precisely those that are more influenced by climate. The analysis only takes into account those activities carried out in the area subject of the study (framed in red)

Figure 3: Central link in the coffee value chain. Source: The authors.

PRODUCTION

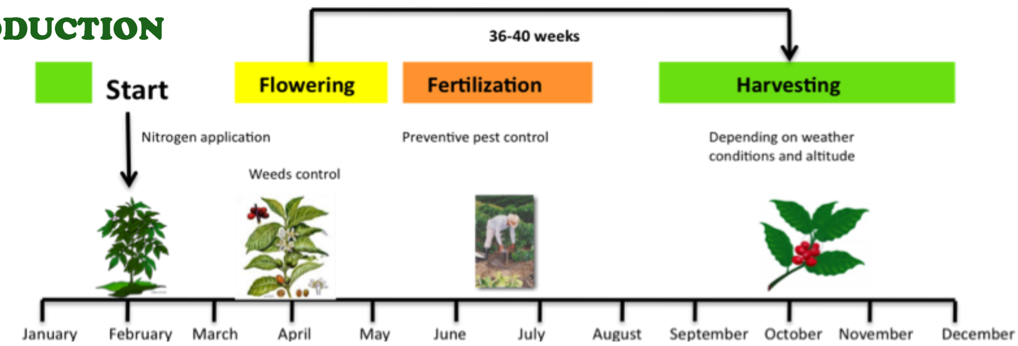


Figure 4: Schedule of the coffee production cycle at Northern Honduras. Source: The authors.

WET MILLING

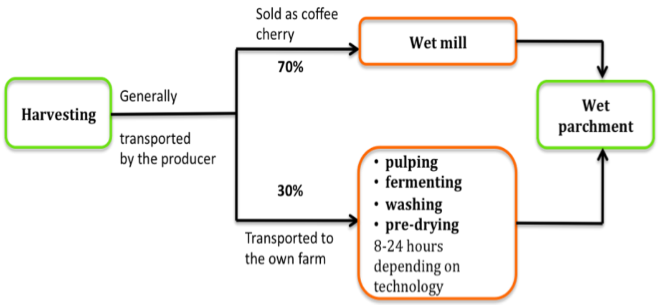


Figure 5. Parchment coffee production routes at the 3 Northern Honduras departments analyzed. Source: The authors

COLLECTING AND DRYING

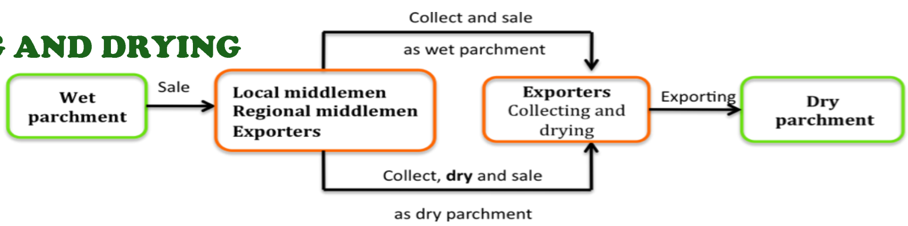


Figure 6: Collecting and drying. Source: The authors

2.2 Most vulnerable critical elements to climate change

A "critical element" is defined as any aspect of the crop cycle or any further phase in the value chain that shows a significant sensitivity or vulnerability to climatic events, so that the impact of climate change on the product quantity or quality may be considerable.

The selection of critical elements shown bellow was carried out by analyzing the value chain activities, particularly at the crop cycle, in order to identify the phases most sensitive to climate. Additionally, a bibliographic review of similar studies performed in other countries was done and some national experts, representatives of local communities and producers were consulted in order to validate the critical elements and jointly determine how they are affected by climatic events.

In order to identify its critical elements, the value chain has been divided in the following phases: flowering, ripening, harvesting and post-harvesting.

FLOWERING STAGE

Two critical elements have been identified in the flowering phase:

1. **Flowering induction** (the flowering onset). The flowering onset is important because it affects the subsequent phases in the chain. If flowering takes place earlier or later, the next phases will also occur earlier or later, and by that time they might lack the necessary temperature and rainfall conditions for their adequate development. By the other hand, a delay in the flowering could also cause a delay in harvesting, with the consequent impact on the coffee price perceived by the producer.
2. **Flowering quantity** (the number of flowers). The quantity of flowers is the first driver (in chronological order) influencing the quantity of beans produced, and it depends on factors such as water stresses or the frequency of the "star flower" phenomenon.

RIPENING STAGE

Two critical elements have been identified at this stage:

1. **Timing of fertilizing**. The plant needs nutrients to mature. If they are not available at the right time, it can abort part of the fruits, keeping only those viable. Fertilizing or supplying nutrients is essential to achieve an adequate number of fruits, but it requires certain soil humidity for the plant to assimilate them. A delay in rainfall at spring crops *"primera"* can prevent the necessary humidity level to be reached by the first fertilizing, between May and June.
2. **Level of vulnerability to pests and diseases.** During ripening, the plant is vulnerable to pests and diseases that reduce the amount and quality of beans and force the producer to allocate resources in order to combat them. Excessive humidity, along with high temperatures, favour the emergence and proliferation of fungi,. Moreover, if the temperature is not low enough during the coldest months (November to January), vulnerability to diseases also increases.

HARVESTING STAGE

In this stage, the main critical element is related to the last phases of coffee ripening, so that when ripening accelerates the harvesting period becomes shorter and the harvested bean builds up. The harvest accumulation occurs when the dry season starts earlier and it causes a number of problems to the producer, such as the need to find additional workforce or to cover additional transportation costs.

POST-HARVESTING STAGE

During the post-harvesting stage, the most relevant critical element has to do with pre-drying in the production areas in order to extract as much humidity as possible. This process is carried out by the producer at his backyard ("patio") or at wet-milling facilities. In case of rain, even minimum, the coffee cannot be outdoors because it may become wet and the quality may be affected.

Furthermore, during the fermentation process there is production of fungi, which in high quantities diminish the coffee quality due to unwanted fermentation. High temperatures and humidity favour fungi development. In case of problem of excessive humidity and fungi infection, the stock-piler can hardly solve it because he has not capacity to handle the product under these conditions.

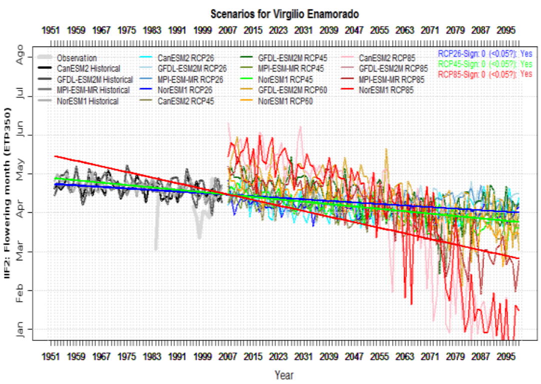
STEP 3: Analysis of the vulnerability of the critical elements identified and of the effects of future climate on them

The future climate scenarios generated and the definition of critical elements are the basis for analyzing the potential future climate impacts on the coffee value chain. For the analysis a set of indexes based on climate information (rainfall, temperature, etc.) is constructed, to assess how every critical element is affected by climate. The indexes are programmed into a computer and applied to the observed rainfall and temperature for verification. Results obtained are discussed in workshops in rural communities with farmers, cross-checking their qualitative perceptions with the quantitative results obtained by applying the indexes to observations. Farmers and experts are also consulted to ensure that the results reflect what has actually happened in the field.

Once verified, these indexes are applied to the generated scenarios, making it possible to determine the temporal evolution of the indexes and its implications for the value chain through different climate models and RCPs.

Examples of indexes and analysis of vulnerability in the coffee value chain in the IFAD Northern Horizons Project

Flowering Induction Index: Potential evapotranspiration (PET) will determine when flowering induction will take place, so that once a certain level of accumulated PET has been reached, a slight rainfall is enough to triggering anthesis. The index was formulated as “Tenth day after accumulating more than 5mm of rainfall once cumulated PET since October 1st has reached 350 mm”, and it measures the moment of the year when the flowering will be induced.



According to the results, we may conclude that by mid century flowering would happen earlier, by the beginning of March, under intermediate scenarios of emissions (RCP 45). As a consequence harvesting would start earlier. It implies difficulties in harvesting, due to the likely concentration of production. The costs would possibly increase because of the need of finding labour force and transportation in a shorter time, the drying process would be more complicated due to the lack of adequate facilities to receive more volume in less time, etc. Along with this, the harvesting period could coincide with more rainy days and with the school season, implying worse conditions to carry out this task.

Figure 7. Flowering Induction Index foreseen evolution in Virgilo Enamorado

Index of Pests and Diseases Due to Absence of Cold: The cold stops the development and spreading of fungi, which means that if the temperature does not drop enough during the coldest months, this pest reduction does not take place. The index was formulated as the “*number of degrees by which the average temperature in the coldest natural month (30 consecutive days) exceeds 18ºC*". The higher the index value, the more likely it is that pests and diseases will remain in viable condition during the coldest months.

The scenarios simulated for this index show that vulnerability to pests and diseases will tend to be higher; fungi, viral and bacterial diseases will be more frequent, strong and wide; and therefore there will be significant impacts both in production volume and quality.

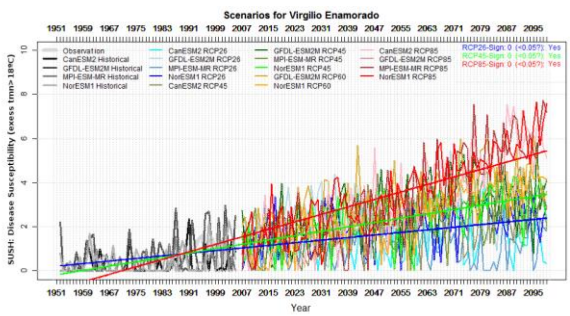
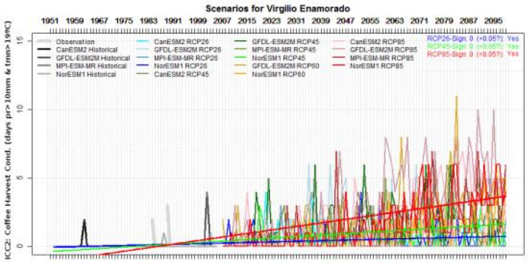


Figure 8. Pest and Diseases Index foreseen evolution in Virgilio Enamorado

Conditions during Harvesting Index: When there is excessive rainfall the soil cannot drain the water, complicating both the harvesting task and the beans transportation. Also, high levels of humidity and temperature provoke a higher incidence of diseases. The index was formulated as "Number of days with minimum temperature above 19ºC and rainfall above 10mm between December 15 and January 15". The higher the index value, the worse the conditions for the producers are.



The scenarios show that the number of days with excessive rainfall and high temperature will slightly increase, so the collection and further milling of beans will be more complicated, therefore part of them may damage if they are not milled on time and appropriately. Along with this, a higher incidence of bacteria may provoke the not pulped beans to ferment more, both in the tree and once harvested

Figure 9. Harvesting Index foreseen evolution in Virgilio Enamorado

Projected scenarios for the different indexes show some significant changes that may generate important impacts on the coffee value chain. The analysis concludes that temperature increases will lead to an earlier induction of coffee blossoming. Being the first phase in the chain, this acceleration will have an impact up to post-harvesting stage. All the subsequent phases will take place at a time different than currently, and therefore the conditions faced by the crop at each stage will not be the same.

If –as scenarios predict- rainfall remains stable and temperature increases during flower buds dormancy months, coffee will face water stress more often during this period, with a positive effect on plant preparing to flowering. Nevertheless, scenarios also indicate that climate change will impact productivity since this first flowering phase, because higher temperatures when flower is moving from dormancy to anthesis will lead to a decrease in the number of flowers and a higher incidence of star flower events.

No changes are expected in rainfall pattern during ripening phase. This means that an earlier flowering will not be accompanied by an earlier onset of the rainy season, so when the plant has higher nutritional needs the weather will still be dry. The absence of rainfall may jeopardize the availability of nutrients through fertilization at key moments for fruit filling and ripening, therefore causing productivity losses.

At that stage the scenarios show significant changes, including temperature increases in July and October and higher average temperatures during the coldest month. This will result in more vulnerability to diseases, having impacts that may be relevant both in terms of product quantity and quality.

The shortening on the whole crop cycle may accelerate harvesting to November or December, when rainfall is higher, which may complicate collecting and transporting tasks. Also, higher night time temperatures may cause harvest to build up in a short time more frequently. This will complicate harvesting practices and subsequent milling, and therefore part of the grain can deteriorate for not being milled on time, along with a higher incidence of bacteria that may cause more bean fermentation, both in the tree and after harvesting.

Something similar happens during the post-harvesting phase, regarding the right conditions for bean drying: while significant changes are not expected, an earlier harvesting will force to dry the beans when the rainfall is higher.

In general terms, impacts will have a double effect. On the one hand, the fall in quantity and loss of quality will reduce producers' income. On the other, and independently to adaptation measures considered suitable, the farmer will be forced to face higher costs, and as a consequence, this crop will be less profitable if the right measures to face these expected impacts are not adopted.

STEP 4: Making recommendations to minimize negative impacts and reinforce the opportunities.

The results of the previous analysis were discussed with national experts and producers with the purpose of jointly assess the potential impacts of future climate on the coffee value chain and propose adaptation actions that minimize the negative impacts and boost the opportunities. The conclusions of this discussion have been gathered in the recommendations below.

1. **Selecting the coffee varieties more suitable to the expected conditions**: In general terms, it is recommended to review the current genetic basis and use those varieties better adapted to future climate conditions, in order to face the consequences of higher temperatures and strengthen the resistance to pests and diseases.
2. **Managing the crop:** One of the most general recommendations to coffee growers is to improve crop shadowing in order to reduce the negative impact of higher temperatures, improve ventilation within the coffee plantation, increase soil protection or coverage in order to reduce water losses caused by higher temperatures, and invest in more efficient irrigation systems. Some fertilization problems caused by an earlier flowering will require to change the timing of this task, and will also demand to use new methods of nutrient provision. Higher proliferation of pests and diseases will demand better crop management and better prevention and control measures. Some techniques, including soaking and reducing the thickness of the sweet pulp coffee mass during fermentation, have a low cost and seem to produce interesting results.
3. **Maintaining and improving facilities**: Farmers proposed to invest in irrigation facilities in order to adapt to more adverse conditions. The potential acceleration of harvesting to a period with more rainfall will require investing more in maintaining the roads. As regards drying, it was proposed to develop facilities adapted to the farmers' characteristics and needs: drying yards, solar dryers, etc.
4. **Promoting more efficient associations and cooperatives:** Small-scale farmers will hardly be able to carry out many of the measures quoted above, due to their lack of appropriate resources and capacity, so it is necessary to promote small-scale farmers' associations in order to undertake joint measures along with support from the State and international development agencies.
5. **Access to information and research development**: The lack of information and research has limited the possibilities of deepening some of the analysis performed. It is recommended to invest in measuring variables related to climate and to undertake more research oriented to obtain evidence about the relationship between climatic events and coffee responses along the value chain.

This brochure has been extracted from the study "Analysis of Climate Change Impacts on Coffee, Cocoa and Basic Grains Value Chains in Northern Honduras", carried out by *Fundación para la Investigación del Clima* (Climate Research Foundation, FIC) and *Instituto de Estudios del Hambre* (Institute for Hunger Studies, IEH) in 2012 and financed by IFAD, as an important input for the formulation of the "Competitiveness and Sustainable Rural Development Project in the Northern Zone" (*Northern Horizons*), a pro-poor value chain development investment, co-funded by IFAD.