academicJournals

Vol. 12(19), pp. 1607-1611, 11 May, 2017
DOI: 10.5897/AJAR2017.12147
Article Number: 4F5E4B864137
ISSN 1991-637X

http://www.academicjournals.org/AJAR

African Journal of Agricultural Research

*Review*

# Impacts of climate change on global coffee production industry: Review

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Received 11 January, 2017; Accepted 4 April, 2017

**Next to petroleum oil, coffee is the most internationally transacted commodity in the world; consumers from all around purchase and enjoy coffee in their daily activities. Climate change has emerged in recent years as one of the most critical topics at almost all actors. The impact of climate variation in all producing countries is predicted to be negative, even though within each country, it would vary a lot. Temperature and rainfall conditions are considered to be important factors in defining potential coffee yield. Both factors interfere with the crop phonology, and consequently in productivity and quality. Coffee supply chains are likely to experience significant disruption due to climate variation over the next forty years. World population would rise to nine billion by 2050 and in this scenario, coffee production is also likely to decrease globally. Coffee price varies inversely with production changes and generates the largest price increase. To overcome these problems, the mitigation of global warming involving taking actions to reduce greenhouse gas emissions is an important option.**

**Key words:** Climate variation, coffee price, coffee yield, world population.

## INTRODUCTION

Coffee is one of the legal international transacted commodities of many countries following petroleum oil, consumers from all around purchase and enjoys it in their daily activities (Iscaro, 2014). In addition, Davis et al. (2012) identified during their study, that coffee is the second most transacted goods in the world. In the world, Brazil is the leading coffee producer and exporter followed by Vietnam and Colombia (DaMatta et al., 2008). In countries such as Uganda, Burundi, Rwanda and Ethiopia, coffee is the most source of revenue of their societies since the crop is the main trade commodities of these countries with global trade sales predictable as US$ 90 billion (DaMatta et al., 2008). Among coffee species, only two species, Coffea arabica L. (Arabica coffee) and Coffea canephora (Robusta coffee) economically dominate the world coffee trade (ICC, 2009; Damatta and Ramalho, 2006). Predominately, Arabica represents 70% of global coffee production and Robusta represents about 30% (Damatta and Ramalho, 2006; Davis et al., 2012). The production and productive of both species are largely dependent on the climate for attain high yields and quality (Killeen and Harper, 2016).

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Most evidence shows that climate change has appeared in recent years and immediately change common perception of many people in few years, makes looking forward the serious topics of all stake holders (Dasaklis and Pappis, 2013). Since early 1900s Climate variation has been perceived and the causes usually anthropogenic and natural drivers of climate (Masters et al., 2009). The effect of climate variation on natural systems has begun as one of the most critical issues of humankind (Jaramillo et al., 2009). Many finding proof that weather alteration is hastening at ample quicker stride than earlier that leading to irreversible changes in major earth systems and ecosystems (ITC, 2010).

According to Kasterine et al. (2010), key cause of the climate change is the burning of coal, oil, natural gas and mineralization of organic matter; these lead to increase in the carbon dioxide ($CO_2$) content of the atmosphere. Carbon dioxide ($CO_2$) and methane ($CH_4$) are the most greenhouse gases that influence global climate through emissions (Masters et al., 2009). Most times, the climate change is felt through changing climate weather such as when the rainy season does not start when it is forecasted to rain, dry season lasts longer than usual, rains too much and causes flood, temperature becomes much colder or hotter than usual (Enomoto et al., 2011). This climatic variability has always been the main factor responsible for the reduction of coffee yields in the world and determines the future coffee production status in the coffee producer's countries (Kasterine et al., 2010).

Coffee requires very specific environmental conditions for successful production, depending on the coffee variety grown. But the crop is perennial, tropical crop that can grow under both humid lowlands and tropical humid/sub humid highlands. Even though the average temperatures required for coffee Arabic range between 15 and 24°C, rain fall 2000 mm per annum and altitudes between 1000 and 2000 m above sea level. Robust coffee required average temperature range between 24 and 30°C, rainfall ~2,000 mm and altitudes of about 800 m above sea level (Killeen and Harper, 2016). The objective of this review paper is to review the impacts of climate change on global coffee production industry.

## LITERATURE REVIEW

### Climate change and coffee production

Most scholars agree that the regular territories of the genus of Coffea are the under storey of African tropical forests (DaMatta et al., 2008). According to Haggar and Schepp (2011), result show Arabica coffee originated in south west Ethiopia in East Africa at altitudes ranging from 1,500 to 2,800 m, where weather climate shows little seasonal. While R. coffee originated from lowland forests of the Congo River basin; with extend up to Lake Victoria in Uganda (Haggar and Schepp, 2011). Climate factors such as solar radiation and relative humidity influence many physiological processes of the coffee tree but are not generally thought to play an important role as thermal and rainfall conditions in defining potential yield or ecological limitations for this crop (Camargo, 2010).

Overall, influence of weather variations on coffee producing countries are predicted to be negative (Ovalle-Rivera et al., 2015). Some countries would lose area suitability while others would gain from variation in weather elements Ovalle-Rivera et al. (2015). Ovalle-Rivera et al. (2015) reveals coffee producing arears such as America, Africa, Asia and Oceania would maintain some suitability for growing Arabica coffee.

### The coffee sector and climate change

Coffee sectors contain huge ramification, includes growers, producers' associations, pulpers, buyers, certification agencies, wholesalers, transporters, retailers, roasters, exporters and consumers (Lossau, 2010). Coffee is the world's most important tropical export crop but recent studies predict severe climate change impacts on Coffea arabica (C. arabica) production (Craparo et al., 2015). The predicted decrease in profitability and greater economic risk of coffee production may locally and temporarily have positive environmental impacts, but overall and over the longer term these impacts will likely be severe and negative (Schroth et al., 2009). According to Potts (2003), identified global coffee production and trades were under risk because of declining forests spp.; water contamination, diminishing biodiversity to persistently uncertain revenues and makes currently an imperfect market in action.

Many scientific justifications predicted coffee sectors are likely affected due to climate variation over the next forty years (Killeen and Harper, 2016). According to Killeen and Harper (2016) reveals coffee production area changed because suitable areas becomes too warm or prone to periodic drought (Killeen and Harper, 2016). Most suitable area becomes unsuitable because of climate variation (Dekens and Bagamb, 2014). The reduction of land suitable for coffee production will influence the world coffee market and increase the price of coffee (Haggar and Schepp, 2011). The influence of this climate variation makes the farmers to be indebted, reduce ability to invest in production and reduce their income generation (Läderach et al., 2010). About 70% of the world's coffee is produced by small-scale farmers, with over 20 million coffee farming families equivalent to more than 100 million people depending on its production for their subsistence (Vega et al., 2003). The climate variations affect coffee industry from production to export (Dekens and Bagamb, 2014). World population will rise to nine billion by 2050 and in this scenario, coffee production is also likely to decrease globally, particularly in Africa and generate the largest price rises

(International Coffee Council, 2009).

## Influence of climate variation on coffee production

### *Influence of weather variation on biodiversity*

Observed changes in climate have already adversely affected biodiversity at the species and ecosystem level, and further changes in biodiversity are inevitable with further changes in climate (Secretariat of the Convention on Biological Diversity, 2009). Davis (2012) stated that the profoundly negative trend for the future distribution of indigenous Arabica coffee would be 65% reduction in the number of bio climatically suitable localities, and at worst (scenarios of almost 100% reduction, by the year 2080 under the influence of accelerated global climate change). In this study, a 90% reduction in area suitable for in situ conservation of coffee genetic resources was projected for the year 2080. Climate change is predicted to increase mean temperatures and change precipitation regimes and as a result, traditional coffee growing regions may disappear and new regions may appear (Laderach et al., 2010). The relationships between the climatic parameters and coffee production are quite complex, because it affect the growth and development of the plants at different growth stages (Camargo, 2010).

### *Impact of climate change on coffee yield and quality*

Haggar and Schepp (2011) revealed the potential yield and quality of coffee is determined by both temperature and rainfall condition since both ability to interfere with the phonological growth of the crop. These impacts include, for example, disrupted flowering cycles and prolonged drought periods, which ultimate result in reduced coffee quantity and quality (Masters et al., 2009). Other climate variation such as soil water balance during different growth stages of the coffee crop, can affect the available soil water and decrease of the final yield (Camargo, 2010). The Arabica coffee is more sensitive to climate variation, specifically during blossoming and fructification stage (Haggar and Schepp, 2011). Especially, coffee flowering triggered by the first rain fall at the beginning of rain season, meanwhile if rain drops off or becomes too heavy, flowers and fruit may drop from the coffee tree (Läderach et al., 2010). The unpredictable rains will make coffee to flower at various times throughout the year, making the farmers to harvest small quantities continuously (Jassogne et al., 2013). This change will affect the crop physiology especially during the flowering and fruit filling stage (Jassogne et al., 2013).

### *Reduction of suitable land for coffee cultivation*

The current areas coverage for growing of Arabica coffee may be replaced by (lower value) Robusta coffee, cattle pasture and food crops in the some parts of continents (Läderach et al., 2010). It is predicted that at the year 2050, 16% of the area suitable for growing of coffee can be reduced (Läderach et al., 2010). Many scholars identified the because of climate change such as flood, land degradation, drought which can reduce the land suitability for coffee production (Läderach et al., 2011). Ovalle-Rivera et al. (2015) estimated that the acreage with aptitude for growing A. coffee would be reduced for all producing countries by 2050, moving the optimal production conditions to areas with higher altitude. Läderach et al. (2010) and Davis et al. (2012) found similar results for Central America and Ethiopia. To meet future demand in 2050, 2.5 the area that is currently available for coffee production is required. Jassogne et al. (2013) stated the climate change mapping showed that the area suitability for A. coffee in Uganda will reduce drastically in the future. The average daily maximum and minimum temperature trends revealed an increase in temperature over the 50-year period (Jassogne et al., 2013). By 2050, it is predicted that global temperatures would increase by 2°C together with some increased seasonality of precipitation. These changes would reduce climatic suitability for A. coffee at low elevations and increase suitability of higher areas (Ovalle-Rivera et al., 2015). Laderach et al. (2011) pointed out in the case study, that coffee-producing zone in Nicaragua is currently at an altitude of elevation between 800 and 1400 masl; by 2050, the optimum elevation will increase to 1200 and 1600 masl. Additional case study in Uganda reveals if temperatures increase, areas suitable for coffee will be higher in the landscape and unfortunately, the areas that will become more suitable for coffee will compete with other crops or national nature reserves (Jassogne et al., 2013).

### *Impact of climate change on pests diseases*

Climate variation is the most favorable for increase of coffee pest disease; the loss estimate globally is 13% of yield reduction (Agegnehu et al., 2015). Major disease that occurred because of climate variation during coffee growing will increase pest and disease prevalence, expanding the altitudinal range in which the fungal disease coffee rust and the coffee berry borer can survive (Läderach et al., 2010). For example, rising temperatures will increase infestation by the Coffee berry borer (Hypothenemus hampeii), particularly where coffee grows unshaded and the cropping is continuous throughout the year (Walyaro, 2010). Jaramillo et al. (2011) predicted that climate change would worsen pest prevalence like “broca” (berry borer) in Eastern Africa. Consequences of this event suffer viability of current high quality producers (Kasterine et al., 2010). Climate change increases need for fungicides and lead to a resurgence of certain pests and diseases on coffee (Gianessi and Williams, 2011). In the case study of Colombia and Ethiopia, an increase in rainfall and temperature threatens the coffee at an alarming rate, respectively and is more conducive, for pests and disease prevalence (Iscaro, 2014).

### *Increased cost of production*

The occurrence of climate variation such as sporadic and low-intensity rains during growing phase coffee or flowering period, and towards the later-phases of flower bud development, is the main reasons for unsynchronized fruit ripening (DaMatta et al., 2008). Climate change increasing atmospheric CO2 concentrations tend to increase the water use efficiency of $C_3$ plants such as coffee and will tend to offset the increased evaporative demand (Schroth et al., 2009). This change makes coffee production to be under irrigated, thereby increasing pressure on scarce water resources (Kasterine et al., 2010). Harvesting often represents the majority of production costs, so if erratic flowering and ripening cycles require additional harvesting cycles, these changes could drastically and unsustainably raise costs (Läderach et al., 2010). All the above mentioned will increase the cost of production, whereas more coffee may grow and need under irrigation (Haggar and Schepp, 2012).

### *Mitigation strategies*

Many scholars revealed climate variation is a phenomenon that will continue to cause severe or negative effect on yield throughout the world (Iscaro, 2014). To overcome this problem, mitigation of global warming involves taking actions to reduce greenhouse gas emissions to enhance sinks aimed at reducing the extent of global warming which is important (International Coffee Council, 2009). One of the limitations to understanding the impacts of climate variability on coffee production is the lack of having precise meteorological data at coffee growing areas which is important for the development of climate-based insurance (Haggar and Schepp, 2011). An ecosystem services payments scheme would be an ideal strategy synergizing the goals of emissions mitigation, biosphere preservation and poverty alleviation (Läderach et al., 2010). Improving new cultivars resistant to pests and diseases, more productive, well adapted to the local climatic and soil conditions, and have acceptable and desired quality for the market is very important (Enomoto, 2011). Ethiopia has a unique genetic diversity of cultivated, semi-wild and wild Arabica varieties with different types of disease resistance environmental adaptations and quality characteristics for future breeding coffee varieties opportunity that are adapted to the changed climate (Lossau, 2010).

### *Coffee adaptation strategies for climate change*

Measures to adapt coffee cultivation to climate change also contribute to reducing $CO_2$. Other environmental benefits include enhanced water storage, the regulation of local temperatures, and biodiversity conservation (Lossau, 2010). Changes in temperature and frequency of rains are associated positively and significantly with a higher probability to implement at least one adaptation strategy to climate change (Zuluaga et al., 2015). Proven approaches build on existing indigenous practices and knowledge to maximize benefits of climate change adaptation (Dinesh and Vermeulen, 2016). As climate change becomes increasingly severe, an assessment of coffee producers' ability and willingness to adapt would be especially valuable to those hoping to create adaptation strategies and policies (Battiste et al., 2016).

Good management practices that reduce soil erosion (e.g. cover crops and contour bunds) and increase water retention (mulching, shade) will further help farmers adapt to climate change and retain the more fertile topsoil (Deressa et al., 2009; Jassogne et al., 2013). Scientists seem to agree that the best way to preserve A. coffee is through the use of shade trees (Jaramillo et al., 2009). Shade trees planted near coffee plants have the ability to block out the sun's impact on the plants. They create lower temperature, reduce up to 4°C better suited for Arabica coffee plants.

## CONCLUSION

Climate change has emerged in recent years as one of the most critical topics. It is predicted that rising temperatures and water shortages will negatively affect coffee production suitability at lower elevations and vice versa. The already perceived and the future predicted impacts of climate change on coffee production will not only be threat small scale farmers but also all actors involved in coffee industry including consumers. World population will rise to nine billion by 2050. In this scenario, coffee production is also likely to decrease globally, particularly in Africa. Coffee price varies inversely with production changing and generating the largest price increase. Only half the area will currently available for coffee production by 2050 G.C. 2.5-times of the current area will be needed to be meet the future demand. Reduced yields and increased prices were shown to reduce the coffee market by more than 5 million tons per year. As a result of the above reason, many authors believe that the area with aptitude for growing coffee would be reduced by 16% by 2050, especially for coffee Arabica.

Mitigation of global warming involves taking actions to reduce greenhouse gas emissions and to enhance sinks aimed at reducing the extent of global warming measures to adapt to coffee cultivation to climate change also contributing to reducing $CO_2$. Other environmental benefits include enhanced water storage, the regulation of local temperatures, and biodiversity conservation. Improved agronomy and sustainable management of resources including the use of drought and heat resistant varieties, irrigation, and shade cover are good first steps.

Many researchers concluded that the fluctuation of climate in the coffee growing area resulted in reduction in the yield and quality, increasing the outbreak of pest disease, increasing cost of production and reduced area of production. The consequence of the problem may make the coffee sector to have negative impact on the producers and consumers. Generally, further research will be focused on discovering climate change adaptation strategies feasible for smallholder producers for practically implement.

## CONFLICT OF INTERESTS

The author has not declared any conflict of interests.

## REFERENCES


Agegnehu E, Thakur A, Mulualem T (2015). Potential Impact of Climate Change on Dynamics of Coffee Berry Borer (Hypothenemus hampi Ferrari) in Ethiopia. Open Access Library J. 2(01):1.

Battiste M (2016). Specialty Coffee Farmers' Climate Change Concern and Perceived Ability to Adapt (Doctoral dissertation, University of Michigan).

Camargo MBPD (2010). The impact of climatic variability and climate change on arabic coffee crop in Brazil. Bragantia, 69(1):239-247.

Craparo ACW , Van Asten PJA , Läderach P , Jassogne LTP , Grab SW (2015). Coffea arabica yields decline in Tanzania due to climate change: Global implications. Agric. For. Meteorol. 207:1-10.

Damatta FM, Ramalho JDC (2006). Impacts of drought and temperature stress on cofeee physiology and production: a review. Braz. J. Plant Physiol. 18:55-81.

Damatta FM, Ronchi CP, Maestri M, Barros RS (2008). Ecophysiolog of coffee growth and production. Braz. J. Plant Physiol.19:485–510.

Dasaklis TK, Pappis CP (2013). Supply chain management in view of climate change: an overview of possible impacts and the road ahead. J. Industrial Eng. Manage. 6(4):1139-1161.

Davis AP, Gole TW, Baena S, Moat J (2012). The impact of climate change on indigenous arabica coffee (Coffea arabica): predicting future trends and identifying priorities. PLoS One 7(11):e47981.

Dekens J, MAK FB (2012). Promoting an Integrated Approach to Climate Adaptation: Lessons from the coffee value chain in Uganda.

Deressa TT, Hassan RM, Ringler C, Alemu T, Yesuf M (2009). Determinants of farmers' choice of adaptation methods to climate change in the Nile Basin of Ethiopia. Global environmental change 19(2):248-255.

Dinesh D, Vermeulen S (2016). Climate change adaptation in agriculture: practices and technologies. Messages to the SBSTA 44 agriculture workshops.

Enomoto R (2011). Climate-friendly and Productive farming Guide for Coffee smallholders in Africa.

Gianessi L, Williams A (2011). Climate Change Increases Need for Fungicides for Coffee Trees.

Haggar J, Schepp K (2011). Coffee and climate change. Desk study: impacts of climate change in four pilot countries of the coffee and climate initiative. Hamburg: Coffee and Climate.

International Coffee Council (2009). Climate change and coffee103rdSession. London, England.

International Trade Centre (ITC) (2010). Climate Change and the Coffee Industry Geneva: ITC, vi, 28 pages (Technical paper).

Iscaro J (2014). The Impact of climate change on coffee production in Colombia and Ethiopia. Global Majority E-Journal, 5(1):33-43.

Jaramillo J, Eric M, Fernando EV, Aaron D, Christian B, Adenirin C O (2011). Some Like It Hot: The Influence and Implications of Climate Change on Coffee Berry Borer (*Hypothenemus hampei*) and Coffee Production in East Africa. PLOS ONE 6(9):1-14.

Jaramillo J, Setamou M , Muchugu E, Chabi-Olaye A , Jaramillo A, Mukabana J, Maina J, Gathara S and Borgemeister C (2013). Climate change or urbanization? Impacts on a traditional coffee production system in East Africa over the last 80 years. PloS one 8(1):e51815.

Jaramillo J , Chabi-Olaye A , Kamonjo C, Jaramillo A, Vega FE, Poehling HM., Borgemeister, C (2009). Thermal tolerance of the coffee berry borer Hypothenemus hampei: predictions of climate change impact on a tropical insect pest. PLoS One 4(8):e6487.

Jassogne L, Läderach P , Asten VP (2013). The Impact of Climate Change on Coffee in Uganda: Lessons from a case study in the Rwenzori Mountains. Oxfam Policy and Practice: Climate Change and Resilience 9(1):51-66.

Kasterine A, Scholer M, Hilten JH (2010). Climate Change and the Coffee Industry. Abstract for trade information services. International Trade Centre, Palais des Nations, 1211 Geneva 10, Switzerland.

Killeen JT, Harper G (2016). Coffee in the 21st century. Will Climate Change and Increased Demand Lead to New Deforestation?

Läderach P, Haggar J, Lau C, Eitzinger A, Ovalle O, Baca M , Jarvis A , Lundy M (2010). Mesoamerican coffee: Building a climate change adaptation strategy. CIAT Policy Brief no. 2.Centro International de Agricultura Tropical (CIAT), Cali, Colombia.

Lossau VA (2010). Agro biodiversity and adapting to climate change: The example of coffee. Agriculture, Fisheries and Food.

Masters G, Baker P, Flood J (2009). Climate Change and Agricultural Commodities. CABI Position Paper.

Ovalle-Rivera O, Läderach P, Bunn C, Obersteiner M , Schroth G (2015). Projected shifts in Coffea arabica suitability among major global producing regions due to climate change. Plos One 10(4):e0124155.

Potts J (2003). Building a Sustainable Coffee Sector Using Market-Based Approaches: The Role of Multi-stakeholder Cooperation.

Schroth G, Laderach P, Dempewolf J, Philpott S, Haggar J, Eakin H, Castillejos T, Moreno JG , Pinto LS , Hernandez R, Eitzinger A (2009). Towards a climate change adaptation strategy for coffee communities and ecosystems in the Sierra Madre de Chiapas, Mexico. Mitigation and Adaptation Strategies for Global Change, 14(7):605-625.

Secretariat CBD (2009). Connecting biodiversity and climate change mitigation and adaptation: Report of the Second Ad Hoc Technical Expert Group on biodiversity and climate change, Montreal. In Convention on Biological Diversity Technical Series No. 41.

Vega FE, Rosenquist E, Collins W (2003). Global project needed to tackle coffee crisis. Nature 425(6956):343-343.

Walyaro J D (2010). Climate change: potential impact on Eastern Africa coffees. Proceedings of the ASIC Conference

Zuluaga V, Labarta R, Läderach P (2015). Climate Change Adaptation: The Case of the Coffee Sector in Nicaragua.