COFFEE PRODUCTION IN THE FACE OF CLIMATE CHANGE:

COUNTRY PROFILES

GLOBAL COFFEE PLATFORM for a sustainable coffee world

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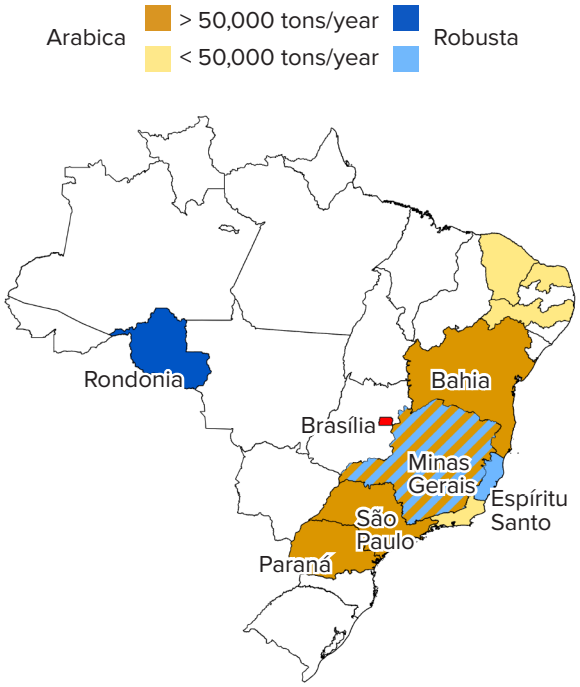
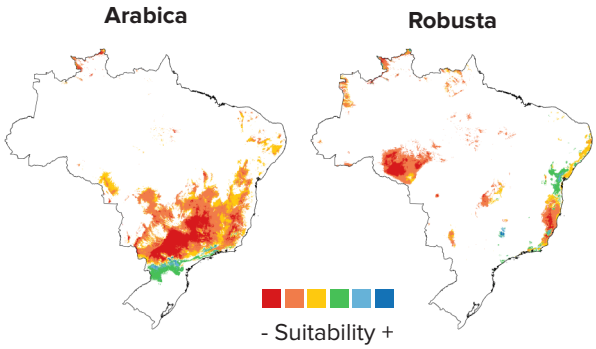
COFFEE PRODUCTION IN THE FACE OF CLIMATE CHANGE: **BRAZIL**

KEY PRODUCTION AREAS IN BRAZIL



The state of Minas Gerais accounts for 53% of overall and 70% of Arabica coffee production. About 30% of Brazil's small coffee producers are located in the state.



Changes in suitability between today and 2050 [20]

OBSERVED AND PREDICTED EFFECTS OF CLIMATE CHANGE IN COFFEE PRODUCING AREAS [8,9,10,27]

Rising Temperatures
- Temperature projections vary widely
- The average of 21 models projects increases of up to 3.5°C over most of the country by 2100

Changing Seasonality
- The dry season in the Amazon will likely get longer and precipitation decrease, especially in the dry season

Changing Rainfall
- 5% increase in rainfall in the west Brazil
- Rainfall decreases of up to 5% in central, north and southeast Brazil

Extreme Weather Events
- Increased drought and increased length of dry period are expected due to stronger and frequent El Niño events

LIKELY IMPACTS OF CLIMATE CHANGE ON COFFEE PRODUCTION

Predicted changes in coffee producing areas:

- Land suitable for coffee production is estimated to be reduced by 18% by 2050 and by 27% by 2070.[10]
- Other sources estimate loss of suitability for 25% [18] and 84% (19) of areas where Arabica coffee is cultivated currently.
- The Robusta producing states Rondonia and Espírito Santo may face losses of suitable areas of about 60%.[20]
- The potential of shifting coffee production to higher elevations is very limited. Southward latitudinal migration may be a possibility but is limited by high temperature variability (including frost) in sub-tropical regions.[21,21]

THE IMPORTANCE OF COFFEE IN THE BRAZILIAN AGRICULTURAL SECTOR[1,2,3,4,5,6,7,14,25]

Coffee production and export in 2017/2018
- Arabica: 2.3 million tons
- Robusta: 750,000 tons
- 1.9 million tons (> 60% of production) were exported
- 10% of exports in form of soluble coffee

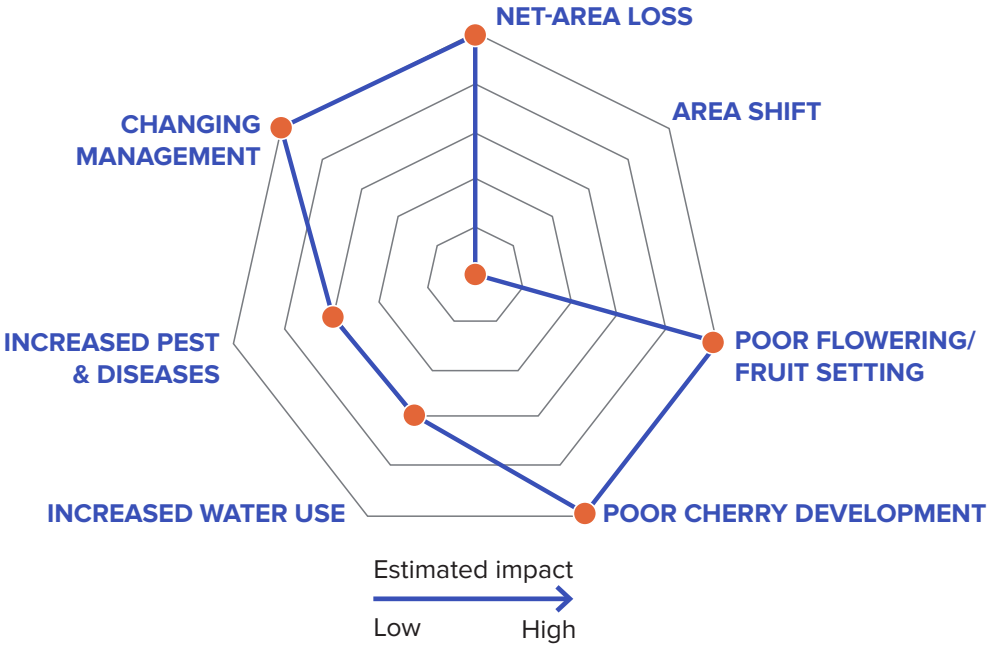
Area under coffee production
Arabica
1.7 million ha

Robusta
410,000 ha

Farms
- 300,000 smallholders (~ 5 ha) represent 75% of coffee growers
- Medium-sized (≥ 10 ha) and large (> 100 ha) producers account for 62% of total production.

Importance in the national economy
Coffee generates:
- 3% of export revenues
- 0.3% of gross domestic product

LIKELY IMPACTS OF CLIMATE CHANGE ON COFFEE PRODUCTION



- Stress caused by heat and drought increases the susceptibility of coffee trees to pests and diseases.
- Large areas will require investments into shade trees and irrigation to cope with the higher evapotranspiration and decreasing rainfall.
- Lack of rainfall during the cherry development period will result in smaller bean sizes, i.e. lower quantity and quality.
- With higher temperatures, cherries ripen very fast. Farmers may experience difficulties to harvest and process the entire crop in a shorter time period and may need to invest in additional labor or mechanization.

PRODUCTION STANDARDS AND PRACTICES

CERTIFIED PRODUCTION

- Brazil is the largest supplier of UTZ and of Rainforest Alliance coffee worldwide.
- The certificate holders are mainly medium and large scale coffee producers.
- Approximately 12% of the total export is sold as certified.

FARM PRACTICES

- Productivity and levels of technology vary from region to region and with farm size. Only larger farms are mechanized.
- In most parts of Brazil (especially Minas Gerais), coffee is grown in an intensive, high input system and under full sun.
- On about 25% to 30% of the area, modern irrigation methods are used.
- Cooperatives are the main distribution channel for lime, fertilizers, agro-chemicals, and seed.

FARM ECONOMY

- Productivity is high, with 1.6 tons/ha for non-mechanized Arabica farmers.[3]
- Production costs have increased over the past years due to rising input and labor costs, affecting the competitiveness of small and medium sized farms especially.
- Farmers receive 85% of export price.[3]

CLIMATE CHANGE ADAPTATION:

STRENGTHS

Technical aspects

New varieties and clones have been developed by Café EMBRAPA Research, partly in partnership with private companies. The new varieties are resistant to Coffee Leaf Rust and highly productive.[11,15] Varieties are multiplied by private nurseries.

Positive experiences using cover crops in coffee production have been made, e.g. with Signal Grass (Brachiaria decumbens). The cover crops improve water infiltration, nutrient availability, and soil carbon sequestration.[12,13]

Economic aspects

Coffee producers have access to crop insurance and finance in the form of subsidies and loans. The National Fund for the Defense of the Coffee Economy (FUNCAFE) offers a special credit line for coffee growers, to finance harvesting, warehousing and trade.

Around 10% if smallholder producers are members of the circa 90 coffee cooperatives. The cooperatives provide access to market and technology.[15]

Political and organizational aspects

Brazil's coffee sector is well organized: the Brazil Global Coffee Platform is governed by the National Advisory Board (public and private sector institutions) and Brazil Working Group (state extension services, standards and roasters). The platform performs advisory functions and seeks to improve sustainability of the coffee sector. [2]

OPPORTUNITIES

Technical aspects

The promotion of good agricultural practices for weed management, soil management and erosion control have clear adaptation co-benefits. These measures will also improve water infiltration and retention and reduce soil temperature, thereby helping to reduce water stress and the need for irrigation.

Economic aspects

Brazil has a very dynamic internal market for coffee, in particular for Robusta coffee. Internal consumption represents around 40% of Brazil's total sales. In combination with the narrow export price differential between Arabica and Robusta, and rising production costs for Arabica shifting production from Arabica to Robusta is an economically viable alternative.[4]

Coffee projects can be funded in the framework of the Low Carbon Agriculture Plan of Brazil (ABC, created in 2010). The ABC plan finances agricultural practices with high productivity and low greenhouse gas emissions.

Organizational aspects

Certifica Minas Gerais, an initiative of the Minas Gerais Government (SEAPA-IMA-EMATER), is a local certification scheme focusing on good agricultural practices and socio-environmental responsibility in coffee production. It offers certification at lower cost in comparison to international standards. It is implemented in partnership with UTZ, ensuring international recognition. Sustainable coffee production and climate change adaptation practices can be further promoted with Certifica Minas Gerais.

WEAKNESSES

Technical aspects

Many coffee farms are located in mountainous areas that cannot be mechanized easily and are not suitable for other cost-saving technologies.[4]

The often excessive use of fertilizers by coffee growers can result in accelerated land degradation and soil fertility decline.[14,15] Getting farmers to optimize fertilizer use in combination with other soil management options will be crucial for continued production.

An estimated 70% of land cultivated with coffee is managed by smallholders. Yet, these farmers produce only between 40 and 50% of coffee.[3,15] Lower production of smallholders is partly linked to lower degree of mechanization.[14]

Economic aspects

Labor costs have risen due to social policies introducing minimum wage. The labor costs have risen two to three times faster than inflation. In conjunction with rising input costs, many of the smaller producers struggle to remain profitable.[4,15]

The already high production costs and low coffee prices (especially for Arabica coffee and Brazilian Special) leave little room for additional investments in sustainable practices.

THREATS

Technical aspects

Coffee Leaf Rust continues to threaten coffee production with losses in the range from 30 to 50%. Coffee Leaf Rust is most severe at elevations below 1,200 meter and for Arabica coffee.[16]

Coffee producers mistrust promises of increased performance of new varieties. In the past new varieties performed well initially, but production declined rapidly. In combination with the high cost for replanting, this mistrust might slow down rejuvenation with adapted varieties. Delays in establishing varieties suited to the changing climate, pests, and diseases could be disastrous for farmers.

Economic and political aspects

Policies and finance for the sustainable development of the agricultural sector (e.g. the FUNCAFE credit line) are driven by factors such as Brazil's 2015 economic crisis or disasters like the severe droughts in southern Minas Gerais and Espirito Santo in 2014/15 and 2015/16 respectively. Proactive and reliable policies and funding are needed adequately address climate change adaptation.

The frequent changes of leadership on national and state level is a challenge for promoting sustainability in the Brazilian coffee sector.

RURAL CREDIT FOR COFFEE PRODUCERS AND CLIMATE CHANGE ADAPTATION IN BRAZIL [17,23,24,28,29]

The Brazilian government has supported the agriculture sector through rural credit programs since the 1960s. These programs are part of Brazil's enabling environment for climate change adaptation.

Two key programs are the Agricultural Plan (Plano Agrícola e Pecuário - PAP) and the National Plan for Family Farming (Programa Nacional de Fortalecimento da Agricultura Familiar - PRONAF). The annual funding available to farmers through these two plans is in the range of USD 60 billion and USD 9 billion respectively.*

A financing program specifically for the coffee sector is the Fund for the Defense of the Coffee Industry (FUNCAFE), amounting to 1.6% of rural credit programs in 2016/17. Financing under FUNCAFE is limited to activities related to harvesting, storage, and coffee trade. Lending rates are between 8.5%-11.25%. Additionally, the program supports coffee farms damaged by e.g. hail, frost and wind, where at least 10% of the farm area was affected.

Medium sized farm businesses can also apply to the National Program to Support Medium Producers (PRONAP). The program has different credit lines for investments into green technologies (e.g. renewables, recycling, soil, and water conservation), establishment of organic production, and related to forestry (including set-aside areas, forest restoration, and agroforestry). Interest varies between 2.5%-5.5%.

Since 2006, Brazil has the Crop Insurance Program (PSR). The program provides subsidies to farmers for agricultural insurance policies. The subsidies range between 35% and 40% of the insurance cost. About 4% of the insurance subsidies for crop insurance paid between 2006 and 20015 was applicable to coffee.

While various financing options are available for the coffee sector in Brazil, in practice access is complicated. The many different and partially overlapping credit lines make it hard for producers and local credit institutes to identify the best option for a given investment and region. Access to credit and conditions vary with credit purpose, location, farm size, and farm revenues. The difficulty in identifying and accessing the most suitable financial product poses a challenge for investments into adaptation and risk management.

An extended overview of financing sources for coffee producers are available in two practical guides in Portuguese by the Global Coffee Platform[24] and the Coffee and Climate Initiative[28].

*Values for the financial year 2017/2018

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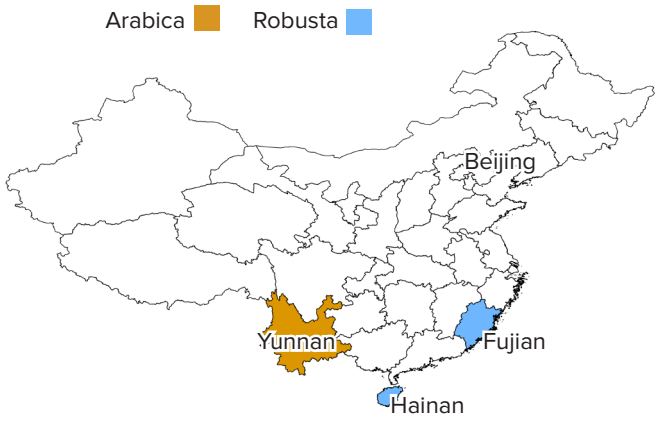
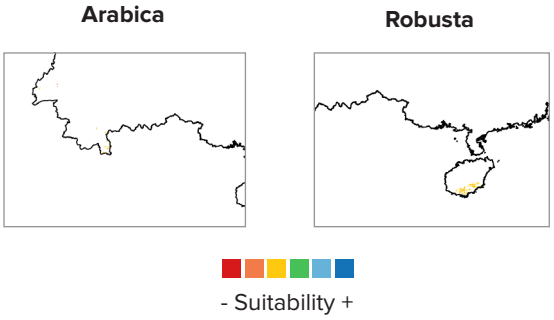
COFFEE PRODUCTION IN THE FACE OF CLIMATE CHANGE: **CHINA**

KEY PRODUCTION AREAS IN CHINA



Over 95% of coffee is grown in Yunnan province. Pu'er is the most important prefecture for the production of Arabica coffee. Small amounts of Robusta are grown on the Hainan Island in South China and in Fujian province. Robusta production is estimated to be less than 5% of China's total coffee production.

Changes in suitability between today and 2050 [14]



OBSERVED AND PREDICTED EFFECTS OF CLIMATE CHANGE IN COFFEE PRODUCING AREAS [6,7,8,13]

Rising Temperatures

- In Southeast China, temperatures are projected to increase by about 3°C by 2100.
- Observed decrease in cool nights and increase in warm nights since 1960.

Changing Seasonality

- Observed changes in seasonal precipitation:
- Increase in summer rain since 1990s
- Spring and autumn rains decreased significantly at rates of > 3 mm/decade.

Changing Rainfall

- Moderate increase of rainfall (0-10%) in south and south-east China by 2100
- Variability of rainfall is expected to increase.

Extreme Weather Events

- Drought frequency and severity has increased in mainland China.
- Increased average number of heavy rainy days in the South.
- Cold weather incidences linked to weaker jet-streams may become more likely.

LIKELY IMPACTS OF CLIMATE CHANGE ON COFFEE PRODUCTION

Predicted changes in coffee producing areas:

- Detailed forecasts of the effect of climate change on land suitability for coffee are not available.
- The majority of Arabica growing areas are located at altitudes above 1,000m, making them less susceptible to global warm.
- Extreme weather - drought and frost - are expected to cause production losses.

THE IMPORTANCE OF COFFEE IN THE CHINESE AGRICULTURAL SECTOR [1,2,3,11,12]

Coffee production and export in 2017/2018

- Arabica: estimated between 80,000-120,000 tons
- Robusta: minor production
- (Rising) internal consumption figures make China a net-importer of coffee. Internal consumption is rising fast.
- About 50% of exports are in processed form

Area under coffee production

Arabica
> 120,000 ha

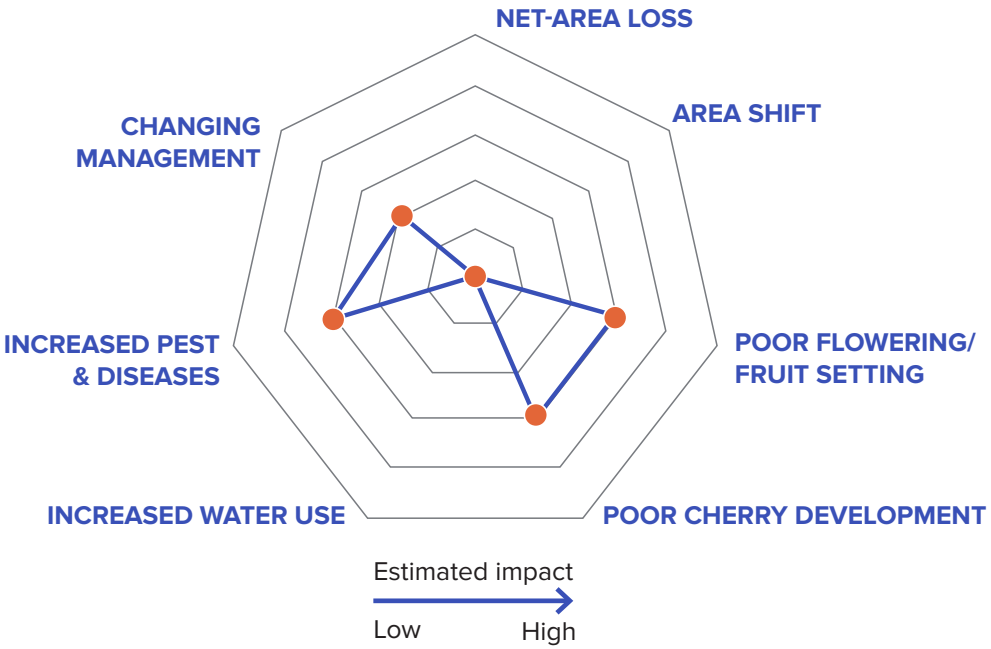
Farms

- Production is dominated by > 200,000 smallholders.
- Few large estates exist.

Importance in the national economy

- No data available.

LIKELY IMPACTS OF CLIMATE CHANGE ON COFFEE PRODUCTION



- The fast expansion of coffee area can be considered a problem, but is not related to climate change.
- Cold spells can significantly reduce or even destroy the seasonal crop entirely.
- Diversification with cold and drought resistant crops can increase resilience of farmers.
- Pests and disease are a serious threat to coffee growers in China. Coffee Leaf Rust and Anthracnose are widespread.[2] Increasing temperature will create more favorable conditions for these diseases and pests like the Coffee Berry Borer.[9,10]

PRODUCTION STANDARDS AND PRACTICES

CERTIFIED PRODUCTION

- About 20.000 tons of coffee were certified with the 4C standard.
- Other, less common standards are UTZ, CAFE Practices and Organic.

FARM PRACTICES

- Most Arabica coffee is the Coffee Leaf Rust resistant Catimor variety.[4,5]
- Other varieties such as Typica and Bourbon are planted with the expectation to access the specialty coffee segment.[4]
- About 70% of coffee farms are mono-culture. The remainder is intercropped with fruit trees.[12]

FARM ECONOMY

- Average productivity is above 1 ton/ha.[12]
- Coffee production is subsidized, stimulating the expansion of coffee growing areas.[11]
- Farmers are to some extent able to hold coffee waiting for better prices.[12]

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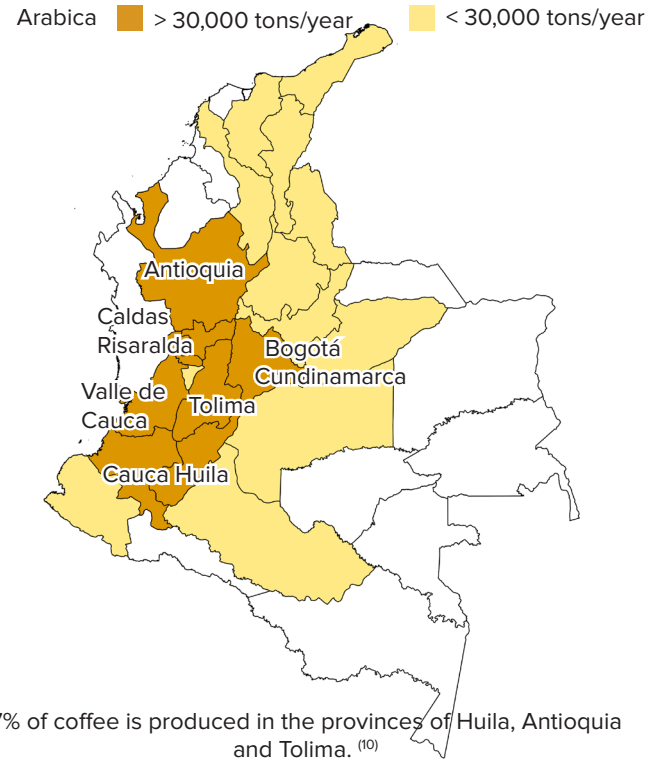
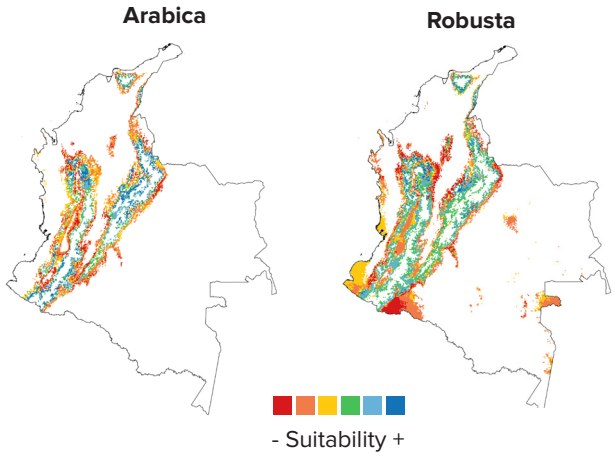
COFFEE PRODUCTION IN THE FACE OF CLIMATE CHANGE: **COLOMBIA**

KEY PRODUCTION AREAS IN COLOMBIA [7]



47% of coffee is produced in the provinces of Huila, Antioquia and Tolima. [10]



Changes in suitability between today and 2050 [16]

OBSERVED AND PREDICTED EFFECTS OF CLIMATE CHANGE IN COFFEE PRODUCING AREAS [5,9,11,14]

Rising Temperatures

- Expected average temperature rise of 1.3-2.5°C
- Expected increase in hot days and nights*

Changing Seasonality

- Seasonal differences between wet and dry season are expected to increase.
- El Niño events are expected to happen more often

Changing Rainfall

- Minimal increase in average annual rainfall.
- Higher rainfall expected mainly at the end of the rainy season, with a possible decrease of at the start of the rainy season.

Extreme Weather Events

- By 2050, extreme rainfall days are likely to increase by around 30%.
- Droughts, high temperatures and precipitation will become more extreme related to El Niño events.

LIKELY IMPACTS OF CLIMATE CHANGE ON COFFEE PRODUCTION

Predicted changes in coffee producing areas:

- Approximately 30% of currently suitable areas located at lower elevations are expected to become unsuitable for coffee. Farmers growing Arabica coffee in these areas will likely have to switch to other crops.[4] Another source[5] states that about 15% of the current coffee growing area is likely to get temperature increases of up to 3°C, making them unsuitable for Arabica coffee cultivation.
- In Colombia, coffee production can shift to higher altitudes, but such an expansion may be in conflict with other land uses, including natural forest.[16]
- All other areas require at least some investments into adaptation to remain suitable.
- Robusta could be an alternative crop for some of the lower lying areas.

THE IMPORTANCE OF COFFEE IN THE COLOMBIAN AGRICULTURAL SECTOR[3,5,6,10,22]

Coffee production and export in 2017/2018

- Arabica: 882,000 tons
- Export: 816,000 tons, of which 93% was exported as green beans

Area under coffee production

Arabica
940,000 ha

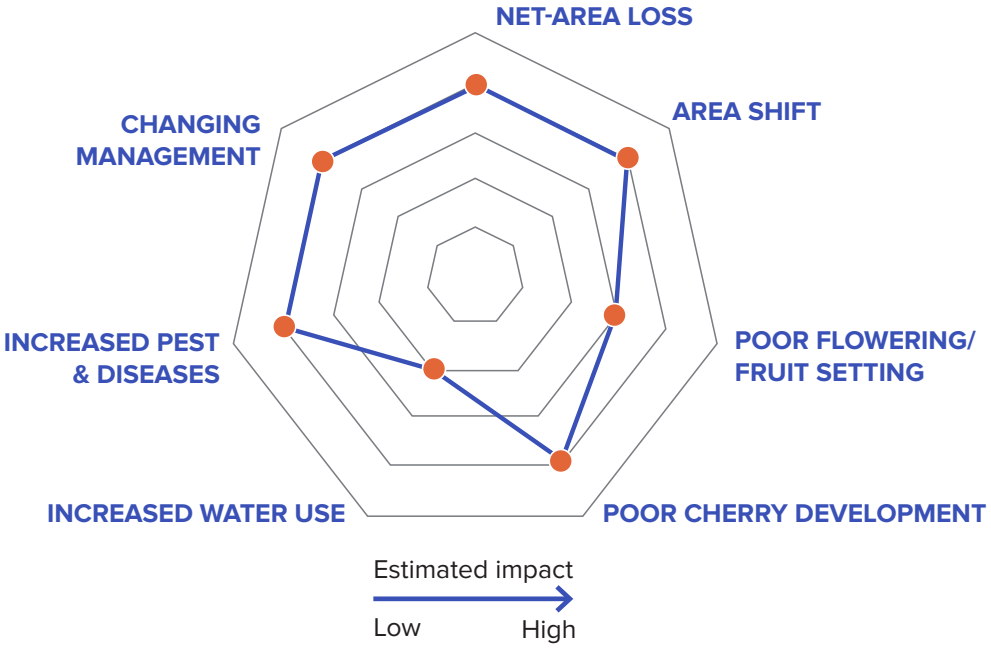
Farms

- 560,000 smallholders (~ 2 ha and < 5 ha) produce 69% of coffee
- 95% of farmers are smallholders

Importance in the national economy Coffee generates:

- 7% of export revenues
- 3,4% of gross domestic product

LIKELY IMPACTS OF CLIMATE CHANGE ON COFFEE PRODUCTION



- Rising temperatures will lead to increasing pest and disease incidences above 1,500 m, especially the Coffee Berry Borer and Coffee Leaf Rust are expected to cause losses.[5,15]
- Rising temperatures and water shortages may have a negative impact on coffee quality and quantity. Planting shade trees and, where feasible, investments in irrigation will be necessary.[2,15]
- The wetter conditions during the more frequently occurring El Niño events are likely to affect flowering and berry development negatively.[11]

PRODUCTION STANDARDS AND PRACTICES

CERTIFIED PRODUCTION

- More than 65% of production is certified by sustainability standards: 4C (vast majority), Fair Trade and UTZ.[24] About 50% of the certified coffee is double certified.
- Only 28% of coffee is exported as certified.[24]

FARM PRACTICES

- Coffee is cultivated in mono-cropping or with shade trees. Main shade tree species are rubber and Spanish Elm.[13]
- Many farmers use too much fertilizer and pesticides.
- 80% of coffee plants are rust resistant varieties.
- Farmers wash and sun-dry the coffee at the farm level.[21]

FARM ECONOMY

- The average yield is 900 kg/ha.[6]
- Labor costs account for ca. 70-80% of the production costs. Costs have risen in the past decade, without a corresponding increase in productivity. Costs vary strongly among different production systems and regions.[8]
- Farmers receive an estimated share of 96% of the export price.[23]

CLIMATE CHANGE ADAPTATION:

STRENGTHS

Technical aspects

About 80% of coffee trees are rust-resistant varieties. Approximately 420,000 ha were replanted between 2012 and 2018 to cope with the Coffee Leaf Rust crisis (Coffee Leaf Rust caused high losses between 2008 and 2011).[10]

The National Federation of Coffee Growers of Colombia (FNC) targets an annual replanting of the remaining areas in the range of 80,000 to 90,000 ha.[10] At this rate, all remaining coffee farms with old trees could be rejuvenated within two to three years. Rust-resistant varieties, developed by the National Coffee Research Center Cenicafé, are available from the research center and private sector nurseries.

Economic aspects

Farmers receive a guaranteed minimum share of 85-90% of the export price since 2013. [8,17]

The volume of coffee traded as specialty coffee is estimated to be between 10%[21] and up to 40%[10] of the export volume, translating into higher prices for farmers. Colombian coffee is an established trademark on the world market, contributing to the development of specialty coffees by roasters.

Organizational aspects

The National Federation of Coffee Growers of Colombia is the biggest coffee farmers association worldwide. It works as an exchange platform for farmers, provides marketing and extension services, and access to subsidized inputs. The federation manages low-interest loan programs for replanting with rust-resistant varieties available from the National Coffee Fund.[11,18] Extension services are also provided by the private sector.

The National Coffee Fund sources funding exclusively from Colombian coffee growers (the main source of finance are levies on coffee exports), i.e. provides services to the sector with funding from the sector.

The National Federation of Coffee Growers of Colombia, the National Coffee Fund and the National Coffee Research Center are closely connected. As a result, public sector actors are perceived to respond well to challenges and new developments.

Political aspects

The Colombia coffee NAMA (draft) identifies four core areas for improvement: fertilizer use, upscaling of agroforestry systems, post-harvest efficiency, and waste management.[17] The implementation of related mitigation actions would also have adaptation benefits.

The Colombia government is planning to produce only certified coffee by 2027.[12]

OPPORTUNITIES

Technical aspects

In the majority of the current coffee growing areas, Arabica coffee can remain a viable crop if adaptation techniques are applied.

Investments into larger, efficient wet-mills for central processing of smallholder coffee would reduce water pollution and costs at farm level.[6,21]

The introduction of/shift to Robusta coffee could help to buffer possible losses of farmers growing Arabica coffee at lower altitudes. There is already increasing interest by farmers to plant Robusta coffee, which is perceived to be less disease-prone and sensitive to climate change than Arabica coffee.[20]

Economic aspects

Improving fertilizer use will contribute to higher yields and potentially reduce costs. Optimized fertilization will help to keep coffee trees healthy and more resistant to stresses posed by climate change.

Adaptation measures such as agroforestry with fruit trees and banana can help to reduce costs for fertilizers[19] and diversify and increase income from shade tree trees.[6]

WEAKNESSES

Technical aspects

The vulnerability of coffee farmers to climate change is emphasized through mono-cropping and high dependency on coffee as the single cash crop.[6,17]

The farm level washing of coffee cherries leads to high water consumption and pollution of streams and rivers.

The use of fertilizers and other agrochemicals is often inefficient, with farmers using too much or too little (e.g. diverting subsidized inputs for coffee to other crops).

Economic and political aspects

The Coffee Leaf Rust crisis, in combination with volatile world market prices and high labor costs, weakened the economic situation of farmers, making coffee farming less attractive.

The average coffee farmer is between 40 and 56 years old, and young farmers often perceive coffee farming as unattractive. The lacking handover to younger generations has been identified as a structural challenge to the Colombian coffee sector.[19]

Private sector players are, in comparison to other countries, little involved in sector development, i.e. in policy formulation and implementation.

THREATS

Technical aspects

Many farmers perceive rejuvenation of coffee farms as a crisis measure (replacement of Coffee Leaf Rust prone coffee trees) rather than a normal part of coffee management which can be implemented gradually and with a long-term view towards sustainable production.[17] Without changing farmers' mind-sets, climate change might cause equally large crises in the future.

Political aspects

The National Federation of Coffee Growers of Colombia and the National Coffee Fund combine public and private roles. The federation is a trade association, designs national coffee policies in the framework of the National Coffee Committee, and regulates and implements exports. The federation also provides a diverse range of trade support activities. The National Coffee Fund, a public account, is managed by the federation. Stakeholders are concerned, that this set-up cannot deliver optimal sector development and benefits to coffee growers.[1,17]

The finance available to the National Coffee Fund depends on coffee production, exchange rates, and world market prices. That is, large drops in production, such as during the Coffee Leaf Rust crisis, may reduce the ability to deliver services when they are most needed.[1]

THE ROLE OF STRONG PUBLIC SECTOR ORGANIZATIONS IN CLIMATE CHANGE ADAPTATION

Most of the 560,000 Colombian smallholder coffee farmers are members of the national coffee growers federation, the "Federación National de Cafeteros de Colombia" (FNC).[11] The federation was established in 1927 as a non-profit organization to promote Colombian coffee production and marketing. They offer extension services to coffee farmers, and trade coffee of farmers and cooperatives.

The National Coffee Fund is a para-fiscal institution. It is funded from levies on exported coffee. It is used to fund activities of the federation and provides loans to coffee farmers. The federation is the current manager of the fund.

The two organizations, with additional funding from the government, were crucial in responding to the Coffee Leaf Rust crisis. The crisis reduced annual production by 30 to 40% from 2008 to 2011. The outbreak was triggered by the wet climate of an "El Niño" event. Aged coffee trees and insufficient use of fertilizer (exaggerated by high prices at this time) made coffee trees susceptible to the disease.[11,18] The "Coffee Prosperity Accord 2010-15", established in 2009, resulted in an ambitious and successful renovation program.

Today, the average age of coffee trees is seven years, production recovered fully by 2013/14 and now exceeds pre-crisis production by 10%.[14,22] While production was stable over the last three years, experts see further potential for increasing productivity and income sustainably, by implementing good agricultural practices and more efficient processing (e.g. collective/centralized washing).[7,21]

The quick and comprehensive response to the Coffee Leaf Rust epidemic shows that climate change-related challenges can be addressed successfully. It remains to be seen if stakeholders in Colombia can be equally successful in implementing adaptive measures before the next crisis hits and if/how the private sector can play a greater role in designing and implementing adaptive measures.

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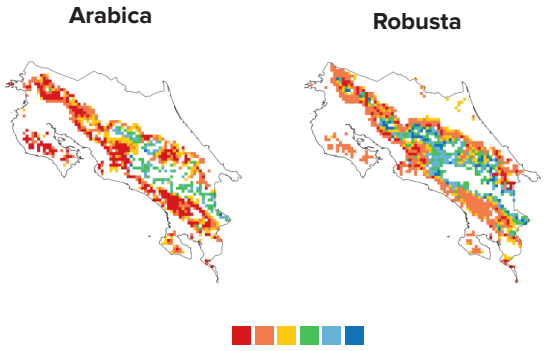
COFFEE PRODUCTION IN THE FACE OF CLIMATE CHANGE: **COSTA RICA**

KEY PRODUCTION AREAS IN COSTA RICA[20]

The main coffee producing areas are in the highlands of central Costa Rica, in the provinces Cartago, San José and the south of Alajuela.



Changes in suitability between today and 2050 [24]

OBSERVED AND PREDICTED EFFECTS OF CLIMATE CHANGE IN COFFEE PRODUCING AREAS [5,13,15,16]

Rising Temperatures

- Estimated average temperature rise of 2-2.25°C.

Changing Seasonality

- Earlier onset of the rainy season.
- More erratic and unpredictable rainfall expected.

Changing Rainfall

- 0-5% decrease in precipitation
- Rainfall is expected to be lower in the rainy season.

Extreme Weather Events

- Higher possibility of hurricane occurrence in Costa Rica.

LIKELY IMPACTS OF CLIMATE CHANGE ON COFFEE PRODUCTION

Predicted changes in coffee producing areas:

- Overall climatic suitability for coffee is expected to decline by 40% or more for 55% of the land currently suitable for Arabica coffee.
- While 40% of the currently suitable land is likely to experience some reduction of suitability for Arabica[35]; another 30% of the land is expected to become unsuitable by 2050.[2]
- Land with optimal coffee growing conditions will shift from currently around 1,200 meters to 1,600 meters.[13] Areas up to 2,500 meters are expected to become suitable for coffee.[2]
- If the country invests into adaptive measures and is able to shift coffee farming to higher altitudes, Costa Rica could compensate for the declining production expected for Nicaragua and El Salvador.[2]
- At lower altitudes, a shift from Arabica to Robusta would be an alternative, especially in combination with best practice management.

THE IMPORTANCE OF COFFEE IN THE COSTA RICAN AGRICULTURAL SECTOR[1,6,7,8,10,16,17,19,23]

Coffee production and export in 2017/2018

- Arabica: 90,000 tons
- Robusta production was legally banned between 1989 and 2018
- 73% of coffee is exported.

Area under coffee production

Arabica
84,000 ha

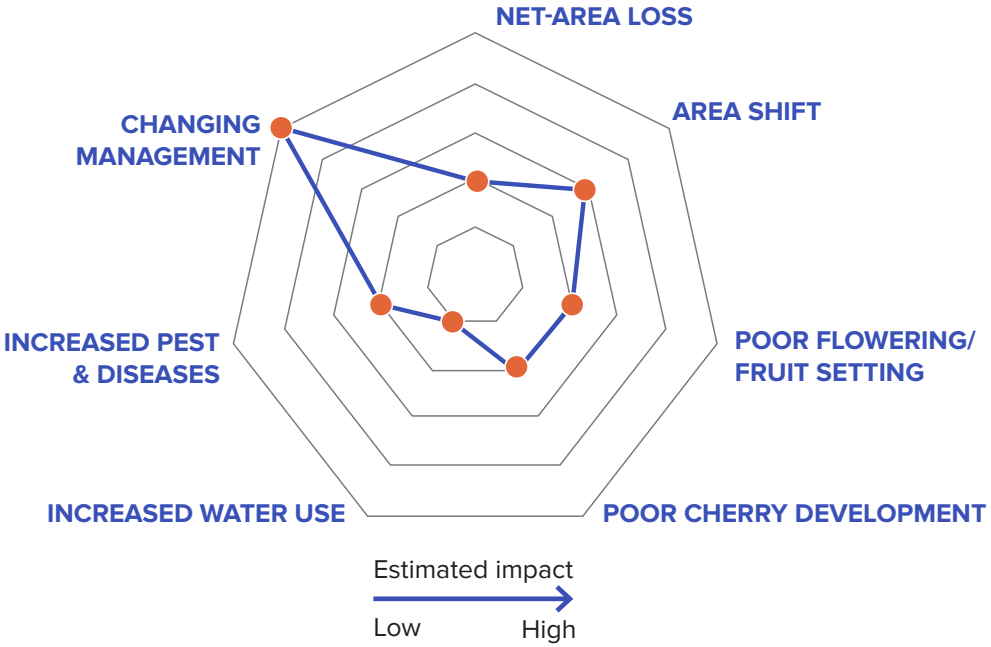
Farms

- 41,000 smallholders (~ 3 ha) produce 60% of the coffee on 97% of the coffee production area

Importance in the national economy Coffee generates:

- 2.7% of export revenues and
- 2.5% of gross domestic product
- Is the 3rd biggest agricultural export commodity

LIKELY IMPACTS OF CLIMATE CHANGE ON COFFEE PRODUCTION



- Higher incidences of pest and disease outbreaks are expected in the future.[2]
- Higher temperatures cause faster ripening of berries, leading to lower quality.[13]
- Erratic rain could lead to irregular flowering and cherry development.[13]

PRODUCTION STANDARDS AND PRACTICES

CERTIFIED PRODUCTION

- Ca. 32% of the coffee production is certified, mostly with Fair Trade and Rainforest Alliance standards.[4]
- 80% of the production enters the specialty market. Costa Rica is the 4th largest specialty coffee producer worldwide.[11]

FARM PRACTICES

- 75% of coffee trees are past peak productivity and between 40-60% of the coffee trees are affected by Coffee Leaf Rust.[1,22]
- Farmers rely heavily on agrochemicals. Usage rates in Costa Rica are among the highest in the world.[16]
- Coffee is mostly cultivated in monoculture. Sometimes lights shade from smaller, nitrogen fixing species is available.[14]
- Coffee cherries are washed by cooperatives, independent processors and multi-national companies. Cooperatives process about 10% of the total volume.[1]

FARM ECONOMY

- Average yield is 1.1 ton/ha.[10]
- Hired labor earns a relatively high minimum wage of about USD 18/day.[1]
- Coffee prices for farmers are regulated by government.
- High production costs (about 3,000 USD/ha*year) in combination with revenues of about 2,000 USD/ha make coffee farming unattractive.[9]

CLIMATE CHANGE ADAPTATION:

STRENGTHS

Technical aspects

Climate-smart strategies like agroforestry, optimizing fertilizer use and reducing the water footprint of coffee processing are already institutionalized in the coffee NAMA and piloted in the framework of the NAMA support project.[16]

The Coffee Institute of Costa Rica (Icafe) conducts research on Coffee Leaf Rust resistant varieties as well as farm practices and processing.[1]

Economic aspects

Farmers receive a minimum price for the coffee, regulated by law.[1,21]

Public banks offer a favorable credit line for rejuvenation of coffee plots. The National Coffee Institute, Icafe, has to confirm the technical feasibility before farmers can access the loan.

Costa Rica focusses on specialty coffee to compete with bigger producer countries.[3,11]

Organizational aspects

About 45% of farmers are connected to cooperatives with micro-mills.[1]

Political aspects

The coffee sector is highly regulated and considered transparent. For example, the Coffee Law (1961) stipulates relationships between producers, processors, and exporters, and includes mechanisms for coffee price setting and credit provision. Laws include also Geographical Indications and Denomination of Origin.[4,9,21]

The country is committed to achieving carbon neutrality by 2021. This has implications for coffee production and processing and is reflected in the coffee NAMA. Key action points for mitigation in the coffee sector are the adoption of agroforestry and reducing emissions on-farm and coffee processing.[12,16]

OPPORTUNITIES

Technical aspects

The Monitoring, Reporting and Verification (MRV) system of the NAMA project includes the improvement of weather forecasts and monitoring of disease outbreaks. The information can help to improve the responsiveness of stakeholders.

Economic Aspects

The introduction of Climate Smart Agriculture as per NAMA and implemented in the framework of the NAMA Support Project is expected to reduce emissions and sequester carbon while improving the financial performance of coffee farmers and processors.

Shade trees planted for climate change mitigation and adaptation can also diversify farm income. Coffee farmers participating in the NAMA are eligible to a Payment for Ecosystem Services of USD 2/tree.

Smallholders could double their yields through rejuvenation and implementation of good agricultural practices.

Organizational aspects

45% of smallholders are already organized in cooperatives. The political empowerment of coffee farmers could be enhanced if more farmers become organized in cooperatives, e.g. for the reformulation and restructuring of the national coffee fund.

Political aspects

In June 2018 the government issued a decree authorizing the cultivation of Robusta coffee at low altitude areas, offering farmers an alternative adaptation option.(18) The financial and technical viability of Robusta has to be explored in detail before investments are made.

WEAKNESSES

Technical aspects

75% of coffee is well beyond peak productivity and in need of rejuvenation.

An estimated 40-60% of coffee is affected by the Coffee Leaf Rust, causing yield losses. Susceptible varieties must be replaced with resistant breeds.

Most coffee is grown in full-sun mono-culture. In particular plantations at lower elevations are prone to damage by the increasing temperatures and other effects of climate change.

Economic aspects

Production costs in Costa Rica are high, reducing the country's competitiveness in the global market.

Low-profit margins provide little incentive to invest in coffee farms. High cost for rejuvenation (estimated to be USD 6,000 per ha) in combination with the subsequent income gap makes such investments very unlikely unless financial support in form of subsidies and soft loans is provided.

Apart from the difficulty to finance investments, the biggest constraint for smallholders is affordable access to extension services/agronomists.

Political aspects

The production of Robusta coffee was prohibited since 1989. While the ban was lifted in 2018, farmers and technical advisory services have little know-how in Robusta cultivation. Additional efforts to bridge this knowledge gap are needed if the re-introduction is to be successful.

THREATS

Technical aspects

The high production costs make farmers in Costa Rica in particular vulnerable to world market fluctuations.

Low profits make the coffee sector unattractive for young farmers. Poor profit margins, high opportunity costs, and losses caused by the Coffee Leaf Rust lead to farmers giving up coffee production. In particular, farms situated at the fringes of urban centers are increasingly converted to other land uses (e.g. in the Valle Central, a key coffee growing region).

Political aspects

The National Coffee Fund is insufficiently monetarized. Stakeholders foresee investment needs in the range of USD 100 million versus the currently available USD 30 million. Furthermore, its structure does not adequately reflect the current situation of the coffee sector.

The cultivation of Robusta coffee is an alternative land use at lower altitudes. However, farm-level investments in Robusta coffee should not take place before the financial and technical viability has been confirmed.

THE COFFEE NAMA OF COSTA RICA

Costa Rica's Coffee NAMA is one of the first "National Appropriate Mitigation Actions" in the agricultural sector globally, and is part of Costa Rica's strategy to become a carbon neutral country by 2021.[17] The coffee sector causes approximately 1.15 million tons of carbon dioxide, or 9% of Costa Rica's greenhouse gas emissions annually.

The Coffee NAMA, implemented through the NAMA Support Project with funding from Germany and the United Kingdom has five objectives, which are implemented on-farm and in coffee processing:

- The reduction of nitrous oxide emissions through the adoption of efficient fertilizer and lime application practices.
- The reduction of methane emissions through improved water management and the introduction of wastewater treatment technologies in coffee washing stations.
- The reduction of methane and carbon dioxide emissions through aerobic treatment and use of the pulp for energy.
- Reduction of carbon dioxide by using improved combustion systems in furnaces and boilers, and greater use of solar drying.
- Increased carbon sequestration through expansion of coffee agroforestry systems.

The agricultural good practices promoted are the replacement of conventional fertilizers with slow-release fertilizer, correct application of agrochemicals, and the establishment of 70 shade trees per hectare coffee.

The NAMA Support Project enables investments by farmers and millers by providing incentives, grants, loans, and guarantees. Participating farmers can receive USD 2 per tree planted in their coffee farm. Businesses are eligible for grant funding of up to USD 10,000 or 10% of the investment volume.

The achievement of the objectives would result in a combined greenhouse gas reduction and sequestration estimated to be 1.85 million tons of carbon dioxide per year.[22]

Putting the NAMA into practice is anticipated to cost USD 30 million in technical and financial assistance. The first phase of NAMA implementation focused on developing and piloting mitigation interventions. The targets of the current, second phase (until 2019) are to enable 6,000 farmers in good agricultural practices and to reduce the water and carbon footprint of 50 coffee mills. The third phase of implementation will place a stronger focus on the private sector and the full implementation of the monitoring and verification system.

Challenges experienced in the implementation if the NAMA are:

- The urgent need to rejuvenate coffee farms/replace coffee trees with disease-resistant varieties. Rejuvenation is capital intensive and results in a temporary loss of income until trees start bearing fruit. The need for expensive rejuvenation in combination with the low profitability of farms may prevent farmers from participation in the NAMA, despite the comparatively low cost of the promoted mitigation practices.
- The provision of farm and processing level data and information to producers as a tool to optimize production is still at an early stage. The piloting farmers and processors are slow to integrate this tool into their management.

More information is available at http://www.namacafe.org and https://www.nama-facility.org/projects/costa-rica-low-carbon-coffee-nama/.

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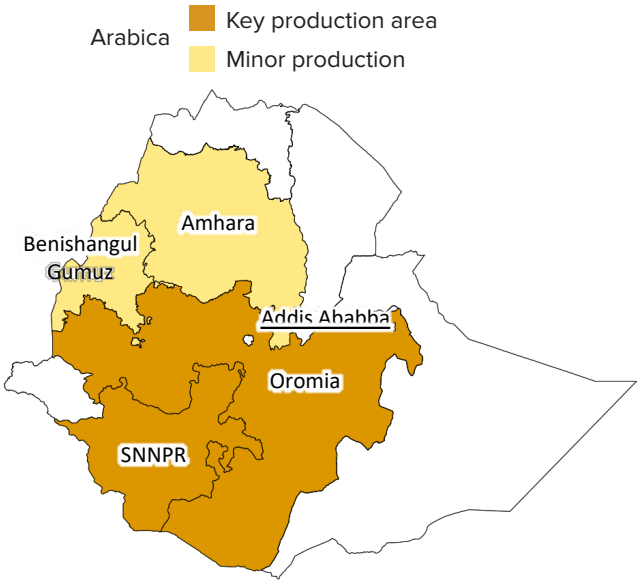
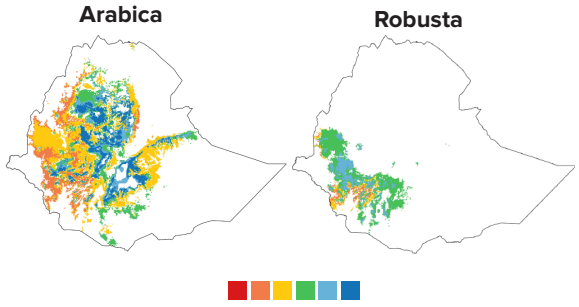
COFFEE PRODUCTION IN THE FACE OF CLIMATE CHANGE: **ETHIOPIA**

KEY PRODUCTION AREAS IN ETHIOPIA



The majority of coffee is produced in the southwest, in the Oromia Region, and Southern Nations, Nationalities, and Peoples' Region (SNNPR). Coffee production in Amhara is growing.



- Suitability +

Changes in suitability between today and 2050 [17]

OBSERVED AND PREDICTED EFFECTS OF CLIMATE CHANGE IN COFFEE PRODUCING AREAS [1,7]

Rising Temperatures

- From 1960-2006 mean annual temperature increased by 1.3˚C.
- Mean annual temperature is predicted to increase 1.1-3.1˚C by 2060, with hot days and nights expected to become more frequent.

Changing Seasonality

- Farmers report increasing uncertainty regarding the onset of the wet season, as well as a prolonged dry season.

Changing Rainfall

- Rainfall is very variable. General circulation models do not agree on future projections of precipitation change.
- Rainfall has declined by about 10% across Ethiopia (1948-2006). The decline is greater for spring/summer rains.

Extreme Weather Events

- Warming is projected for all four seasons, which can cause more frequent heatwaves.
- Drought is the most significant climate hazard.

LIKELY IMPACTS OF CLIMATE CHANGE ON COFFEE PRODUCTION

Predicted changes in coffee producing areas:

- Forecasts by experts[8] predict an 85% reduction of localities where indigenous coffee Arabica is growing naturally by 2080.
- Forecasts for 2050 by CIAT (below) show shifts in areas suitable for coffee growing to higher altitudes. The reduced suitability of current production areas can likely be offset by increasing suitability in other regions.
- Areas becoming suitable for Arabica coffee production are located at higher elevations, previously too cool for Arabica. Cultivation of coffee is starting in some of these areas.[2]
- Robusta, currently not produced in Ethiopia, could be an alternative crop for areas where Arabica coffee will be most affected by climate change.

THE IMPORTANCE OF COFFEE IN THE ETHIOPIAN AGRICULTURAL SECTOR [1,2,3,4,5,6]

Coffee production and export in 2017/2018

- Arabica: 450,000 tons
- 240,000 tons or ca. 53% were exported

Area under coffee production

Arabica

Approx. 525,000 ha

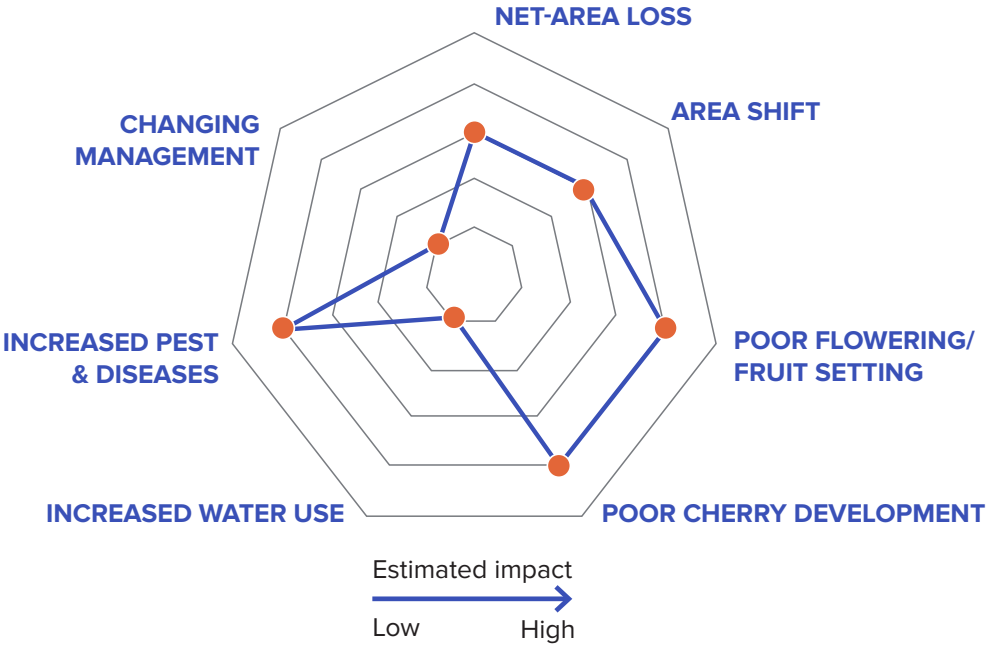
Farms

- 90% of coffee is produced by 2 million smallholders with an average farm size between 0.5-2 ha
- Only about 200 larger farms and estates (> 10ha) exist

Importance in the national economy Coffee generates:

- 25% of export revenues
- 1.1% of gross domestic product
- Coffee is key livelihood source for 15 million Ethiopians (16% of the population)

LIKELY IMPACTS OF CLIMATE CHANGE ON COFFEE PRODUCTION



- Reliance on rain-fed production systems makes coffee vulnerable to shifting rainfall patterns and drought.
- Erratic rainfall at the beginning of the rainy season can cause abortion of flowers.
- High temperatures (> 28-30˚C) have been observed to reduce flower bud formation and cherry production.[8]
- The increasing temperatures create a more favorable environment for the Coffee Berry Borer. Losses caused by the insect are expected to increase.
- Droughts are expected to cause production losses and, in extreme cases, death of coffee trees.[1]

PRODUCTION STANDARDS AND PRACTICES

CERTIFIED PRODUCTION

- In 2013, 3% of exports were certified or verified by sustainability standards.
- Good agricultural practices are practiced on about 6% of farms.

FARM PRACTICES

- Coffee grown under full shade is common in the southwest. Elsewhere, coffee is grown in agroforestry with variable shade.
- Smallholder farms typically use family labor and often practice mixed-cropping techniques.
- Nearly all coffee production is rain-fed. Some irrigated production systems exist in Amhara, Benishangul Gumuz, and in the northeast of Oromia.
- Most smallholders do not use agro-chemicals, making about 95% of coffee organic-quality.[6]

FARM ECONOMY

- Yield is low, with about 0.5 tons/ha produced on average.[4]
- Due to the low input use, production costs are relatively low with about 190 USD/ha.[5] However, costs can be very high for farms relying on hired labor.
- Farmers receive approximately 60% of export price.[5]

CLIMATE CHANGE ADAPTATION:

STRENGTHS

Technical aspects

Ethiopia has two authorities protecting which preserve the genetic diversity of landraces and wild coffee: the Ethiopian Biodiversity Institute and the Jimma Agricultural Research Center. Over time, farmers have contributed to the genetic diversity of coffee by "developing" wild coffee into special "landrace" varieties.[9,10]

The Jimma Agricultural Research Center can rely on Ethiopia's coffee genetic diversity to develop improved varieties resistant to pests and diseases which are expected to increase with climate change.

Economic aspects

Ethiopian coffee varieties are already well-known, and in high demand by the global market. The organic-quality of Ethiopian coffees contributes to the high demand. There is growing potential development of specialty coffee.[1,10]

Organizational aspects

The Jimma Agricultural Research Center has a long track record of developing improved coffee varieties.

Political aspects

The Growth and Transformation Plan II aims to double coffee production by 2020 and reform the Ethiopian Commodity Exchange to boost export of specialty coffee.

OPPORTUNITIES

Technical aspects

There is significant potential for increasing yields from the current 0.5 to over 1 ton per ha by implementing good agricultural practices and rejuvenation.[4]

Economic aspects

By improving productivity, coffee has significant potential for increasing farmer incomes and boosting the national economy. The net-income of farmers could more than double with good agricultural practices and rejuvenation.[5] Income could be increased further by switching from sun-dried to washed coffee.[6]

The total national supply of coffee could be increased by roughly 20-80% if coffee farms are rejuvenated and good agricultural practices (GAP) are implemented.[4] An estimate of the potential value added for country is 573m USD.[5]

The Coffee and Tea Development and Marketing Authority intends to offer farmers greater access to credit and a better extension packages (e.g. coffee management, distribution of new varieties).

Political aspects

Ethiopia is a signatory to the Convention on Biological Diversity and the World Heritage Convention. The country's engagement in forest conservation through biodiversity protection regulations and actions is key to preserving wild coffee and the diversity of the Arabica gene pool and adaptation to climate change.

WEAKNESSES

Technical aspects

The adoption rate of good agricultural practices and the use of agro-chemicals is very low. About 80% of coffee is well beyond peak production. Together, these factors contribute to the low productivity.[12]

Robusta, a potential alternative to Arabica in the future, is not cultivated in Ethiopia.

Economic aspects

Due to the low productivity of and income from coffee, other crops – in particular, Khat – are favored in some regions, with Khat gradually replacing coffee farms.

Rejuvenation of coffee farms is investment intensive. Smallholders have limited financial resources for the investment.

Smallholders are highly credit constrained. Roughly 70% complain about inability to access credit, and 14% complain about the high cost of credit.[4] The limited access to finance limits the ability of farmers to purchase inputs and rejuvenate their farms.

Organizational aspects

The distribution of improved coffee seed from research stations and by extensions services is limited, reducing the potential to rejuvenate coffee farms with high yielding, and pest and disease resistant varieties.

Few smallholders have adequate access to public extensions services.

The majority of smallholders growing coffee are either in loose or weakly connected value chains. The resulting low prices for producers are a disincentive for investments into better management.

Only about 10% of coffee growers are members of cooperatives. Cooperatives usually don't have the financial & technical capacity for extension services but improve market access and in some cases access to inputs.

Political aspects

Ethiopia's second Growth & Transformation Plan includes increasing coffee production. However, the set production goals were not achieved so far, pointing to inadequate instruments and/or funding for implementation of the plan. Key constraint to reaching these targets are management practices and old coffee trees (see above).[2]

The best quality coffee is reserved for export, i.e. should not be traded domestically. However, farmers could achieve higher prices for high quality coffee on local and national markets, thereby providing an incentive to invest in sustainable production of high quality coffees.

THREATS

Technical aspects

The improved varieties (incl. clones) of coffee are not very accepted by the growing specialty market, which is, however, still very small.

Political and organizational aspects

Some farmers have started to plant coffee at higher elevations which were previously unsuitable for coffee cultivation.[2] Uncontrolled expansion of coffee will contribute to land degradation and deforestation.

The gene pool of Arabica coffee is threatened by deforestation and forest degradation. The threat is compounded by the incomplete mapping of Ethiopian wild coffee diversity and limited ex-situ conservation.[10]

PRESERVING THE GENETIC DIVERSITY OF ARABICA COFFEE IN ETHIOPIA

Arabica coffee is native to the Boma plateau in South Sudan, and along the west and east sides of the Rift Valley in southern Ethiopia.[13] Ethiopia, often called the birthplace of Arabica coffee, retains much of the genetic diversity of coffee. This diversity is reflected in the various, globally known coffee provenances such as Limu, Jimma, Ghimbi, Lekempti, Sidamo, Yirgachefe, Illubabor, Harar, Tep and Bebeka. It is argued that comprehensive research on the genetic diversity of Arabica coffee in Ethiopia is a prerequisite for implementing long-lasting conservation efforts.[10,13] Without this knowledge, the value and opportunity for maintaining the coffee sector climate resilient will not be captured.

The global industry relies on varieties which are descended from a small collection of individual plants with little genetic variation – just 10% of the diversity found in the wild. Wild coffee possesses genetic variation which is needed to breed varieties adapted to climate change and resistant to pests and diseases. Without this diversity, the sustainability of the coffee industry may be under threat.[14]

Within Ethiopia, farmers cultivate local "landraces" and the "improved" coffee varieties. The local landraces were derived from wild coffee, by farmers collecting and cultivating coffee from the forest evolving them into specific varieties. The improved coffee includes around 40 varieties which have been bred by the Ethiopian Coffee Research Institute based in Jimma to be disease resistant, high yielding, and high quality. The increasing shift from cultivation of local landraces to improved varieties in combination with deforestation (incl. loss wild coffee populations) may have an impact on coffee diversity within Ethiopia over time.

Arabica coffee is part of Ethiopia's high biodiversity preserved in the remnant Afromontane forests located in the highlands of southwest and southeast Ethiopia.[15] However, deforestation is a major threat to these key habitats and thus, the genetic diversity of coffee. Within the last 40 years, Ethiopia has lost one third of its forest cover in the southwest.(14) According to the Ethiopian Biodiversity Institute, the Arabica gene pool is "highly endangered" due to increasing settlements and land pressure on the montane forests.[9]

Researchers at the Kew Royal Botanic Gardens in London have modelled how climate change will impact regions where indigenous coffee Arabica occurs in Ethiopia. They forecast an 85% reduction of localities with wild coffee in these regions by 2080.[8]

Ethiopia is signatory to various international biodiversity policies including the Convention on Biological Diversity and the World Heritage Convention.[9] Coffee conservation efforts within Ethiopia include gene banks and research centers. The two institutes working on conservation are the Ethiopian Biodiversity Institute and the Jimma Agricultural Research Center. The Ethiopian Biodiversity Institute is responsible for implementing the Convention on Biological Diversity and the National Biodiversity Strategy & Action Plan (2015-2020) for national conservation research.[16] To conserve coffee and other crop varieties, the Institute has established field gene banks throughout the country. Over 6,200 varieties of coffee, spices, root and tuber crops were catalogued.[9] Three of its field gene banks (Choche, Bedesa & Yayo) protect coffee species.[9] The Jimma Agricultural Research Center has the mandate to coordinate national coffee research and breeding. Conservation is carried out by cultivating varieties in Jimma and nine sub-centers or testing sites in the main coffee producing zones. In December 2006, the center included 4,780 samples.[11]

Different land management models are being implemented in Ethiopia to address deforestation and thus protect Arabica coffee and its genetic diversity within its natural habitat. These models include strictly protected areas, community managed forests and small church or sacred forests. UNESCO Biosphere Reserves have been established in the forests of Yayu, Kafa, and Sheka. The Ethiopian Biodiversity Institute has established 15 conservation sites in the Benshangul Gumuz, Oromia and Southern Nations, Nationalities and Peoples regions. However, many forests re-main without strong legal protection making them prone to degradation and deforestation.[9]

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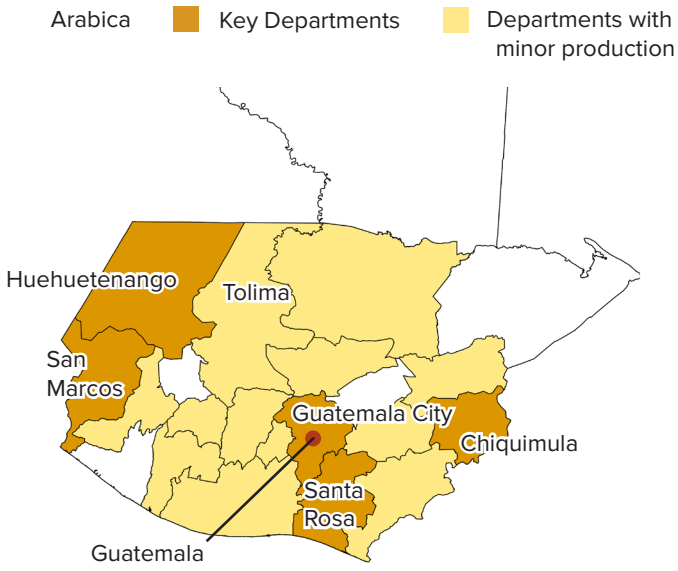
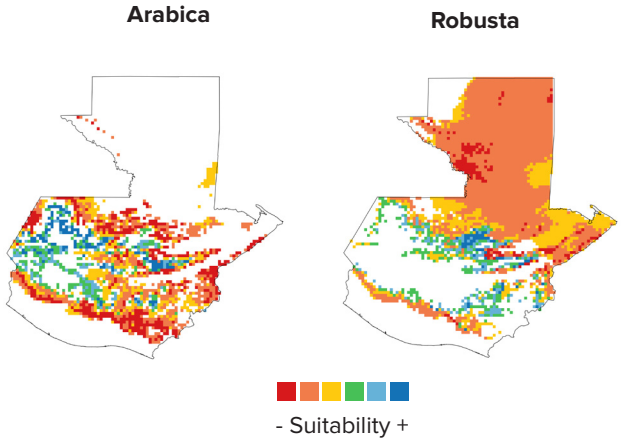
COFFEE PRODUCTION IN THE FACE OF CLIMATE CHANGE: **GUATEMALA**

KEY PRODUCTION AREAS IN GUATEMALA



Huehuetenango and Chiquimula departments produce the largest quantity of coffee, followed by Santa Rosa, Guatemala and San Marcos.
More than 80% of coffee is cultivated above 1,370m, qualifying it as "Strictly Hard Bean".[5,12]



Changes in suitability between today and 2050 [14]

OBSERVED AND PREDICTED EFFECTS OF CLIMATE CHANGE IN COFFEE PRODUCING AREAS [4,7,8,9,10,11,13]

Rising Temperatures

- Guatemala is projected to experience an increase in temperature of 2-2.5°C by 2050.

Changing Seasonality

- Climate variability is expected to increase.
- The number of dry months is expected to decrease from 5 to 4.

Changing Rainfall

- Expected decrease in average rainfall of 13% by 2050. Less rain in particular towards the end of the rainy season.

Extreme Weather Events

- 70% of the country is at risk of extreme weather events (drought, hurricanes) linked to more frequent and intense El Niño cycles.

LIKELY IMPACTS OF CLIMATE CHANGE ON COFFEE PRODUCTION

Predicted changes in coffee producing areas:

- Optimum conditions for Arabica coffee, currently between 700 and 1,700m, will shift upwards to 1,200 to 2,400 m by 2050. Arabica cultivation below 1,000m will likely cease to be feasible.[13]
- Around 13% of the land where Arabica can be cultivated currently will likely lose suitability entirely.[7] Coping strategies include the replacement of Arabica coffee with other cash crops such as banana and cocoa.[13] Robusta is already seen as an alternative crop in Guatemala and promoted by the national coffee association.[4]
- About 25% of the currently suitable land will become less suitable, requiring adaptation measures.[7] The remaining land will remain suitable but would profit from basic adaptation measures, to mitigate losses during extreme weather events.
- Areas in the high plateau of central and western Guatemala are expected to become more suitable for Arabica coffee. However, these areas coincide with protected areas and forests. Persistent cold fronts during El Niño could limit the upward movement of coffee.[7,13]

THE IMPORTANCE OF COFFEE IN THE GUATEMALAN AGRICULTURAL SECTOR[1,2,3,4,5,6,12]

Coffee production and export in 2017/2018

- Arabica: 220,000 tons
- Robusta: < 10,00 tons
- About 90% of coffee is exported.

Area under coffee production

Arabica
305,000 ha

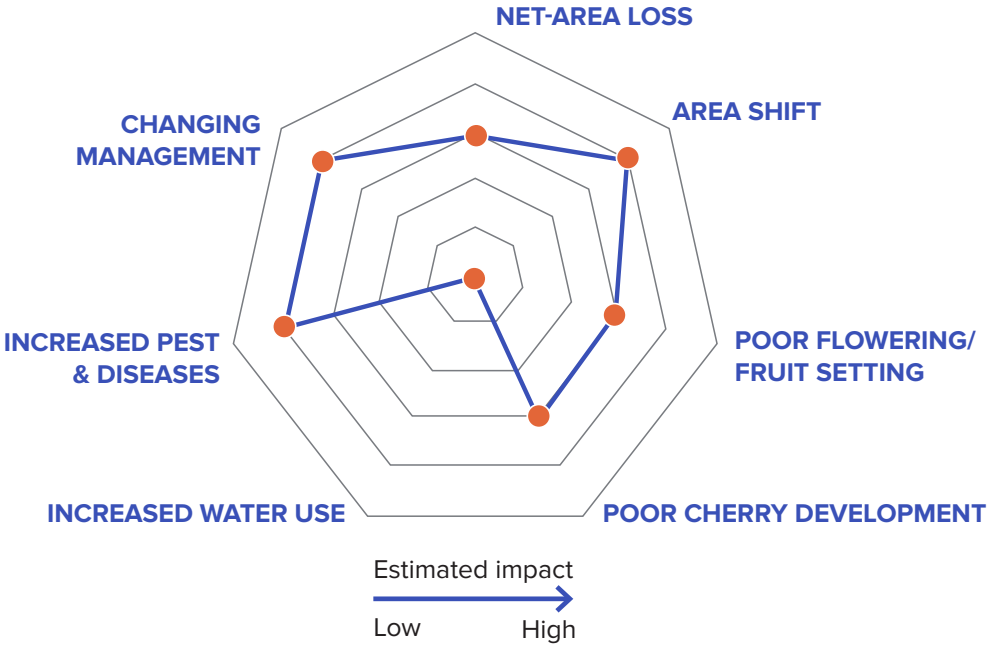
Farms

- 120,000 smallholder farmers account for 90% of coffee area but only 47% of total output. Their average plot size is 1.2 ha.

Importance in the national economy Coffee generates:

- 6.2% of export revenues (40% agri. export revenue)
- 2% of gross domestic product

LIKELY IMPACTS OF CLIMATE CHANGE ON COFFEE PRODUCTION



- Diseases (e.g. Coffee Leaf Rust) and drought would reduce production.[7]
- Higher humidity (La Niña) can lead to abortion of cherries and accentuate outbreaks of diseases, including less common ones such as Coffee Thread Blight and American Leaf Spot.[7]
- Hurricanes and persistent storms in La Nina years will continue to cause damage to coffee farms and processing equipment.[7]
- Longer dry seasons can lead to defoliation of coffee and shade trees, in extreme cases causing dieback of plants.[7,8] Farmers can adapt to some degree by managing shade and soils well to reduce moisture loss.

PRODUCTION STANDARDS AND PRACTICES

CERTIFIED PRODUCTION

- 13% of coffee produced in Guatemala was certified in 2012.[6]
- Certification is highest in Huehuetenango province with 30% of the total area certified.[6]
- The majority of certificate holders are independent farms (> 60%).[6]

FARM PRACTICES

- 98% of coffee in Guatemala is shade-grown.[5]
- About 20% of coffee are rust-resistant varieties.[5]
- 98% of Guatemalan coffee is washed at centralized wet mills or independent washing stations.[5] Some farmers own small pulping machines at the farm level, others use cooperative-owned facilities[12]
- In most regions washed coffee is sun-dried. In more humid regions (e.g. Cobán in the north), coffee is partly dried with electric dryers owned by cooperatives.[5,10]

FARM ECONOMY

- Average productivity is 0.65 ton/ha.[1]
- Inputs are the biggest cost item for smallholders (> 50%), followed by labor. To remain financially viable, small farmers limit input use and discount own labor from production costs.[1]
- Coffee qualifying as “Strictly Hard Bean” can fetch higher prices.[5,12]
- Farmers receive between 70% and 85% of export price, depending on region.[12]

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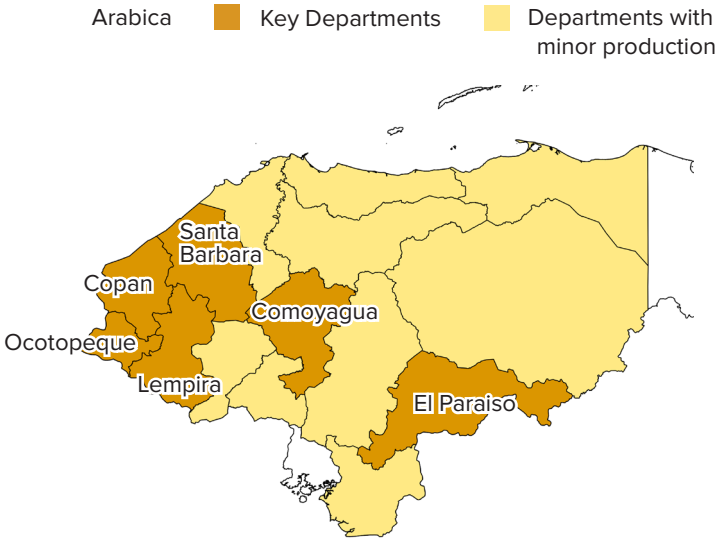
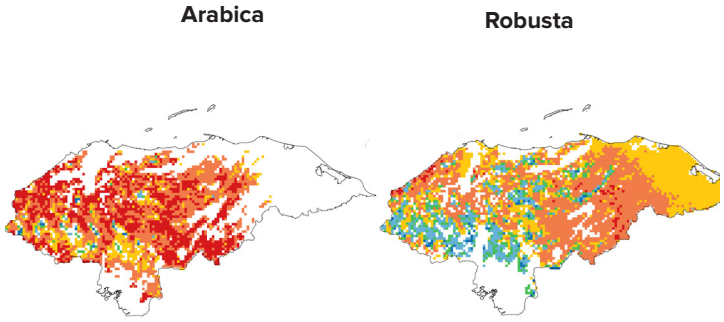
COFFEE PRODUCTION IN THE FACE OF CLIMATE CHANGE: **HONDURAS**

KEY PRODUCTION AREAS IN HONDURAS



Most Arabica coffee is grown in the Sierra Madre mountains, crossing the country from the south-east to the west. About 30% of coffee is grown at altitudes below 900 m. Robusta is not produced in Honduras.



Changes in suitability between today and 2050 [5]

OBSERVED AND PREDICTED EFFECTS OF CLIMATE CHANGE IN COFFEE PRODUCING AREAS [4]

Rising Temperatures

• The annual mean temperature is projected to increase by 1.9°C by 2050. This increase is expected to be more pronounced in the west.

Changing Rainfall

• Predictions for changes in rainfall vary widely between models. Changes in annual rainfall are expected to be small, but more pronounced in western Honduras.

Extreme Weather Events

• The region is prone to droughts, excessive rains and severe flooding. Droughts are expected to become more likely and more severe.

LIKELY IMPACTS OF CLIMATE CHANGE ON COFFEE PRODUCTION

Predicted changes in coffee producing areas:

• Land with basic suitability will be 200 m higher than today.[4] Coffee farmers in areas below 1,000 m will likely have to transition to other crops.

• 45% of land currently suitable for Arabica coffee requires comprehensive adaptation measures to remain suitable.[4] This includes more costly investment such as replacing coffee trees with new varieties, installation of irrigation and water harvesting structures, and use of polymers for water retention.

• There is limited potential to shift coffee to higher areas in western Honduras. Forest areas above 1,800 m are protected.

THE IMPORTANCE OF COFFEE IN THE HONDURAS ECONOMY[1,2,3,4]

Coffee production and export in 2017/2018

• Arabica: 501,000 tons
• About 95% are exported without processing
• Over 30% of exports are specialty coffees

Area under coffee production

Arabica
342,000 ha

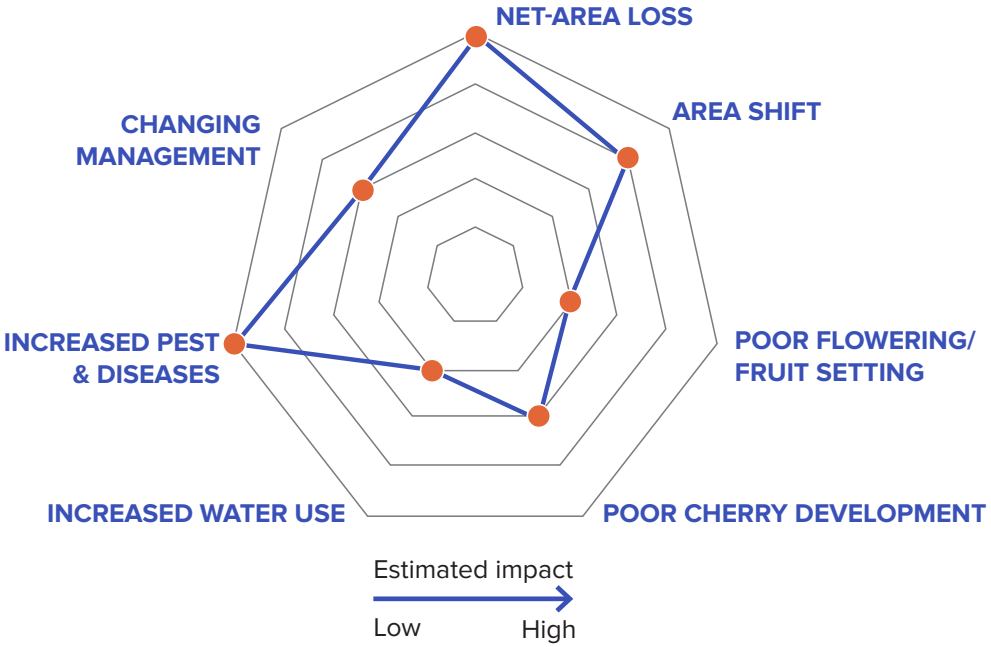
Farms

• For >100,000 farm households coffee is the primary income
• 70% of producers have farms below 2ha and 25% between 2-7ha; together they produce 70% of coffee

Importance in the national economy

Coffee generates:
• 20% of foreign exchange
• 4% of overall and 30% of agricultural gross domestic product

LIKELY IMPACTS OF CLIMATE CHANGE ON COFFEE PRODUCTION



- More frequent and severe droughts will reduce production unless farmers invest in water management.[4]
- The climatic changes will likely cause higher incidences of pest and diseases:[4]
- The coffee leaf rust crisis (2012-2014) was likely linked to rising minimum temperatures.
- Reproduction rates of the coffee berry borer benefit from higher temperatures. Infestations are expected to be more severe and to occur at higher altitudes.
- Other fungal diseases (e.g. Leaf Spot Disease) are linked to moist conditions (higher rainfall, shade trees). Farmers will have to adjust canopy cover, balancing the need for temperature regulation while avoiding excessive moisture.

PRODUCTION STANDARDS AND PRACTICES

CERTIFIED PRODUCTION

- About 20% of coffee is certified with Rainforest Alliance/UTZ, Organic and Fairtrade International.[4]
- A smaller share is certified by other standards.

FARM PRACTICES

- Smallholder coffee farmers grow food crops for subsistence.
- Commonly coffee is grown under shade. About 20% is grown under full sun.[4]
- The majority of farmers sell coffee washed but without drying.

FARM ECONOMY

- The average yield is 1.1 tons/ha.[3]
- Smallholder farms rely largely on family labor.
- Farmers receive about 75% of export price.[3]

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GLOBAL COFFEE PLATFORM for a sustainable coffee world

coffee & climate

CONSERVATION INTERNATIONAL

idh the sustainable trade initiative

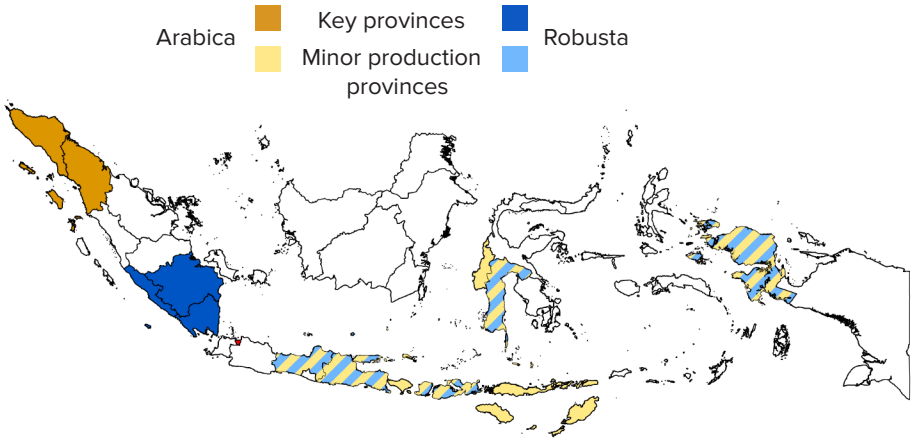
Specialty Coffee Association

Consulting Services Provided By:

UNIQUE forestry and land use

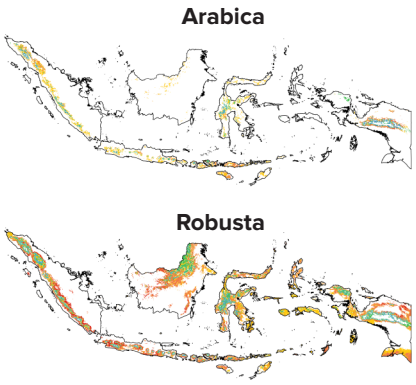
COFFEE PRODUCTION IN THE FACE OF CLIMATE CHANGE: **INDONESIA**

KEY PRODUCTION AREAS IN INDONESIA



Over 60% of Robusta coffee is produced in the southern half of Sumatra. Key Arabica production areas are located in northern Sumatra. Small quantities of Liberica coffee are produced on Sumatra and Kalimantan.[2]

Changes in suitability between today and 2050[8]



OBSERVED AND PREDICTED EFFECTS OF CLIMATE CHANGE IN COFFEE PRODUCING AREAS[8,9,10,11,12,16]

Rising Temperatures

- Average temperature increase of 1.7°C
- Increased number of hot days and nights
- Decrease of cold nights, likely to zero by 2060

Changing Seasonality

- More frequent delays in the onset of monsoon rains
- Intermittent rain in the dry season

Changing Rainfall

- Increasing rainfall on northern Sumatra, Sulawesi, Bali and Flores
- Slightly decreasing rainfall on southern Sumatra and Java

Extreme Weather Events

- Higher proportion of rain falling in heavy events

LIKELY IMPACTS OF CLIMATE CHANGE ON COFFEE PRODUCTION

Predicted changes in coffee producing areas:

- Currently suitable land in Arabica production areas is expected to be reduced by > 80%. This can be offset partially by higher altitudes becoming suitable for Arabica. Overall, land suitable for Arabica production is expected to be two-thirds of today's area suitable for Arabica.[12]
- Some of the areas cultivated with Arabica today will remain suitable for Arabica but require adaptive measures to mitigate the effects of climatic changes.[12]
- Farmers may be able to change from Arabica to Robusta in some areas.
- Changes for Robusta growing areas are expected to be of equal magnitude but have not been as well researched yet.

THE IMPORTANCE OF COFFEE IN THE INDONESIAN AGRICULTURAL SECTOR[1,2,3,4]

Coffee production and export in 2017/2018

- Arabica: 90,000 tons
- Robusta: 520,000 tons
- Ca. 40% are consumed in Indonesia
- Less than 10% of exports are processed

Area under coffee production

Arabica
310,000 ha
Robusta
930,000 ha
Liberica
< 10,000 ha

Farms

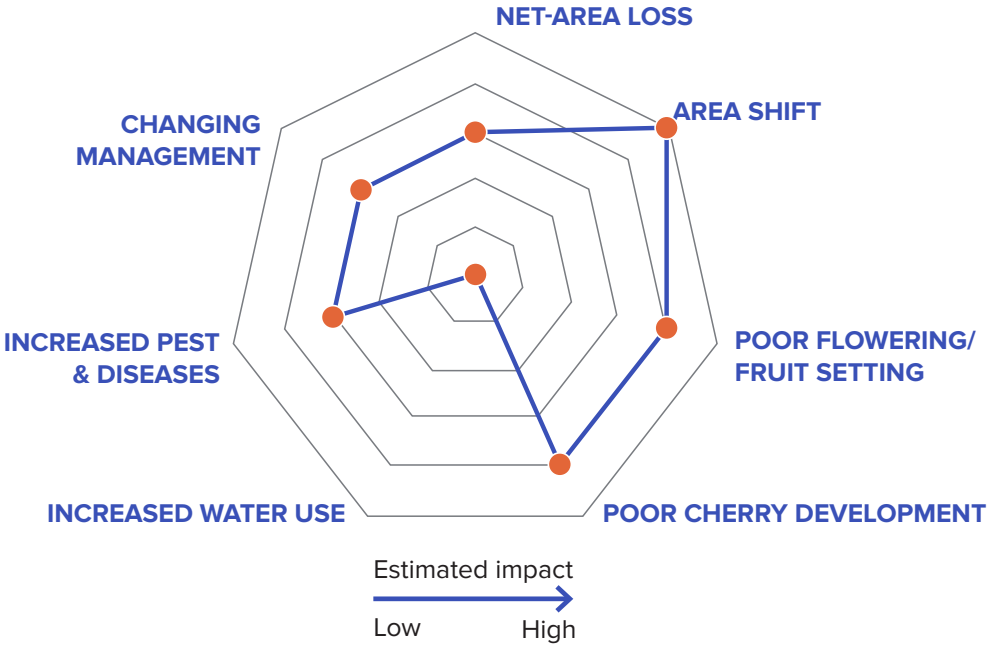
- 1.5 million smallholders (~ 1ha) manage > 95% of coffee plantations
- Only an estimated 0.5 million farmers are considered "active"

Importance in the national economy

Coffee:

- Is the 4th largest foreign exchange earner
- Generates 0.2% of gross domestic product

LIKELY IMPACTS OF CLIMATE CHANGE ON COFFEE PRODUCTION



- The predicted temperature rise allows additional life cycles of the coffee berry borer, increasing losses. The altitudinal range of the borer is expanding upwards (from previously 1,000m to 1,200m currently), affecting additional coffee plantations (Arabica).[13]
- Yields are expected to decline, due to:
- Decreasing rainfall on southern Sumatra and Java
- Heavy rain and wind damaging flowers[6]
- Intermittent rainfall throughout the year, leading to continuous flowering and fruit setting, and interruptions in sun drying, requiring:
- Adjustments to farm management
- Investments (e.g. storage capacity to aggregate the lower quantities of beans before selling, drying kilns)

PRODUCTION STANDARDS AND PRACTICES

CERTIFIED PRODUCTION

- About 7% of exported coffee is certified with sustainability standards: UTZ, 4C, Rainforest Alliance and Fair Trade.[4]

FARM PRACTICES

- Ageing coffee stock is common. Rejuvenation and access to improved planting material is limited.[7]
- Adoption of good practices such as pruning and integrated pest management is low.[3,6]
- Commonly, coffee is grown under (dense) shade.[6]

FARM ECONOMY

- Low yields: < 800kg/ha on average [3,5]
- Low cost/input system with high reliance on family labor.[3]
- Coffee contributes to livelihoods, but is often not the main source of income.[5]
- Arabica growers have access to higher value specialty coffee markets.[6]
- Farmers receive about 80% of export price[4]

CLIMATE CHANGE ADAPTATION:

STRENGTHS

Technical aspects

Coffee is often grown under shade and in combination with other tree and annual crops, i.e. in agroforestry systems. This ensures a basic resilience of farm systems and households against climate change.

Comprehensive manuals for good agricultural practices for Robusta and Arabica have been developed by experts. Feedback from users can be incorporated over time, making the manuals suitable for all user groups.

The Indonesia Coffee and Cocoa Research Institute (ICCRI) has developed planting material for Arabica and Robusta with a stronger rooting system (suitable for drought-prone areas and resistant against Nematodes), different Robusta varieties adapted to drought and rainfall throughout the year, as well as varieties with higher disease resistance.[14]

Economic aspects

Indonesian farmers in northern Sumatra produce different specialty coffees (Arabica). These coffees generate substantially higher revenues and are an incentive to invest in better farm management.

The government in cooperation with local banks offers "farmer business credits". Some of the existing financial institutions customize their products to cater to coffee farmers' needs.

Organizational aspects

Certification with international sustainability standards is well established in the core Arabica production areas in northern Sumatra.

The coffee sector in Indonesia is fully liberalized, permitting direct trade linkages between farmers and exporters/processors. Such linkages are an important condition for private sector driven extension services.

The Social Forestry Program will improve land tenure, providing an incentive to invest in the rehabilitation of deforested land (e.g. establishing coffee agroforestry systems) while protecting natural forests.[17]

OPPORTUNITIES

Technical aspects

Yields can be raised significantly by rejuvenating coffee trees and the adoption of good agricultural practices, with the potential to more than double profits.[3] The required technical and financial support can be provided in public-private partnership building on (and improving) the existing government initiatives and the interest of the private sector to secure future supply.

Organizational aspects

Coffee farmers can market their coffee more profitably jointly, i.e. through farmer organizations. Such farmer organizations constitute viable entry points for private and public sector extension services promoting sustainable management practices.

The Social Forestry Program provides an entry point to coffee industry players to secure future supply. The industry can support the establishment (or rejuvenation) of coffee on suitable community land, provide technical assistance and supply value chain financing.[6]

Political aspects

Indonesia could maintain its production in a sustainable manner by designing and implementing policies that:

- Help farmers to increase productivity in areas which will remain suitable
- Support farmers in the transition from Arabica to Robusta where applicable
- Guide farmers to select areas for coffee cultivation which (i) are currently not used for coffee and (ii) will remain or become suitable and (iii) do not compromise the integrity of natural ecosystems regardless of their protection status.

WEAKNESSES

Technical aspects

The successful participation of communities in the Social Forestry Program requires substantial support from the public for planning, throughout the application process, and implementation. Government is not able to provide sufficient support to roll out the program as planned.

Economic aspects

Productivity and income of coffee farms are low. Causes are the aged coffee trees, poor farming practices, and very low input use. As a result, coffee is not perceived as a lucrative land use.

Coffee is a side business for many farmers, especially those growing the lower value Robusta coffee. The limited disposable income is more likely to be used for investments into other crops or business activities, affecting the adoption rate of good agricultural practices and implementation of adaptive measures.

"Farmer business credits" catering specifically to coffee farmers are available in southern Sumatra and East Java only. The credit scheme is poorly communicated, seeing little uptake by farmers. Affordable, longer-term credits would be crucial for investments into the rejuvenation of aged stock and more expensive inputs such as fertilizer.

Organizational aspects

With few exceptions, coffee farmers are not organized. The dispersed coffee farms, low production levels and poor infrastructure make investments in sustainable production unattractive for downstream private sector actors.[4]

Responsibilities in the coffee sector are divided between several national institutions. A national body specific to the coffee sector does not exist, making coordination of sector stakeholders inefficient.

Political aspects

The development of the coffee sector is not a strategic priority of the Indonesian government. As a result service provision to coffee farmers is low in comparison to other crops (extension, research, inputs, access to finance).

THREATS

Technical aspects

Coffee production in Indonesia is highly variable depending on weather conditions, in particular, heavier than usual rainfall. Climate change may emphasize the year to year variability of productivity further, reducing the economic viability of coffee.

Economic aspects

Replacing old coffee stock with new, more suitable planting material is often not affordable for farmers due to the multi-year gap in production. Likely, only farmers directly supported by projects will make the transition to coffee adapted to the effects of climate change.

Political aspects

The expected upwards shift of land suitable for coffee production may lead to the conversion of forest to compensate for areas lost.[15] While Indonesia has committed to REDD+, the country has not yet a good track record in protecting its forests.[18]

CAN INDONESIA'S SOCIAL FORESTRY PROGRAM CONTRIBUTE TO A SUSTAINABLE COFFEE SECTOR?

Many of the current and future potential coffee growing areas are located on designated forest land. Hence, the potential displacement of coffee cultivation to higher altitudes may become a driver of deforestation in the future.[15] Government policies play an important role in guiding the relocation of coffee farming to suitable areas. The Social Forestry Program has the potential to support this process.

Social forestry, commonly known as community forestry, was established in Indonesia in 1999. However, only with the start of the Social Forestry Program in 2016 has community forestry become truly important in Indonesia. In the framework of the program, the Indonesian Government intends to allocate 12.7 million hectares of land to communities. Important aims of the program are to reduce deforestation and reverse land degradation, contributing to REDD+.

Land can be allocated to whole communities, community groups or cooperatives, or individual families. Agroforestry management systems can be implemented on land classified as production forest (which is often heavily degraded forest or deforested). Such agroforestry systems must include a minimum of 400 timber or native fruit trees per hectare.

Communities decide together with the authorities how to manage the allocated land, i.e. where to restore and protect forest, and where to set the focus on production. The private sector can partner with communities and groups, supporting them to implement sustainable production systems.

Coffee is already part of community-based forestry programs in Indonesia. Experiences from social forestry schemes initiated before 2016 show that communities and households were able to improve their incomes and food security, and increased their investment in land rehabilitation. An example of the positive impacts of Social Forestry is documented for Lampung in southern Sumatra.

However, the implementation of the Social Forestry Program faces several challenges:

- Adequate verification of the permit areas and management plans by local government
- Provision of technical and financial support to restore degraded land and for business development
- Need to strengthen local institutions and capacity of communities to manage land sustainably and to distribute benefits equitably.

The community forests established successfully to date were supported by civil society organizations. Similar support will be needed in the future, but can and should include private sector driven initiatives.

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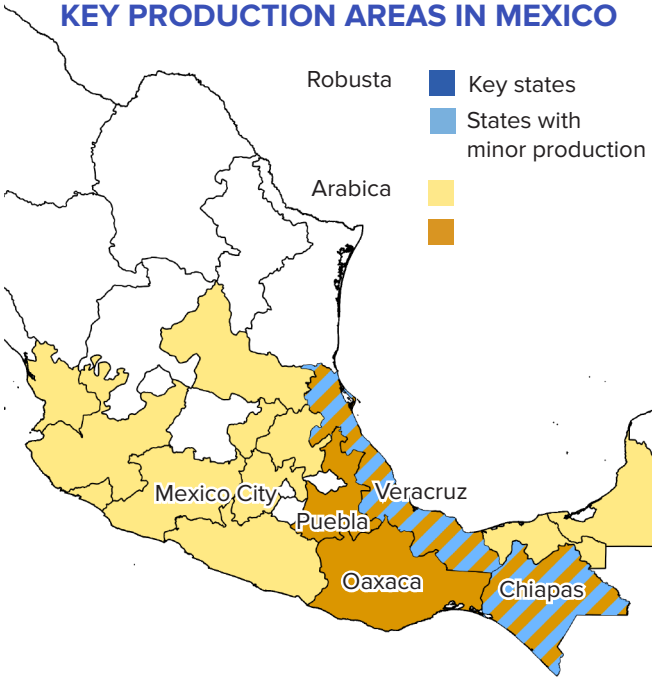
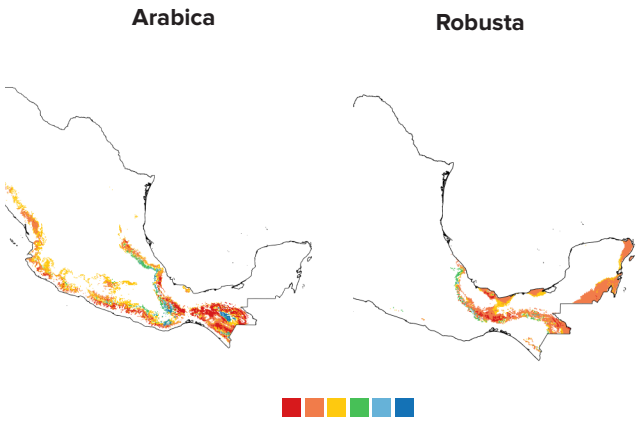
COFFEE PRODUCTION IN THE FACE OF CLIMATE CHANGE: **MEXICO**

KEY PRODUCTION AREAS IN MEXICO



The majority of coffee is produced in the southern Sierra Madre mountains. About 90% of national production comes from Chiapas, Oaxaca, Veracruz and Puebla.[17]
Roughly 1,600 ha in Chiapas and 2,000 ha in Veracruz have been converted from Arabica coffee to Robusta for the production of soluble coffee.[2]



Changes in suitability between today and 2050 [15]

OBSERVED AND PREDICTED EFFECTS OF CLIMATE CHANGE IN COFFEE PRODUCING AREAS [7,8]

Rising Temperatures

- Temperatures are projected to increase by 2.1-2.2°C in the Sierra Madre de Chiapas and Veracruz by 2050.

Changing Seasonality

- Increased frequency or duration of the El Niño with dry weather
- The maximum number of dry months is expected to increase from 5 to 6 months in Veracruz

Changing Rainfall

- Rainfall in the Sierra Madre is forecasted to decrease by 4-5% by 2050.

Extreme Weather Events

- The Chiapas coastal region will likely be affected by increasing frequency and intensity of hurricanes.

LIKELY IMPACTS OF CLIMATE CHANGE ON COFFEE PRODUCTION

Predicted changes in coffee producing areas:

- Rising temperatures will have negative impacts on coffee production at lower elevations, potentially causing a shift of the coffee growing areas to higher elevations.[7,11]
- The estimated loss of areas suitable for Arabica coffee production by 2050 varies from 29% - 53.2%.[9,10] Farmers growing Arabica below 900 m will most likely have to shift to other crops, including Robusta coffee.[7]
- Veracruz is projected to experience a 32% decrease in land suitable for high (high acidity/quality) coffee production.[8]
- The conditions for Arabica coffee above 1,700 m will likely improve. However, the actual room for expansion of coffee to higher altitudes is limited by other land uses, incl. forests and protected areas.[7]
- The potential area for growing Robusta may be reduced by up to 80% in 2050.[6]

THE IMPORTANCE OF COFFEE IN THE MEXICAN AGRICULTURAL SECTOR[1,2,3,4,5,6,14,17]

Coffee production and export in 2017/2018

- Arabica: 240,000 tons,
- Robusta: < 10,000 tons
- Imports coffee products: > 50,000 tons
- Internal consumption and export are roughly equal

Area under coffee production

Arabica
500,000 ha
Robusta
80,000 ha

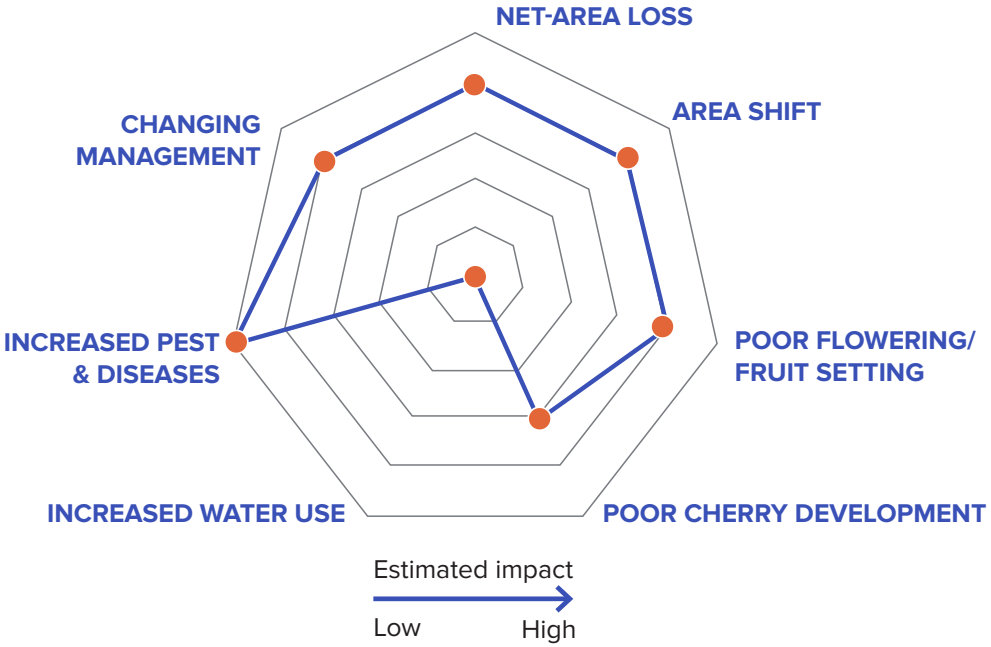
Farms

- More than 500,000 smallholders (0.5-1.5 ha) cultivate about 60% of the total area and produce about 40% of coffee.

Importance in the national economy Coffee generates:

- 0.1% of export revenues in 2015
- 0.07% of gross domestic product

LIKELY IMPACTS OF CLIMATE CHANGE ON COFFEE PRODUCTION



- Bee species are projected to decline in Central and Southern America because of the warming climate by 2050[10], potentially reducing pollination.
- If rainfall events in the onset of the rainy season decrease or are too heavy, the coffee plant may drop its flowers and fruit, producing beans of smaller size and lower quality.[7]
- Coffee Leaf Rust has caused significant production losses.[2] Higher temperatures are expected to increase the spreading of coffee pathogens, especially at higher altitudes.[12]
- Droughts will increase the risk of wildfires in coffee growing regions.[7]
- Adaptation measures include the planting of coffee varieties resistant to high temperatures and drought, and processing technologies which require less water.[7]

PRODUCTION STANDARDS AND PRACTICES

CERTIFIED PRODUCTION

- Certified coffee is produced by about 7-8% of growers.[2]
- About 10% of coffee exported is certified as organic.[12]

FARM PRACTICES

- Coffee is largely grown under forest shade and partly in agroforestry systems with fruit trees.[2,13]
- In recent years, Coffee Leaf Rust caused substantial losses. On many coffee farms, trees are old, good practices are not implemented, and fertilizer use is low/ incorrect.[2]
- Coffee is traded washed or semi-washed. Wet-processing on-farm is common.[7]

FARM ECONOMY

- The average yield of smallholders is very low with 0.2-0.4 tons/ha.[2,17]
- Most smallholders rely exclusively on coffee for income.[5] Producers reported higher production costs than income in 2018.[3]
- Farm labor accounts for > 80% of production costs.[2]
- Farmers receive an estimated 70% of export prices.[17]

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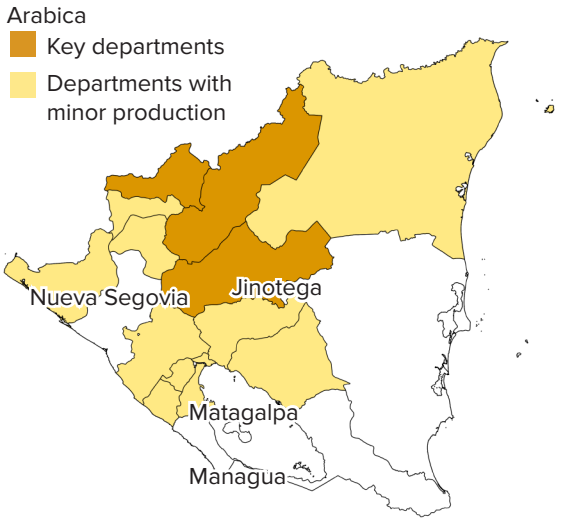
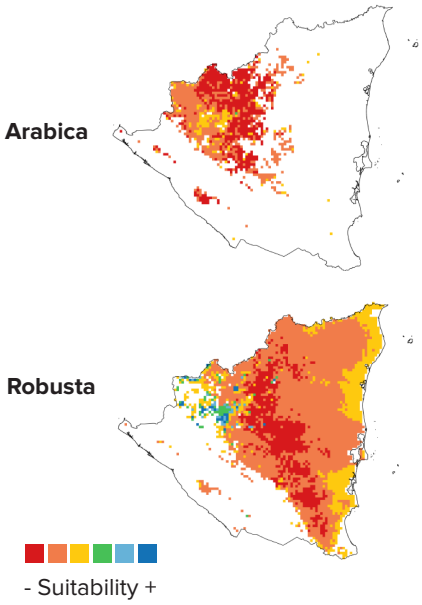
COFFEE PRODUCTION IN THE FACE OF CLIMATE CHANGE: **NICARAGUA**

KEY PRODUCTION AREAS IN NICARAGUA[5]



The main coffee regions are located in the north of Nicaragua, in the departments Nueva Segovia, Jinotega and Matagalpa.



Changes in suitability between today and 2050 [12]

OBSERVED AND PREDICTED EFFECTS OF CLIMATE CHANGE IN COFFEE PRODUCING AREAS [4,8,10,11]

Rising Temperatures

- Mean annual temperature rise of 2.2 °C by 2050.
- The mean daily temperature range will slightly increase.

Changing Seasonality

- The number of dry months will likely remain unchanged.

Changing Rainfall

- A decrease in annual rainfall in the range of 5-10% or around 100mm is expected
- Rainfall will continue to be erratic, likely with greater extremes.

Extreme Weather Events

- More frequent El Niño events will amplify drought, frequency of hurricanes and floods

LIKELY IMPACTS OF CLIMATE CHANGE ON COFFEE PRODUCTION

Predicted changes in coffee producing areas:

- At the moment, the optimum elevation for Arabica coffee is between 800 and 1400 m. This optimum is expected to shift to 1,200 – 1,600 m by 2050.[11]
- In Nicaragua, about 100,000 ha equivalent to over 80% of today's Arabica coffee growing areas will likely be unsuitable for Arabica by 2050. In most of these areas, farmers will have to transition to other crops, e.g. cocoa. However, about a quarter of the current coffee growing area may become unsuitable for other crops commonly grown in Nicaragua.[4]
- The drastic change in suitable land requires concerted and fast effort by government and development partners helping farmers to transition to other, more suitable crops and off-farm income.
- There is increasing interest from the private sector to plant Robusta coffee. At the moment, Robusta can only be established at least 30 kilometers away from Arabica plantations and below 400.[2]

THE IMPORTANCE OF COFFEE IN THE NICARAGUAN AGRICULTURAL SECTOR[1,2,3,4,13]

Coffee production and export in 2017/2018

- Arabica: 142,000 tons,
- Robusta: 2,000 tons
- 94% of coffee is exported as green coffee

Area under coffee production

Arabica
124,000 ha

Robusta
2,000 ha

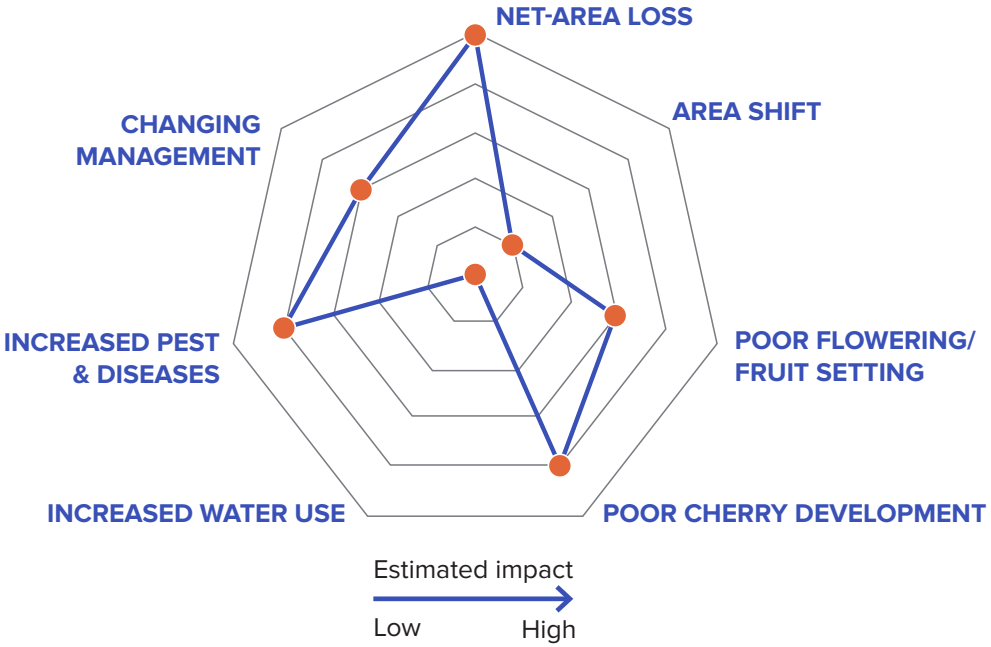
Farms

- 40,000 small-holders (~ 2 ha) manage 60% of the area.
- Larger farms (>14ha) dominate national production with 60% of total.

Importance in the national economy

Coffee:
- 20-25% of export revenues, and
- 7.2% of gross domestic product
- Is the largest export commodity and most important crop

LIKELY IMPACTS OF CLIMATE CHANGE ON COFFEE PRODUCTION



- Rising temperatures speed up the coffee ripening, leading to poorer cup quality.
- Pests and diseases, in particular, Coffee Leaf Rust and the Coffee Berry Borer will affect coffee at higher altitudes.
- Erratic rainfall at the beginning of the rainy season could cause inconsistent flowering and/or the abortion of flowers and cherries.
- Inconsistent flowering and ripening would likely prolong the harvesting season, causing additional costs.
- Hurricanes will damage coffee plantations and infrastructure.

PRODUCTION STANDARDS AND PRACTICES

CERTIFIED PRODUCTION

- 4-5% of coffee was certified as organic in 2009, mostly double certified with Fair Trade.[9]

FARM PRACTICES

- The majority of coffee is grown in agroforestry systems.
- 44% of the coffee area needs rejuvenation, replacing old plants susceptible to Coffee leaf Rust.[1]
- About 30% of farms practice integrated pest and disease management.[6]
- Input use is very low.[7]

FARM ECONOMY

- Average yield is 0.7 tons/ha.[2]
- Labor is the biggest cost factor with > 60%, followed by inputs with 24%. Labor migrates seasonally from other parts of the country.
- Many smallholders sell coffee through middlemen.[3] While Nicaragua is well placed for speciality coffee, farmers are not able to capture the price premium giving them little incentive to invest.[1]
- Cooperatives export about 20% of coffee.[3]
- Farmers receive about 68% of the export price.[3]

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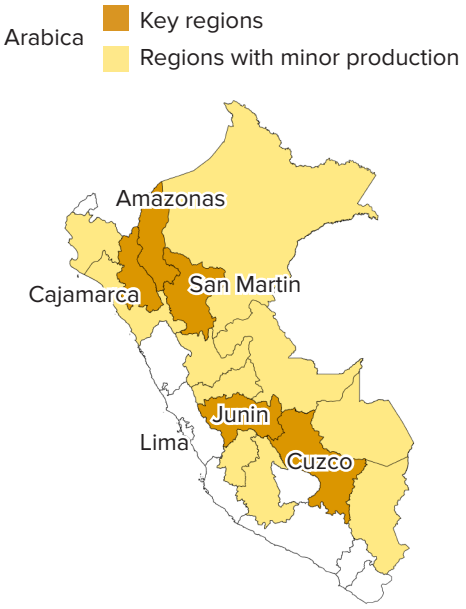
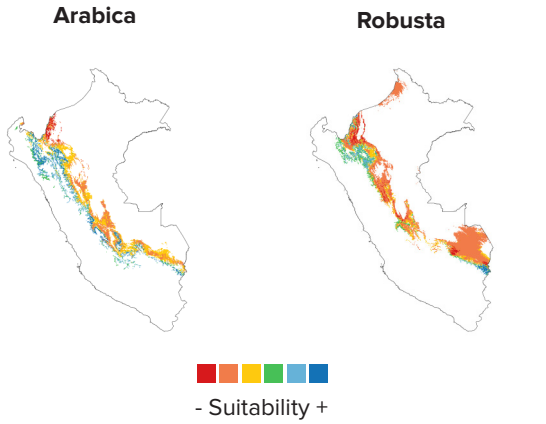
COFFEE PRODUCTION IN THE FACE OF CLIMATE CHANGE: **PERU**

KEY PRODUCTION AREAS IN PERU[9]



Over 60% of land cultivated with coffee is located in the regions of Cajamarca, Amazonas and San Martín.[11] About 65% of Peru's coffee is produced here.[9] Chanchamayo province in Junin region, is another important growing area, accounting for 16% of national production.[4]



Changes in suitability between today and 2050[15]

OBSERVED AND PREDICTED EFFECTS OF CLIMATE CHANGE IN COFFEE PRODUCING AREAS[7,8,10,11,12]

Rising Temperatures

- Temperature increases of 2-3°C and 4-6°C are projected for maximum and minimum temperatures respectively for 2050.

Changing Rainfall

- Large uncertainty regarding the frequency and strength of El Niño and its effect on climate
- Precipitation is expected to increase 100-170 mm in the Andes, with more rain in the wet season by 2050.

Changing Seasonality

- The number of dry months in the Andes is projected to increase from 1 to 2 months.

Extreme Weather Events

- More frequent wet years related to El Niño events in the Andes.

LIKELY IMPACTS OF CLIMATE CHANGE ON COFFEE PRODUCTION

Predicted changes in coffee producing areas:

- A study [11] focusing on the northern key coffee regions indicates that:
- Around 30% of coffee growing areas will remain suitable but would benefit from good agricultural practices to increase resilience.
- Circa 15% of the current area will require systemic adaptation to remain viable, such as new varieties, adjustments in shade management, and investments in technology and infrastructure.
- Farmers in the remaining areas should reduce reliance on coffee as their main source of income or shift to other crops altogether. In particular, farms below 1,000 m will be affected.
- Future suitable areas are found in the key production provinces, Cajamarca, Amazonas, and San Martín. Many of these areas are currently forested and protected áreas.[11] Between 2001 and 2016 coffee was the main driver of deforestation [16,17]. If not managed well, upwards expansion of coffee will continue past deforestation trends.

THE IMPORTANCE OF COFFEE IN THE PERUVIAN AGRICULTURAL SECTOR[1,2,3,4,5,6,14]

Coffee production and export in 2017/2018

- Arabica: 258,000 tons
- Export: 230,000 tons as green beans
- Domestic consumption is low and mainly in the form of soluble coffee

Area under coffee production

Arabica
385,000 ha

Farms

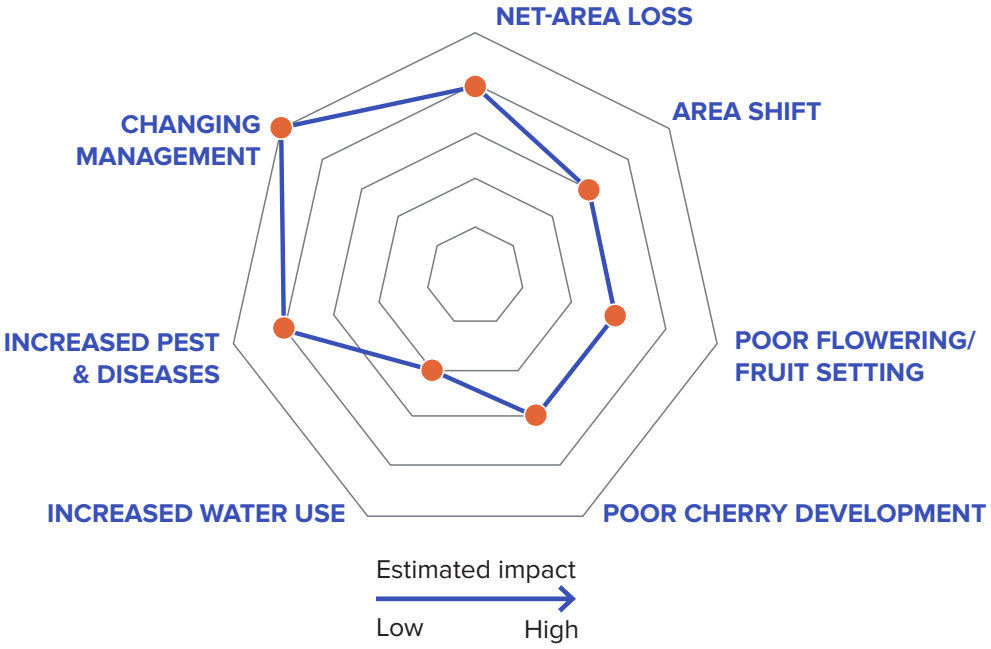
- About 60% of farmers are smallholders (132,000) with an average farm size of 2.3 ha

Importance in the national economy

Coffee generates:

- 2.6% of export revenues (2011)
- 0.6% of gross domestic product
- More than 850,000 jobs

LIKELY IMPACTS OF CLIMATE CHANGE ON COFFEE PRODUCTION



- Peru is already highly water stressed. Glacial retreat caused by climate change is likely to decrease water availability further.[7] This may compromise the potential for irrigation or the production of washed coffee.
- The appearance of new pests (e.g. Red Spider Mite, Leaf Miner) and incidences of existing pests and diseases were already observed and are expected to increase.[11]
- Higher temperatures may accelerate growth without proper maturation of cherries leading to a reduction of quality.[11]
- The shift to more resistant varieties may result in lower cup quality.[11]

PRODUCTION STANDARDS AND PRACTICES

CERTIFIED PRODUCTION

- In 2015, certification by major standards (Fair Trade, Organic, 4C, UTZ, Rainforest Alliance) covered at least 150,000 ha, likely more.[13]
- 73% of the production is considered organic, but not certified.[5]
- In 2015/16, 17% of coffee exports were certified.[14]

FARM PRACTICES

- Most coffee is shade-grown, with minor sun-grown production.[6]
- The main producers of organic coffee are farmers unable to purchase agro-chemicals.[2]
- Coffee is sun-dried and hulled on-farm.[4,5]
- At lower altitudes some farmers irrigate coffee.

FARM ECONOMY

- Average yield: 0.7 tons/ha.[4]
- Labor constitutes 80% of production costs.[5]
- Organic fertilizer (guano from Peru) is cheaper in Peru than in many other countries.
- Price premiums for organic coffee are low (≤ 40 USD/kg), not compensating for lower productivity.[4]
- Farmers receive 85% of the export price.[5]

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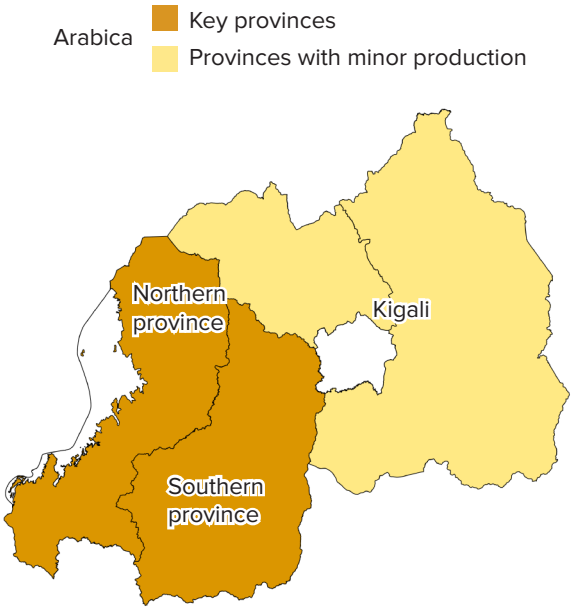
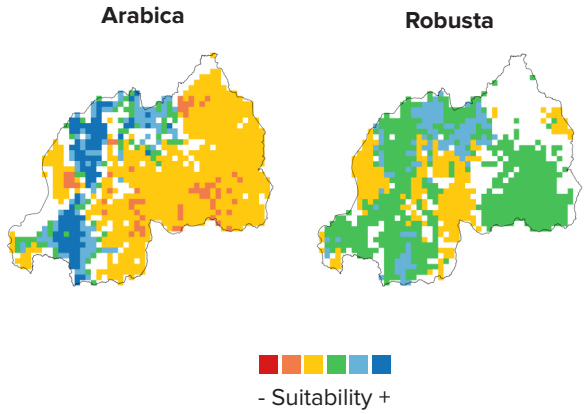
COFFEE PRODUCTION IN THE FACE OF CLIMATE CHANGE: **RWANDA**

KEY PRODUCTION AREAS IN RWANDA



Coffee is produced across Rwanda. Production is concentrated in the Southern and Western Provinces, especially around Lake Kivu. Most coffee is produced at elevations between 1,000 and 1,700 m.[10]



Changes in suitability between today and 2050 [17]

OBSERVED AND PREDICTED EFFECTS OF CLIMATE CHANGE IN COFFEE PRODUCING AREAS[9,10,11]

Rising Temperatures

- Predicted increase in annual mean temperature by up to 2.5°C by 2050.

Changing Seasonality

- Dry spells during the rainy season
- Drier dry seasons

Changing Rainfall

- Highly variable rainfall
- Predicted change for annual rainfall ranging from -100 mm to +400 mm for 2000-2050.
- Increased rainfall in parts of the western, northern and southern provinces and reduction in the Eastern and parts of southern province

Extreme Weather Events

- More heavy rainfall events causing floods, erosion and landslides in particular in the western half
- Increased frequency of prolonged drought in the south & southeast
- Extreme winds and hail in highland areas

LIKELY IMPACTS OF CLIMATE CHANGE ON COFFEE PRODUCTION

- Land suitable for Arabica coffee is predicted to shift from 400-2,000 m to 800-2500 m. Losses at lower elevations will theoretically be offset by increasing climatic suitability at higher altitudes.[15] However, highland areas are densely populated and contain natural forests which are partly protected. Moving coffee upwards would displace current land uses and cause deforestation.
- Coffee production is likely to be hit hardest in the Eastern Province, where droughts are more likely.
- Producers at lower altitudes could theoretically change to Robusta coffee. However, Rwanda's development strategy favors the production of high-value crops, including specialty coffee.
- An adaptation strategy, applicable to most of the current production areas is the establishment of shade trees or banana in coffee plots.

THE IMPORTANCE OF COFFEE IN THE RWANDAN AGRICULTURAL SECTOR[1,2,3,4,6,13,14]

Coffee production and export in 2017/2018

- Arabica: 15,700 tons
- Robusta: 500 tons
- 99% of coffee is exported, mostly as semi-washed and washed

Area under coffee production

Arabica & Robusta
42,000 ha

Farms

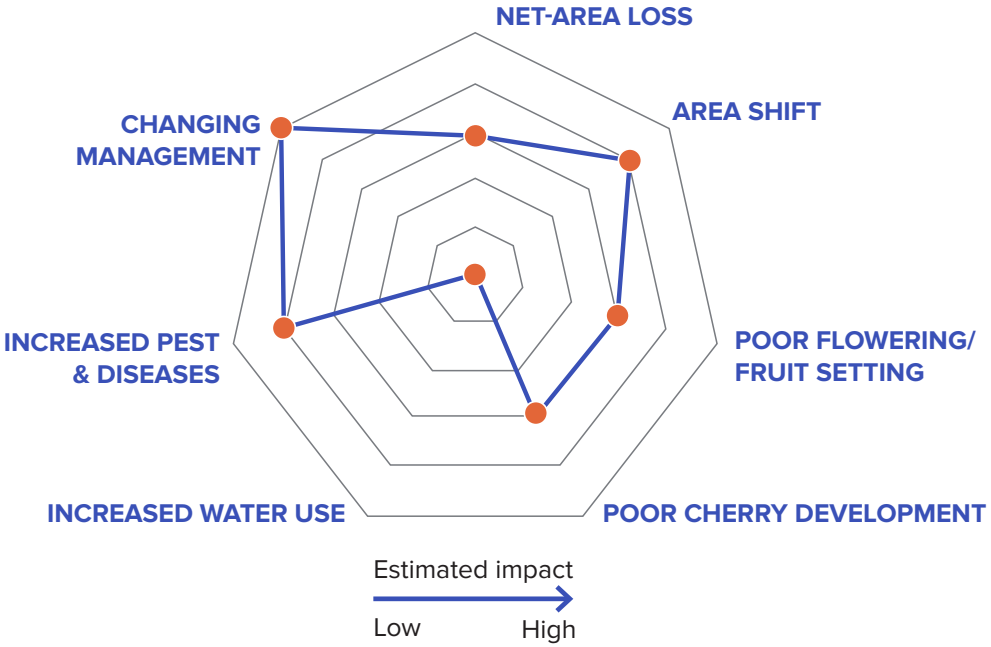
- 355,000 smallholder with average coffee farm size of 0.1 ha produce the majority of Rwandan coffee

Importance in the national economy

Coffee generates:

- 7.1 % of export revenues
- 1.4 % of gross domestic product

LIKELY IMPACTS OF CLIMATE CHANGE ON COFFEE PRODUCTION



- Higher temperatures will increase the altitudinal range of the Coffee Berry Borer, worsening the situation for producers who already face frequent losses by Coffee Leaf Rust and Coffee Berry Disease. Coffee Leaf Rust is likewise expected to affect coffee grown at higher altitudes.(8) Better pest and disease management, including rejuvenation with resistant varieties, is crucial throughout Rwanda.
- Erratic rainfall at the beginning of the rainy season and dry spells during the rainy season would affect flowering and cherry development.
- Heavy rainfall events, including hail, will cause floods, soil erosion, and damage crops. Shade trees and soil and water conservation measures can help to reduce damage.

PRODUCTION STANDARDS AND PRACTICES

CERTIFIED PRODUCTION

- About 30% of production is certified by UTZ/Rainforest Alliance and Fair Trade. Starbucks, Nespresso AAA and 4C are also present in Rwanda.[3]
- Certified exports are about 30% of certified production.[13]

FARM PRACTICES

- Coffee is cultivated in monoculture or intercropped with food crops.[4,12]
- Agro-chemicals are subsidized. However, input use, including organic, is low.[5,7]
- About 25% of trees are more than 30 years old.[5] The varieties cultivated in Rwanda are susceptible to all major pests and diseases.[2,16]
- Farmers sell fresh cherries to central washing stations owned by cooperatives and private sector.[7] Semi-washed coffee is processed at home.[3]

FARM ECONOMY

- The average yield is 0.4 tons/ha.[2,13]
- Labor (family and hired) is the biggest cost factor (78%), followed by inputs (15%).[7]
- Losses of up to 50% caused by Coffee Leaf Rust, Coffee Berry Disease, Coffee Berry Borer are common.[3]
- Farmers receive 69% of FOB value.[13]

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coffee & climate

CONSERVATION INTERNATIONAL

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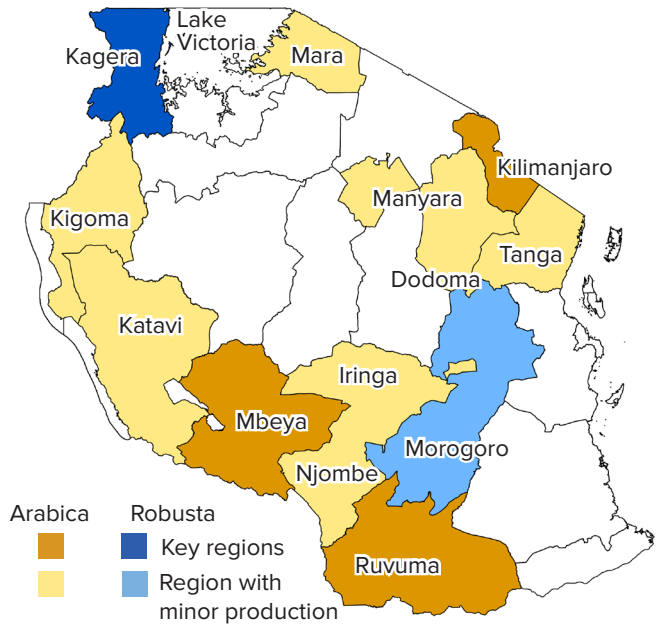
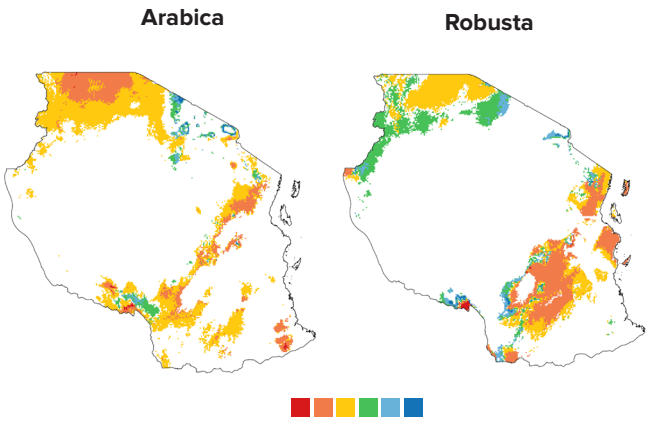
COFFEE PRODUCTION IN THE FACE OF CLIMATE CHANGE: **TANZANIA**

KEY PRODUCTION AREAS IN TANZANIA



The most important regions for Arabica coffee are the Southern Highlands and areas around Mt. Kilimanjaro. Robusta is predominantly grown in Kagera Region.



Changes in suitability between today and 2050 [17]

OBSERVED AND PREDICTED EFFECTS OF CLIMATE CHANGE IN COFFEE PRODUCING AREAS [8,10,12,16]

Rising Temperatures

- Mean annual temperature increase of 2.3°C by 2050.
- The daily temperature range is expected to decrease.
- Cold days and nights are expected to decrease to almost zero.*

Changing Seasonality

- Seasonality will be more pronounced, with wetter rainy and drier dry seasons (especially in the Southern Highlands).
- The cumulative number of dry months may decrease.

Changing Rainfall

- Annual precipitation is expected to increase by 48 mm by 2050. Increases are expected to be greatest in the Lake Victoria Basin (Kagera) and the north (Kilimanjaro, Arusha, Manyara).

Extreme Weather Events

- Heavy rainfall and flooding, and severe and recurring droughts are expected to increase due to increased frequency and intensity of El Niño cycles.

LIKELY IMPACTS OF CLIMATE CHANGE ON COFFEE PRODUCTION

Predicted changes in coffee producing areas:

- Currently the optimum for Arabica coffee is between 900 and 1,800 m. By 2050, the optimum is expected to be between 1,400 and 2,500 m. Nonetheless, the majority of the key Arabica areas (Kilimanjaro and Southern Highlands) are expected to remain moderately suitable. By 2050 land suitable for Arabica will likely be concentrated in these regions.[12]
- Suitability for Arabica below 1,200 m will likely be lost, constituting a decrease of about 20%.[13] Suitability gains at higher altitudes fall to a large extent in forested and protected areas, i.e. are to a large extent not available for coffee cultivation.[12]
- The most important Robusta coffee areas in Kagera are expected to remain suitable.
- Adaptation options for areas with decreasing suitability are the introduction of varieties with higher temperature tolerance, good agricultural practices to retain soil moisture and use of shade trees/banana. Irrigation may be an option in some cases but requires public investments into infrastructure, is likely not affordable for most farmers and may be restricted by overall water shortages.[16]

THE IMPORTANCE OF COFFEE IN THE TANZANIAN AGRICULTURAL SECTOR [1,2,3,4,5,11]

Coffee production and export in 2017/2018

- Arabica: 29,000 tons
- Robusta: 12,000 tons
- About 95% is exported

Area under coffee production

Arabica
210,000 ha
Robusta
55,000 ha

Farms

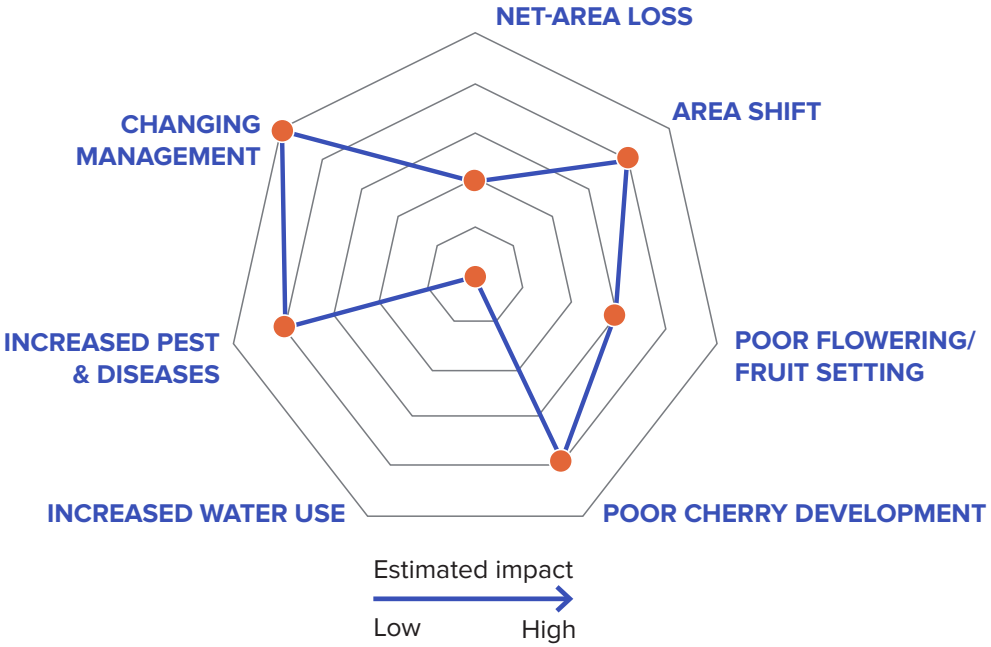
- 450,000 smallholders (~ 0.8 ha) produce about 90% of coffee

Importance in the national economy

Coffee generates:

- 5 % of export revenues
- 0.2 % of gross domestic product

LIKELY IMPACTS OF CLIMATE CHANGE ON COFFEE PRODUCTION



- Dispersed rainfall at the beginning of the rainy seasons/during flowering will lead to heterogeneous cherry development. Yield, harvesting, and processing will be affected.[9]
- The incidences of diseases (Coffee Leaf Rust, Coffee Wilt Disease) are expected to increase with rising temperatures and lower diurnal temperature range. Resistant varieties are available, but not yet widely adopted.[14]
- The coffee berry borer is found at higher altitudes today than previously. The upward trend of the pest is expected to continue.[15]

PRODUCTION STANDARDS AND PRACTICES

CERTIFIED PRODUCTION

- About 7% of coffee is exported as certified.[3]
- High costs of being standard compliant and low price premiums discourage farmer participation.[7]

FARM PRACTICES

- Coffee is grown in full sun in the Southern Highlands and intercropped with bananas (main crop) in the north-west.[4,8]
- The use of agrochemicals is limited across the country. In the Southern Highlands, adoption is slightly better.[5,8]
- About 70% of farmers grow old varieties with low pest and disease resistance.[5]
- About 45% of Arabica coffee is processed at central washing stations. The majority of the remainder is semi-washed. Robusta is sun-dried.[5,6]

FARM ECONOMY

- Productivity is low with estimates ranging between 0.2 tons/ha (Arabica & Robusta) to 0.5 tons/ha (Robusta).[1,11]
- Farmers receive 68% of the export price.[11]
- Production costs at farm level are relatively low. Due to the low yields, coffee farming is not very attractive.[3]

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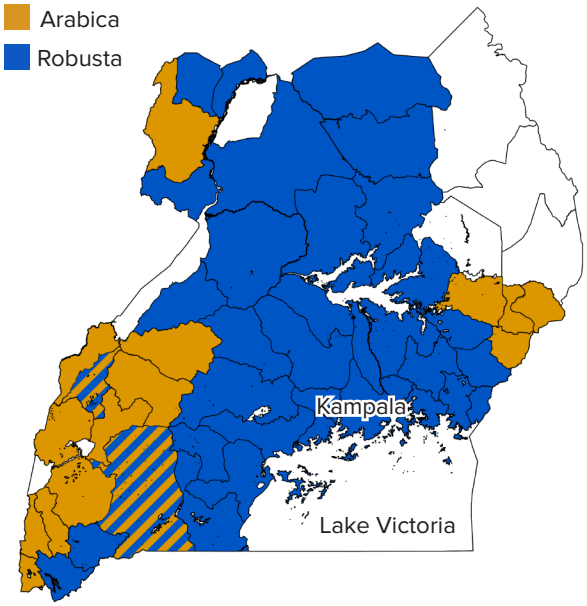
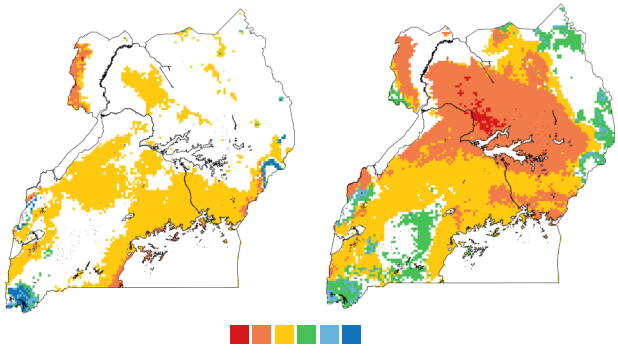
COFFEE PRODUCTION IN THE FACE OF CLIMATE CHANGE: **UGANDA**

KEY PRODUCTION AREAS IN UGANDA



Coffee is produced across Uganda. Most of the Robusta coffee is produced in a wide belt around Lake Victoria. Arabica coffee is restricted to the mountainous regions in the east and west of the country.[6]

Arabica **Robusta**



Changes in suitability between today and 2050 [18]

OBSERVED AND PREDICTED EFFECTS OF CLIMATE CHANGE IN COFFEE PRODUCING AREAS [9,10,11,13]

Rising Temperatures

- Average annual temperature is expected to increase by 1.5°C.
- Increase in hot days and nights.*
- Cold days and nights decreasing to zero.*

Changing Rainfall

- Rainfall amount and seasonality are strongly influenced by El Niño Southern Oscillation, making rainfall projections uncertain.
- Observed decreasing rainfall.
- Predicted slight increase in rainfall.

Changing Seasonality

- Delayed onset of the first rainy season in areas with bimodal rainfall, leading to a shorter season.

Extreme Weather Events

- Increase in the frequency of both high and low rainfall days causing floods and droughts.

LIKELY IMPACTS OF CLIMATE CHANGE ON COFFEE PRODUCTION

Predicted changes in coffee producing areas

- Loss of about 25% of land currently suitable for Arabica and limited potential for altitudinal migration[12]
- Net-loss of land suitable for Robusta and potential shift to higher altitudes and from the interior towards Lake Victoria[13]
- Coffee production is expected to reduce by 50%-75% due to loss of suitable land and decreasing yields[9]

*"Hot" or "cold" day/night is defined by the temperature above/below which 10% of days or nights are recorded in current climate.

THE IMPORTANCE OF COFFEE IN THE UGANDAN AGRICULTURAL SECTOR[1,2,3,4,5]

Coffee production and export in 2017/2018

- Arabica: ~ 70,000 tons
- Robusta: ~ 230,000 tons
- Almost all coffee exported as green beans
- Domestic consumption: 4%

Area under coffee production

- Estimated 350,000 ha, of which circa 30% is Arabica and 70% Robusta

Farms

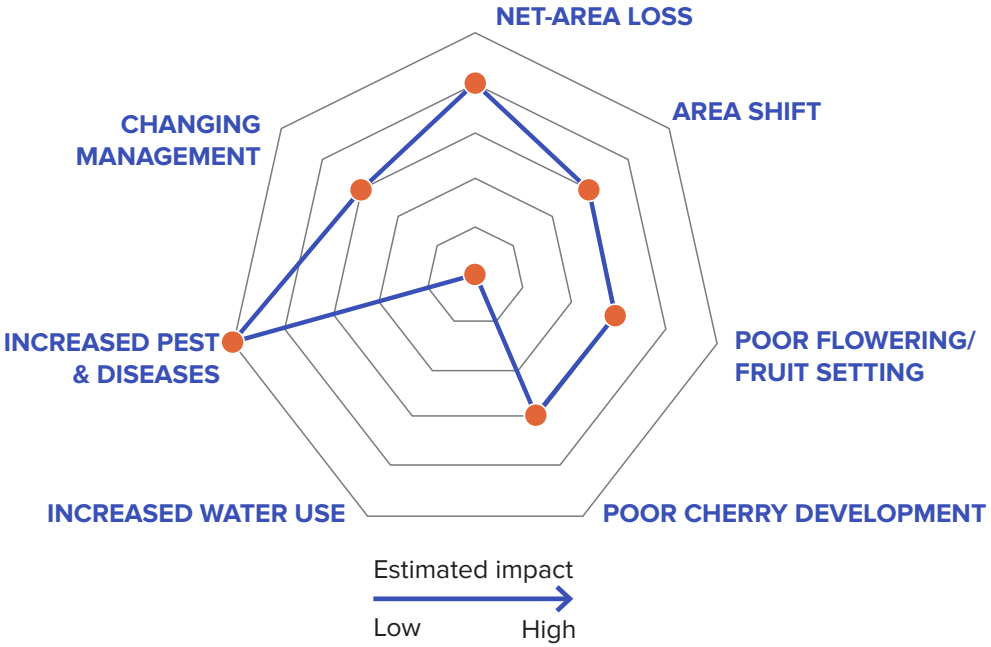
- 1.7 million smallholders with farms of 0.5-3 ha produce 85% of coffee

Importance in the national economy

Coffee Generates:

- 25% of export revenues
- 2% of gross domestic product
- Most important agricultural commodity by value

LIKELY IMPACTS OF CLIMATE CHANGE ON COFFEE PRODUCTION



- Increased occurrence and damage from leaf miners, mealy bugs, Coffee Leaf Rust, Coffee Berry Borer and Coffee Bacterial Wilt are observed and are likely related to climate change.[8,14]
- The Coffee Berry Borer is expected to complete up to 10 life cycles per year by 2050 versus the 1-5 cycles currently.[15]
- In particular at lower altitudes (≤ 1,300m) abortion of flowers and poor filling of cherries is expected.

PRODUCTION STANDARDS AND PRACTICES

CERTIFIED PRODUCTION

- Approximately 20% of coffee produced is certified according to sustainability standards.
- Only 3% of coffee is exported as certified coffee.

FARM PRACTICES

- Smallholders usually intercrop coffee with food crops.
- Coffee is frequently cultivated under shade from banana or trees.
- Low input use: farmers use insufficient fertilizer due to high cost and limited availability.
- About 70% of coffee trees are more than 40 years old.[2]
- About 50% of coffee Arabica is washed [3]

FARM ECONOMY

- Low cost production using family labor. The biggest cost items are fertilizer (46%) and harvest (22%).
- Low yields with an average of 0.6 tons/ha.[7]
- Farmers receive an estimated 75% of the export price.[2] However, many farmers sell coffee before it is harvested at prices well below regular market price.[7]
- On average, coffee is grown on 20% of farm but generates > 50% of income.[3]

CLIMATE CHANGE ADAPTATION:

STRENGTHS

Technical aspects

In Uganda, many farmers traditionally cultivate coffee in combination with banana. Research shows the beneficial aspects of the coffee-banana agroforestry-system with regard to climate change adaptation and resilience of farming households. Details on the coffee-banana system are provided below.

A detailed training manual for coffee farming is available from the Uganda Coffee Development Authority. The manual was developed and tested together with Ugandan research institutions, NGOs, and private sector.

Organizational aspects

The coffee sector is fully liberalized, making the supply chain efficient and allowing direct interaction between producers and exporters. However, trade is dominated by agents and brokers at aggregator level.

Uganda has sub-sector specific government bodies, the Uganda Coffee Development Authority and the National Coffee Research Institute, working closely with other researchers, the private sector, development partners, and NGOs to develop the coffee sector in Uganda.

Supported by the private sector, development partners and NGOs, producer organizations for about 250,000 coffee farming households were established to date. The producer organizations and the related national apex organizations: the National Union of Coffee Agribusinesses and Farm Enterprises and the Uganda Coffee Farmers Alliance provide marketing and other support services. Producer organizations help to close the gaps left by the national extension system.

Political aspects

Coffee is a very important agricultural sub-sector in the Ugandan economy. This is reflected in the existence of dedicated government institutions and a regularly updated coffee policy. The target of the Coffee Road Map, developed in 2017, is to quadruple coffee production by 2030. The planned measures are geared towards increasing productivity and area under coffee cultivation amongst others.

OPPORTUNITIES

Technical aspects

Robusta coffee is native to Uganda, giving researchers an advantage in breeding new varieties with high productivity suited to the changing climatic conditions and with higher resistance to pests and diseases.

Disease resistant varieties (e.g. Coffee Wilt Disease) and technologies to control pests (e.g. Black Coffee Twig Borer) are available. However, their multiplication and uptake requires concerted effort by all stakeholders. A positive example is the multiplication of new varieties by private sector nurseries.

Economic Aspects

Uganda is Africa's biggest producer and exporter of Robusta coffee. The potential to sustainably increase production of Robusta is significant despite the anticipated climatic changes if producers invest into better management practices that increase productivity and resilience to climate change.

Management measures with adaptive benefits (rejuvenation with new varieties, soil nutrient management and planting of shade trees) could double the net-income of farmers by increasing productivity.

Organizational aspects

Less than one fifth of coffee farmers are affiliated to producer organizations. For more farmers to benefit from services provided by producer organizations, investments into organizational development are needed. In the long run, services provided by producer organizations will reduce the burden on government extension services.

WEAKNESSES

Technical aspects

The uncertainty of climate models for Uganda is high. As a result, planning for climate change adaptation is difficult. Options range from no/limited need for interventions over targeted investments into climate-smart coffee production to a shift to other, more suitable crops in current coffee growing areas.

The accessibility of quality agro-inputs, including improved coffee varieties, is low for smallholder farmers.

Little basic research on the genetic diversity of Robusta coffee in Uganda is available, limiting the potential for the development of new varieties.

Economic aspects

Many farm households rely on pre-selling their coffee crop to cater for urgent financial needs such as school fees or hospital bills. Coffee pre-sold to agents and brokers is commonly sold well below market value, reducing the financial appeal of coffee farming and the likelihood of investments into better management.

Due to the small quantities produced per farm and low penetration of farmer organizations, certification in Uganda is expensive. Furthermore, only a fraction of the certified coffee is exported as certified coffee, implying low demand for certified [Robusta] coffee. Premiums paid for certified coffee, especially Robusta, are too low to be an incentive for additional investments. Hence, certification is an unlikely tool for scaling of sustainable production methods.

Organizational aspects

The government extension system and advisory services are inadequate. Despite past and ongoing efforts, the government is not able to ensure the quality of agro-inputs available in the market.

Only about 15% of coffee farmers are members of producer organizations [2]

Political aspects

The target to quadruple coffee production by 2030 set by political leaders is not realistic, and may, in fact undermine the sustainable development of the sector as decisions are taken and investments made without adequate consideration of the technical and financial feasibility. The necessary instruments, like incentives or subsidies for the adoption of new technologies, are not in place.

THREATS

Technical aspects

The upwards shift of land suitable for Arabica coffee may lead to increased pressure on the forests and protected areas located in these areas.

Economic aspects

Coffee farming is dominated by the oldest household members. Agriculture is often not perceived as an attractive livelihood by younger family members. Household heads are reluctant to share responsibility for and benefits of the cash crop with other household members. This often results in income loss at the household level, and lower ability and willingness to invest into quality and productivity.

Political aspects

Forests in Uganda are poorly protected, a fact illustrated by the high deforestation rate of 2% per year for the period 2000-2015. Agriculture is one of the key drivers of deforestation. The genetic biodiversity of Robusta coffee is under threat from deforestation and forest degradation.

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Coffee-banana intercropping systems are traditional farm management systems in south-western and eastern Uganda. Here, an estimated 75% of farmers intercrop coffee and banana on at least part of their coffee farm.[16] But a large share of coffee farmers in central and western Uganda do not intercrop their coffee with banana and do not have adequate shade trees on their coffee farms.

Correctly established and managed, coffee-banana intercropping systems can deliver an increase in food security and income, improve climate resilience, and provide climate change mitigation benefits.[8]

Intercropping coffee with banana has some straightforward benefits:

• The in-situ mulch from the banana improves soil fertility and structure and suppresses weeds.
• The mulch and banana canopy help to reduce soil erosion.
• Banana (bearing fruit after 1 to 1.5 years) planted together with coffee can offset cash flow constraints in the first few years, i.e. before coffee starts yielding.
• Once established, banana provides regular income throughout the year, while coffee results in larger cash amounts once or twice per year.

Specific adaptation and mitigation benefits of integrating banana into coffee gardens are:

• Regulation of micro-climate by providing shade for coffee trees within one year after planting
• Improved water retention capacity of soil
• Increased ability to withstand drought
• Additional carbon sequestration in the above and below ground biomass and as soil carbon.

Furthermore, the combined system contributes to household resilience by diversifying income and leveling out irregular cash flows in comparison to coffee mono-cropping. Household food security benefits directly (consumption of bananas), as well as indirectly from increased purchasing power.

Research of the coffee-banana intercropping system shows that:[8]

• Intercropping with banana has no significant negative impact on coffee yield in comparison to coffee as a mono-crop. On the contrary, total income can be 50% higher in comparison to banana or coffee monocrops, while having a positive effect on coffee quality.
• While bananas are quite sensitive to drought, they are also more efficient at regulating than many shade trees. This allows banana to remain hydrated under drought stress and compete less for water with the coffee plants than some other shade trees.
• Some agroforestry tree species are known to be secondary host to coffee pests and diseases such as Coffee Leaf Rust and Black Coffee Twig Borer. In banana shaded coffee plots, incidences of these were found to be 50% less compared to tree-shaded systems.

The coffee-banana intercropping system is especially viable for small farms in densely populated areas, i.e. where land is limited but labor readily available.

Some constraints to a wider adoption of the system exist:[8,16]

• Diseases like Coffee Wilt Disease or Banana Bacterial Wilt have wiped out one of the two crops completely in some cases. Reestablishing the system requires access to disease-resistant varieties and the ability to invest.
• To sustain high productivity, a combination of mineral fertilizer, manure, and compost is needed.
• To yield optimal results, coffee-banana intercropping systems must be adjusted to the specific sites, i.e. recommendations must be flexible.
• The management requires knowledge on how to regulate competition for water, nutrients, and light between the two crops, application of fertilizers and organic nutrient inputs, and practicing soil and water conservation.

A detailed manual for trainers/extension officers is available Banana-coffee system cropping guide.[17]

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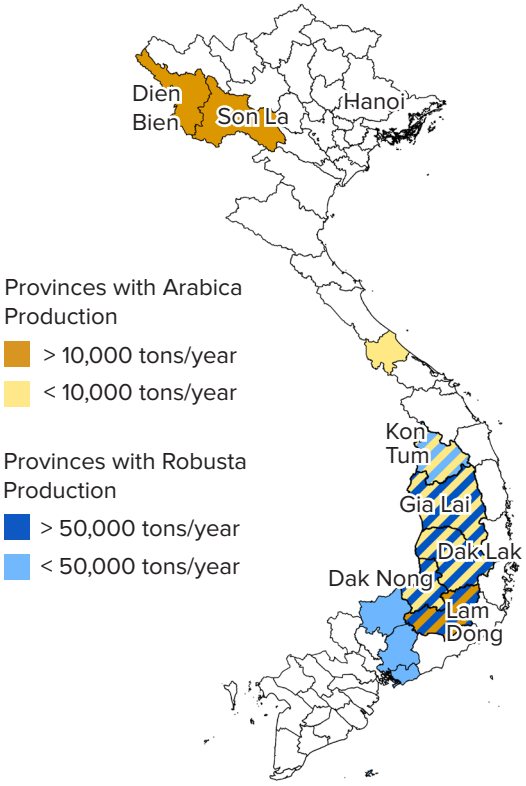
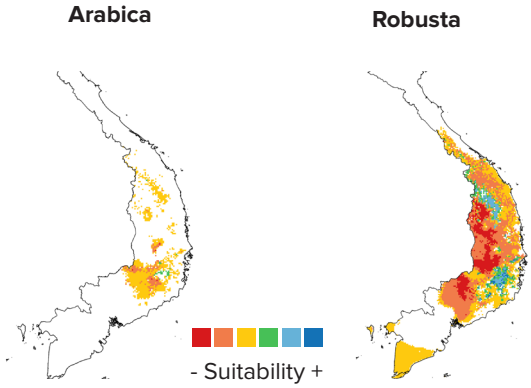
COFFEE PRODUCTION IN THE FACE OF CLIMATE CHANGE: **VIETNAM**

KEY PRODUCTION AREAS IN VIETNAM



About 90% of coffee is produced in the Central Highland provinces Dak Lak, Lam Dong, Dak Nong and Gia Lai.[2]



Changes in suitability between today and 2050 [7]

OBSERVED AND PREDICTED EFFECTS OF CLIMATE CHANGE IN COFFEE PRODUCING AREAS [6,7,8,9,10]

Rising Temperatures

- Annual mean temperature expected to increase by 1.8°C by 2050
- Increase in hot days and nights and decrease in diurnal temperature range

Changing Seasonality

- Longer rainy season
- More days with very little rain in the dry season

Changing Rainfall

- Slight increase in rainfall, with more rain in the wet and less rain in the dry season

Extreme Weather Events

- More frequent heavy rainfall events in the wet season
- Droughts becoming more frequent and intense

LIKELY IMPACTS OF CLIMATE CHANGE ON COFFEE PRODUCTION

Predicted changes in coffee producing areas:

- Over 20% of the area suitable for Arabica coffee today is expected to become unsuitable by 2050.[8]
- The altitudinal range for Robusta cultivated in the Central Highlands will likely shift from today's 300-900m to 600-1,000m by 2050. Suitability below 550m will decline sharply.[10]
- The loss of suitable area for Robusta will be biggest in Gia Lai and Dak Lak the provinces, with about 30% of the currently suitable area. Lam Dong and Dak Nong will remain suitable, with higher areas becoming more suitable.[10] However, these areas are likely forested or used for other crops, i.e. not available for coffee.
- Overall, about 100,000 farmers may have to have to transition to other crops. Adaptive measures on the remaining land require additional investments.

THE IMPORTANCE OF COFFEE IN THE VIETNAMESE AGRICULTURAL SECTOR [1,2,3]

Coffee production and export in 2017/2018

- Arabica: 90,000 tons
- Robusta: 1.68 million tons
- 90% exported in the form of green beans

Area under coffee production

Arabica
90,000 ha

Robusta
600,000 ha

Farms

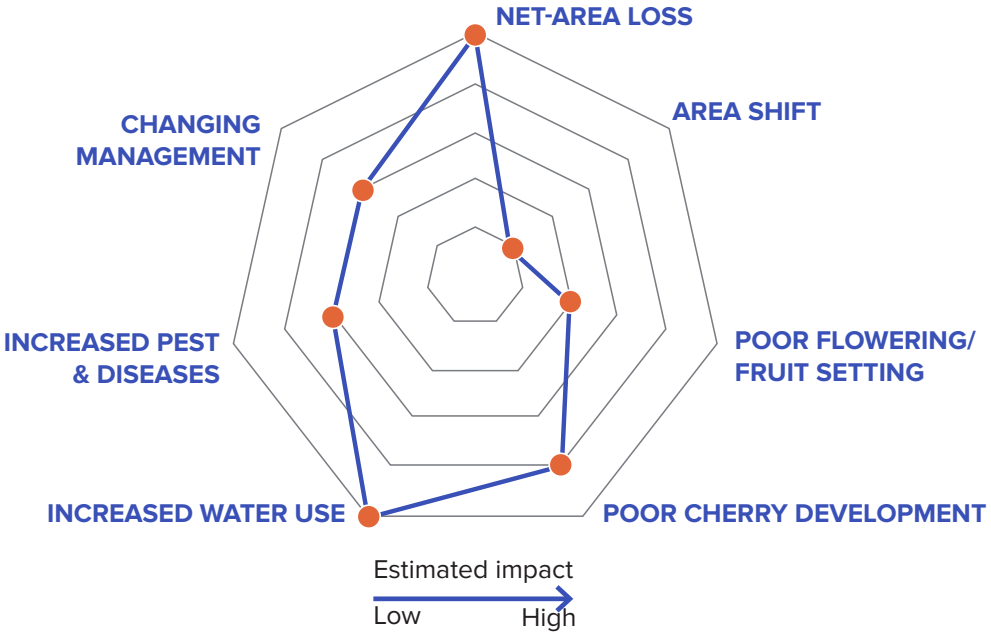
- 600,000 smallholders (~ 1ha) produce 95% of coffee

Importance in the national economy

Coffee generates:

- 1.5% of export revenues
- 3% of gross domestic product
- Is the 2nd most important agricultural commodity

LIKELY IMPACTS OF CLIMATE CHANGE ON COFFEE PRODUCTION



Water demand for irrigation under business as usual is expected to increase times, leading to: [12]

- Reduced stream flow and seasonal depletion of aquifer.
- Water shortages are forecasted every 5 years and acute shortages every 10 years.
- Rainfall late in the dry season may hinder pollination, causing reduced and heterogeneous fruit setting.
- The prolonged wet season can make sun-drying difficult and lead to reduced quality unless farmers invest into drying facilities.
- Rising temperatures result in additional life cycles of the Coffee Berry Borer.
- The lower diurnal temperature range creates more favorable conditions for Coffee Leaf Rust, allowing the fungi to spread faster, causing more damage.[6]

PRODUCTION STANDARDS AND PRACTICES

CERTIFIED PRODUCTION

- More than 25% of producers are certified according to sustainability standards: 4C, UTZ/Rainforest Alliance.
- Only 10% of coffee is exported as certified.

FARM PRACTICES

- Coffee is cultivated in mono-cropping and with Black Pepper. Shade trees rarely exist.
- Farmers rely heavily on fertilizer and irrigation - often using too much.
- An estimated 50% of irrigation needs are covered from groundwater. Water is pumped from private wells and without any control of quantity used.[4]
- Coffee cherries are mostly sun-dried.

FARM ECONOMY

- Yields are high with an average of 2.4 tons/ha.[3]
- Low cost production using family labor.
- The biggest cost items are fertilizer (46%), harvest (22%) and irrigation (13%; includes labor and energy, water is free).[5]
- Farmers receive an estimated 95% of the export price, the highest share worldwide.[3]

CLIMATE CHANGE ADAPTATION:

STRENGTHS

Technical aspects

The potential of using less water without compromising yield has been proven by science and early adopters.

Ongoing research focuses on more precise weather forecasts, groundwater availability and managed aquifer recharge.

Good practice manuals for coffee provide common guidance for all extension service providers (national, private, project), including key practices such as saving water in irrigation and prudent use of agro-chemicals.

Economic aspects

Field trials and past projects prove the economic and environmental benefits of using less but high-quality fertilizer and reduced water use.

Organizational aspects

Various projects and private sector already promote good agricultural practices which have climate change adaptation benefits.

Government agencies and parastatals are actively promoting sustainable development through research, plant breeding, and concessional finance.

The Vietnamese Coffee Coordination Board provides an important platform for coordination within the sub-sector and across ministries.

Political aspects

Political will for adjustments in the sector exists, expressed e.g. in the Master Plan for Agricultural Production Development, the Nationally Determined Contribution to climate change mitigation and adaptation, and the National Action Programme on REDD+:

- Promoting improved irrigation technologies and supporting farmers in coffee renovation
- Modernization of the hydro-meteorological observation system and forecasting technology
- Further expansion of agriculture into current forest land is expected to be minimal with REDD+ implementation

OPPORTUNITIES

Technical aspects

About 50% of the coffee growing area is stocked with old trees.[4] These can be gradually replaced with more suitable varieties.

Economic aspects

High-value crops such as Black Pepper and fruit trees are suitable for intercropping, helping to diversify farm income.

The potential to reduce cost and increase yield by adopting best irrigation and fertilization practices is a viable incentive for farmers.

Organizational aspects

The establishment of wells and the use of water resources concerns everyone within a given farming community. The potential to establish community-based monitoring systems ensuring equitable and sustainable use of water should be explored.

Existing integrated/landscape level approaches, e.g. as described in the "adaptation highlight" for Vietnam, can be up-scaled / transferred to other regions.

Political aspects

Continue the ongoing research and expansion of monitoring infrastructure to further improve the knowledge framework for adaptation and mitigation.

WEAKNESSES

Technical aspects

The vulnerability of coffee farmers to climate change is emphasized by mono-cropping and high dependency on irrigation.

Over 20% of coffee farms were established on unsuitable or only marginally suitable land, leaving no room for improvement through adaptive measures. In some locations, the share of coffee farms established on unsuitable land is much higher.[4,13]

Poor agricultural practices (e.g. incorrect/excessive use and poor synchronization/quality of fertilizers and irrigation, and the absence of shade trees) leads to soil acidification, and higher rates of evapotranspiration. Degraded soils are associated with lower yields and infestation by Nematodes.

Organizational aspects

Information on soil and water resources is very limited, as is the infrastructure for testing of nutrient content of soil and leaves. The absence of information contributes to the excessive use of water and fertilizer by coffee farmers.

Low level of organization amongst farmers poses a barrier against collective action (e.g. investments in drying facilities or harmonized use of water at micro-watershed level).

Political aspects

Regulations on water use and the establishment of wells are not enforced. Water for irrigation is free of charge, resulting in little interest to reduce water use.

Improved irrigation technology in combination with optimal land allocation (i.e. replacing coffee grown on unsuitable land with crops or land uses suitable to these locations) would result in substantial reserves of groundwater resources in many areas even in drought years.[15] However, at the moment the commitment from government to plan for and implement landscape-level action outside donor funded projects is limited.

THREATS

Technical aspects

For some impacts of climate change (reduced pollination due to rain during flowering) viable solutions do not yet exist. Where these impacts are very high, coffee farming may cease to be viable.

Economic aspects

Farmers may resist change to more suitable crops, agroforestry systems and renovation of coffee farms due to the likely short to medium term loss of income before new crops and coffee trees reach maturity.

Viable markets/market access for new or additional crops may not exist, especially for products without strong internal demand, relatively low production volume (high cost of aggregation) or not qualifying for international standards.

Coffee renovation on (degraded) soils infested with nematodes might be more costly/slower than anticipated.

Organizational aspects

Concepts or strategies for farmers having to exit coffee farming because of climate change do not exist, potentially resulting in increasing pressure on non-farm land to compensate for declining yields and/or loss of livelihoods.

Sensitization and training of all farmers are expensive. To cover this cost and reach all farmers in a short time, private and project-based extension providers/programs are needed but may not be available.

IMPROVING WATER USE IN COFFEE IRRIGATION IN VIETNAM

In the Central Highlands, water for irrigation is sourced from reservoirs (ca. 20%), rivers (ca. 28%) and groundwater. Groundwater is pumped from privately owned wells. In the Central Highlands, the biggest coffee growing area in Vietnam, more than 70% of the locally available water resources are used for agricultural production every year. In times of drought, water resources are sometimes depleted well before the end of the dry season (e.g. in 2005/06, 2009/10 and 2015/16). Impacts are not just felt by farmers but also by other businesses and domestic users. Reported production losses for coffee only in years of drought are in the range of 20% to 25%.

Coffee in the Central Highlands is irrigated two to four times, depending on the on- and offset of the wet season and sporadic rainfall during the dry season. Farmers often use more than double the amount of water needed, accelerating the seasonal depletion of water resources. Access to water and the period over which ground water is available from the shallow aquifer varies strongly within watersheds. Farmers in the upper areas and slopes of the watershed will experience water deficiency first, especially if groundwater resources are tapped excessively.

Research[5] and field trials proved that water use can be reduced from the frequently more than 1,000 liters used per tree and round of irrigation to less than 400 liters per tree and round of irrigation. With the adjusted irrigation regime, yields of three to four tons per hectare (1,100 coffee trees), i.e. well above the current average production, can be achieved. The research findings resulted in an adjustment of irrigation standards by the Ministry of Agriculture and Rural Development in 2013 to use between 400 and 500 liters per tree and round of irrigation.

Farmers can implement the improved irrigation regime without any additional cost, i.e. continue to use micro-basin irrigation. Pivot irrigation, another common system is 44% less efficient[11]. Full adoption of the standard would result in cost savings at the farm level and reduce water use by about 30%. The water footprint per kilogram green bean can be reduced from currently about 5.500 l/kg to about 3.800 l/kg.[16]

An example of the ongoing interventions, the “More Coffee With Less Water” project, focuses on improving water management. The project provided important evidence for decision makers, developed concrete tools for farmers, and explores additional measures which may help to mitigate water shortages:

- A hydrogeological study for Dak Lak shows the impact of current irrigation practices versus improved practices on water resources. A pilot for groundwater monitoring was established, providing further details on the impact of excessive water use versus best practice.*
- Led by Hanoi University, an improved weather forecasting service was established. More precise forecasts together with detailed but practical management guidelines can help farmers to fine-tune irrigation and application of agro-chemicals.*
- Together with the International Water Management Institute, the project explores the potential for managed aquifer recharge. The technology may help to extend the duration of groundwater availability throughout the dry season.

**Farmers can access a manual for good agricultural practices and the weather forecast via smart phone.*

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