Addis Ababa University

አዲስ፡አበባ፡ዩኒቨርሲቲ

SEEK WISDOM, ELEVATE YOUR INTELLECT AND SERVE HUMANITY !

COLLEGE OF SOCIAL SCIENCES

GRADUATE PROGRAM

DEPARTMENT OF GEOGRAPHY AND ENVIRONMENTAL STUDIES

EFFECTS OF QUALITY COFFEE PRODUCTION ON LAND USE AND CLIMATE CHANGE ADAPTATION IN THE CONTEXT OF LOCAL VALUE CHAINS IN YIRGACHEFFE DISTRICT, ETHIOPIA

PHD THESIS

ASNAKE ADANE

OCTOBER 2021

ADDIS ABABA, ETHIOPIA

ADDIS ABABA UNIVERSITY

COLLEGE OF SOCIAL SCIENCES

EFFECTS OF QUALITY COFFEE PRODUCTION ON LAND USE AND CLIMATE CHANGE ADAPTATION IN THE CONTEXT OF LOCAL VALUE CHAINS IN YIRGACHEFFE DISTRICT, ETHIOPIA

A DISSERTATION SUBMITTED TO THE DEPARTMENT OF GEOGRAPHY AND ENVIRONMENTAL STUDIES IN PARTIAL FULFILMENT TO THE REQUIREMENTS FOR THE DEGREE OF DOCTOR OF PHILOSOPHY (PHD)

ASNAKE ADANE

SUPERVISOR: WOLDEAMLAK BEWKET (PROFESSOR)

ADDIS ABABA, ETHIOPIA
OCTOBER 2021

To my mother Ayalnesh Assefa

and

to the memory of my father, Adane Ejigu

Statement of the Author

By my signature below, I declare that this thesis is my own work. I have followed all ethical principles of scholarship in the preparation, data collection, data analysis and completion of this dissertation. I have given all scholarly matter recognition through citation and reference. I affirm that I have cited and referenced all sources used in this document. I submit this dissertation in partial fulfilment of the requirement for a PhD from Addis Ababa University. I declare that I have not submitted this dissertation to any other institution anywhere for the award of any academic degree, diploma, or certificate.

Name: ______________________________Signature: ____________ Date:____________

Addis Ababa University

College of Social Science

Graduate Program

This is to certify that this dissertation prepared by Asnake Adane entitled "**Effects of Quality Coffee Production on Land Use and Climate Change Adaptation in the Context of Local Value Chains in Yirgacheffe District, Ethiopia "** and submitted to the Department of Geography and Environmental studies in partial fulfilment of the requirements for the degree of Doctor of Philosophy in Geography and Environmental Studies is defendable and complies with the regulations of Addis Ababa University and meets the accepted standards with respect to originality and quality.

Supervisor

__________________________________signature__________________date____________

____

Chair of the department or graduate program coordinator

Addis Ababa University

Acknowledgements

First, I would like to thank and give praise to the Almighty God for providing me with the opportunity to pursue my PhD and helped me to finish this work. My special gratitude goes to my dissertation supervisor, Professor Woldeamlak Bewket, for shaping my study beginning from the early stage up to the completion of the dissertation. His critical comments began during the designing phase of the research, which provided me with a clear road map of the study. Above all, the scientific standards of the published and publishable articles of the dissertation owe much to his repeated reviews and editing of each article. His patience and unbounded assistance in evaluating and commenting the entire work thoroughly helped me develop resilience to stress particularly due to the COVID- 19 pandemic and then complete my PhD work successfully.

This work was also supported by the GVC- project-, the role of global value chain in transition to sustainability, funded by the Research Council of Norway. I am particularly grateful to Professor Karen O'Brien for giving me the chance to participate in the project, as well as her abundant encouragement, and hosting me for six months in the department of sociology and human geography, university of Oslo, Norway. During my stay in Oslo, I benefited greatly from the foreign residencies, particularly from the team members of the AdaptationConnects led by Professor Karen. Many thanks for all members of the AdaptationConnects and the staffs of the department of sociology and human geography for providing amiable work environment and hospitality in Oslo

My heartfelt gratitude also goes to the 'kebele', district, zone, and regional authorities, coffee development agents and experts. All of you had really facilitated the progress of the study especially during my fieldwork. I would also like to extend my thanks to the staff members of the department of Geography and Environmental Studies at Wollo University for their supports morally and material assistances. Individual households involved in the questionnaire survey, focus group discussions, key informant interviews as well as enumerators deserve special acknowledgement. My special appreciation goes to my family for encouraging my efforts. My lovely wife, Addis Moges, had taken most of the burden of family chore as I was away from the family for the study purpose. Special thanks to my children Bemnet Asnake and Dagmawi Asnake for sharing my burden during the study period and for being source of happiness and refreshment over the course of my PhD work.

TABLE OF CONTENTS

CHAPTER ONE …………………………………………………………………………….

GENERAL INTRODUCTION

1.1 INTRODUCTION

Coffee production is a land resource-based activity that has been undertaken for centuries and with its impacts on the environment (Daviron and Ponte 2007; Bacon et al., 2008). It is a vital component of the rural economy of countries throughout the tropics, and a particularly important source of livelihood to smallholders (ICO, 2015). Coffee production systems support ecosystem services and functions of natural habitats of the Afromotane Biodiversity Hotspot (ABH) (Iscaro, 2012; Ovalle-Rivera et al, 2015). However, these systems are under increasing pressure due to rapid rate of land degradation associated with land use land cover change and climate change, which affects both environmental and socio-economic sustainability (Perfecto et al, 2014). These changes are driven by complex and interacting biophysical and socioeconomic factors operating at different scales of space and time (Hailu et al, 2018; Hettig et al, 2016; Lambin et al, 2001; Rahn et al., 2018 ; Woldu et al, 2015). For instance, Hettig et al (2016) found that demand for agricultural products significantly affected land use decisions in tropical coffee production areas.

On the other hand, market saturation for commodity coffee has led to increasing product differentiation in the global coffee market (Ludi et al,2011; Ponte and Gibbon, 2005). Quality coffee production has gained momentum in the global coffee production; quality coffee refers to a single-origin and highest-grade, organically produced coffee, differentiated by its superior flavour and it claims price premiums (Minten et al, 2019; Ponte and Gibbon, 2005). Its production also involves material variables (i.e. tools, cultivars, water and nutrients), structural variables (i.e. institutions and markets), and subjective factors, such as individual and shared values and beliefs. The quality of coffee can therefore be maintained by, but not limited to, inherent factors such as the genetic type of the coffee tree, agro-climatic conditions (soil type, rainfall, altitude), and factors like sustainable land management (Beshah et al, 2013; Fischer and Newig, 2016). As quality coffee production involves various farm management practices, it is likely to have land use change and climate change adaptation effects while it also demands the collaborative efforts of different stakeholders (Laderach et al., 2010; Meyfroidt et al, 2013).

Quality coffee production has strong links with elements of ecological systems (e.g. climate). Coffee crops are highly sensitive to changes in climate, which can decrease both quantity and quality of harvest. This is a particular case for Arabica coffee, which requires very specific environmental conditions for successful production (Harvey et al., 2018; Ruiz Meza, 2015), including an optimum mean temperature range of between 15 to 23^{0}C. Globally, many suitable areas of coffee production are suffering from increases in temperature and in some of them growing quality coffee is likely to become impossible by 2080 (Ovalle-Rivera et al., 2015). Thus, climate change is a major threat to coffee production and the livelihoods of communities that are dependent on coffee as a primary source of income (Bunn, 2015; Schroth and Ruf, 2015).

Located in the ABH of eastern Africa (CEPF, 2012) and known to be the birthplace of coffee (Maskala and Teshome, 2014), Ethiopia is the center of diversity and a major producer of coffee (Baker, 2015). Ethiopia's role in the global coffee market lies mainly on the fine quality of its coffee (Daviron and Ponte, 2007). Ethiopian quality coffee enjoys a high global demand in the international market, as it is sold at high premiums, as quality coffee of single origin. Fine quality coffees from different origins in Ethiopia are kept separate from each other and sold with their regional names (Minten et al, 2019). One such quality coffee producing areas is Yirgacheffee in southern Ethiopia, which produces quality coffee (as a variant of quality coffee) that fetches premium prices in the global market (Degefa, 2016).

Coffee plays a pivotal role in the Ethiopian economy. Nearly a fifth of the Ethiopian population depends on coffee for their livelihood, where about five million smallholders produce 95% of total production in a low input - low output production system (Meskela and Teshome, 2014). It contributes up to 50% of the country´s export and more than 25% of the country's foreign exchange earnings (Jha et al., 2011). Coffee production in Ethiopia also has positive contributions to adapting to climate change, as the agronomic and land management practices generally enhance adaptive capacities of the production system. More than 45% of the coffee comes from forest and semi-forest areas in which local biodiversity as well as traditional practices are well maintained (Minten et al, 2019). Even in areas where coffee is produced in gardens and plantations, it is grown under large trees such as indigenous leguminous trees (Meskela and Teshome, 2014).

However, most coffee producing areas in Ethiopia are under increasing population pressure and associated land use change. Ethiopian coffee production has been increasing in the last 25 years (Baker, 2015) that can be attributed to new production area through land use change; not by increasing yield on existing land (Minten et al, 2014). Evidently, over the past 10 to 15 years, while production increased by 3600 t/year, annual yield decreased by 18.8 kg/ha. This indicates that there has been expansion in coffee production area; though the extent and impacts at local level remain unknown. The influence of coffee production on land use is therefore significant (Bunn et al., 2015; Li, 2015;Lambin and Meyfroidt, 2011). Borrella et al. (2015) also stated that the global demand for quality coffee and its resultant effects on prices affect local land use decisions at coffee farms and thereby affect land use patterns and management practices.

The increasing population pressure on land and climate change undermine the economic and ecological performance of the coffee sector. Ethiopia has already experienced climate change; mean annual temperature has increased by 1.3 ^{0}C between 1960 and 2006, an average rate of 0.28 ^{0}C per decade (Mcsweeney et al, 2010). The same study has also found that increase in temperature in Ethiopia has been most rapid from July to September, at a rate of 0.32 ^{0}C per decade. The mean annual temperature is projected to go up by 1.1 to 3.1^{0}C and 1.5 to 5.1 ^{0}C by 2060 and 2090, respectively (Moat et al, 2017); albeit there are marked microclimatic variations. Land degradation and climate change therefore pose a threat to the ecological and socio-economic performance of the Ethiopian coffee sector.

The land degradation and climate change related challenges to the Ethiopia coffee sector also suggest that collaborative decisions and actions by stakeholders are important to capacitate coffee farmers for improved coffee production while ensuring sustainable and climate-resilient land management practices. Land use and climate change adaptation decisions and actions for quality coffee production can be determined by decisions and actions of stakeholders along the value chain, as coffee is a commodity crop. For some land users such as quality coffee producers, quality coffee production activities are therefore not just confounded by farm level efforts but also by other stakeholders beyond the farm level; it depends on many factors and actors along the value chain. Riisgaard et al. (2010) also pointed out that the value chain for coffee is particularly useful in understanding the role of stakeholders in these quality-maintaining practices in general and in land use and climate change adaptation in particular, due to the ecological significance of coffee production. However, those decisions and actions have not been comprehensively studied and there is no comprehensive understanding of the role of multilevel actors in quality coffee production and associated land use and adaptation to climate change by coffee farmers (Borrella et al., 2015).

While many studies exist on the effects of land use change and climate change on coffee production, only few studies are available on the effects of quality coffee production on land use and climate change adaptation(Ayele et al, 2019; Negash, 2007; Hylander et al, 2013). Economic aspects like the demand for quality coffee drive quality coffee production. For instance, Rueda and Lambin (2013) also stated that the main driver of land use change is peoples' response to economic opportunities like demand for commodities mediated by institutional factors. Nevertheless, this has not been studied in connection with coffee production in Ethiopia. Previous studies on coffee in Ethiopia (e.g., Kodama, 2007; Mojo et al, 2015; Minten et al, 2014) are focused on structural bottlenecks like institutional and marketing issues or biophysical factors related to coffee production (e.g., Jaramillo et al, 2011) or on modelling current and projected impacts of climate change (e.g., Lundy and Ramirez, 2011) in a separate way. The subjective human dimensions and economic driving factors of land use and climate change adaptation for quality coffee production have been missing in many studies (Elena and Meza, 2017).

Additionally, studies on effects of quality coffee production on land use and management show mixed results. For example, Pender et al (2006) reported improvements in land management and land use in the highlands of central Kenya due to coffee production. In Uganda, adoption of organic land management practices and perceived improvements in resource conditions and livelihoods were attributed to coffee and banana production (Nkonya et al., 2008). In contrast, there are other studies that found cash crop production to be negatively associated with sustainable land use practices (Hylander et al, 2013; Jassogne et al, 2013). Hence, effects of quality coffee production on land use and adaptation to climate change are site specific, despite there are global drivers to the quality coffee production and associated land use change.

This study was therefore aimed at investigating how quality coffee production affects land use and climate change adaptation by smallholders in Yirgacheffe, southern Ethiopia, which is a typical case of quality coffee producing areas in Ethiopia and perhaps in east Africa. The specific objectives were (i) to evaluate effects of quality coffee production on land use and land cover, (ii) to explore coffee farmers' perceptions about local climate change, (iii) to determine the impact of quality coffee production on adaptation to climate change (iv) to assess stakeholders' roles and linkages in quality coffee production and its implications for climate change adaptation.

1.2 STUDY AREA DESCRIPTION

The study was conducted in Yirgacheffe district (woreda) of the Gedeo Zone in southern Ethiopia (Figure 1). Located between 6°09' and 6°32' N and $38^0$08' and $38^0$32 E, the district is part of the eastern escarpment of the Rift Valley System of Ethiopia with altitudinal range of 1501 to 2300 m asl (Negash, 2007), which indicates that it has a humid temperate(*woina dega*) agro-ecological zone of Ethiopia. The dominant soil type is dystric nitosols (Umbric), which is known to be well-drained and suitable for forests and perennial crops.

The climate of Yirgacheffe is humid, and measurements at Dilla ($6^0$20' N, $38^0$20'E at altitude of 1579 m asl) show that annual rainfall ranges between 1200 and 1800 mm, with a bimodal distribution. The main rainy season, which is known as *Kiremt*, lasts from June to November and the second rainy season, which is known as *Belg*, lasts from March to May. The mean annual temperature varies from 15 to 20 ^{0}C. The vegetation cover of the area includes different types of trees and shrubs, along with perennial crops like coffee and enset (*E.ventricosum*)[1]. The area supports widespread practice of agroforestry (Negash, 2007).

With an average population density of 969 persons/km^2 , Yirgacheffe is one of the most densely populated districts of Ethiopia (its density exceeds the regional average of 916 persons/km^2 and far exceeds the national average of 118 persons/km^2) (CSA, 2017). It is also a high-quality Arabica coffee producing area (Alambo and Yimam, 2019), and it has the largest proportion (52%) of farmers producing coffee in the Gedeo Zone (Degefa, 2016). The livelihoods of people are heavily dependent on an indigenous agroforestry system, which involves growing coffee (*C. arabica*), *enset (E. ventricosum*) and varieties of fruits such as mango (*M. indica) and* avocado *(*P. *americana*) (Legesse et al , 2013; Ayele et al, 2019). This represents modified forest land use and perennial- based agroforestry, rather than annual crop-

[1] Enset is a staple food in the study area.

based agricultural system (Mulugeta and Mebrate, 2017). The coffee harvest time is from December to March. This agroforestry practice has contributed to a sustained human carrying capacity, and supported biodiversity and ecosystem services for many years (Legesse et al, 2013); though the area has come under increasing pressure in the last few decades.

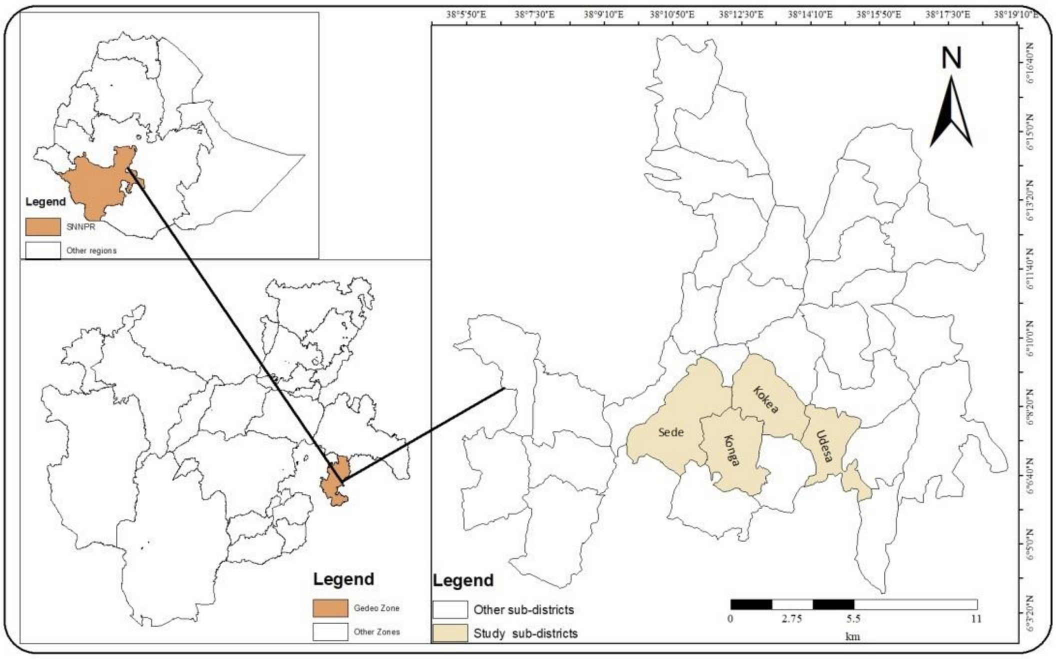


Figure 1: Location map of the study area

There were many reasons for the selection of Yirgacheffe as the site for this study. First, unique flavoured coffee beans that are recognized internationally and marketed at high premiums are produced in Yirgacheffe (Minten et al, 2014). Second, as compared to the south-western highlands of Ethiopia that host the majority of the country's coffee production, the southern part of Ethiopia, where Yirgacheffe district is found, is densely populated, and categorized as areas under population pressure and highly vulnerable to climate change. Third, Yirgacheffe is one of the most important coffee production areas in Ethiopia with well-established institutions and stakeholder linkages like primary market systems, cooperatives and unions as well as processing systems like washing stations that have their own implications to land management and sustainability of local livelihoods(Kodama, 2007; Minten et al, 2014). Finally, the diverse environmental conditions in Ethiopia demand site-specific studies to find local solutions for local problems (Bewket and Abebe, 2013).

1.3 METHODOLOGICAL DESIGN

1.3.1 Research paradigm

A paradigm is a worldview or framework through which knowledge is filtered (Kuhn, 1962; Lincoln et al, 2011) and it is a philosophical orientation guiding a set of assumptions about the world. In other words, a research paradigm refers to a body of literature that shares fundamental assumptions about what the world looks like, how we should research it and more specifically what the key objects of analysis for researchers should be (Shaw et al, 2010). Hence, research paradigms are distinguished based on how the world or reality is considered (ontology). Ontology is a philosophical pattern of beliefs about the nature and form of reality (e.g., whether it is patterned and predictable or constantly socially re-created) (Kothari, 2004). As such, opposing ontological assumptions exist about the nature of reality. There is, for example, an ontology of becoming, which capitalizes on a changing and emergent world, and ontology of being which places emphasis on a permanent and unchanging reality (Gray, 2004). Thus, ontological belief systems inform both our sense of the social world, and correspondingly, what we can learn about it and how we can do so (Crotty, 1998).

Another philosophical tenet of research used to distinguish assumptions of research is epistemology. An epistemology is a philosophical belief system about how research proceeds and the nature of the research that a researcher brings to the study. The objectivist epistemology contends that reality exists independently of mind; there is an objective reality 'out there' and research is about unpacking those objective truths (Gray, 2004). A theoretical perspective distilled from objectivism is positivism. In view of this, biophysical and social phenomena are experienced as constant, regular, recurring and predictable.

Within this broader view, the positivist perspective (which entails the quantitative approach) upholds the existence of universal and cumulative knowledge and a unique reality whose facts and laws, can be discovered scientifically in a systematic and objective way (Hesse-Biber and Leavy, 2017). Facts and laws exist independently of the researcher. The process of discovering the existing laws is to be value free and a researcher's role or involvement is considered as neutral, with no effect on the outcome. Research designs informed by positivism emphasize hypothesis testing by using quantitative methods with the ultimate purposes of generating objective knowledge, generalizations and testing of theories (Creswell, 2012).

By contrast, the constructivist epistemology recognizes the multiple perceptions of reality and is created by the subject's interactions with the world. Thus, meaning is constructed, not discovered, and subjects construct their own meaning in different ways, even in relation to the same reality (Gray, 2004). A theoretical perspective drawn from constructivism is interpretivism. The interpretivist perspective considers representation of reality as constructed, locally and specifically. Based on this perspective, qualitative approaches posit that neutral observation is impossible; and reality is experienced as dynamic, changing and unpredictable. Thus, research focus on qualitative methods generate socially constructed knowledge and results in different versions of an event by different researchers and participants (Flick, 2002).

One point of departure for this research is to look into the values and beliefs of coffee farmers about their response to socio-ecological changes (climate change and land use) and to measure the impacts of quality coffee production on land use and adaptation to climate change. In view of this, while positivism imposes structural laws and theories that do not fit to all aspects of reality (e.g. marginalized groups), interpretivism does not go far enough in supporting action to help individuals (Leavy, 2017). Thus, this study resorts to the mixed methods approach (Creswell, 2012) with the assumption that a combination of the two approaches can compensate for the inherent weaknesses of one method by the respective strength of the other.

1.3.2 Research Design

Given the research paradigm defined above and the interdisciplinary nature of the research, the research design that guided this study was a combination of designs from the positivist and constructivist paradigms. Accordingly, survey design was employed to collect data from subjects who responded to a series of questions about socio-economic and biophysical characteristics of the study area. The survey design was used in line with the positivist perspective, as it is one of the most widely used positivist research methods (Leavy, 2017).The quantitative data were collected household survey from the randomly selected coffee households in the study area. These quantitative data were coded and analysed using the quantitative research software, i.e., SPSS version 27 and STATA version 16.1. The satellite image analysis in land use/ cover study was also in line with the quantitative interpretation of the change in land use/cover in the study area over the study period.

Coupled with this, observational research, also called field research, was used to observe smallholder coffee producers' socio-cultural settings. More importantly, a systematic and extended form of fieldwork, namely ethnographic design, was employed to get insights into the shared socio-cultural values, beliefs and worldviews of the local community in association with coffee production (Schensul et al, 1999). The fieldwork was also carried out to assess how quality coffee production is taking place; and how it is having effects on the land use and climate change adaptation practices by coffee farmers. In this fieldwork, data were collected through semi-structured interviews and focus group, and photographs taken by the researcher. Also, field notes were recorded.

A stakeholder analysis specifically the Process Net Mapping and Participatory Analysis Matrix were undertaken to assess the roles and interactions of stakeholders in quality coffee production and it implications for local climate change adaptation. In addition to the descriptive understanding of how the land use practices are changing, a stakeholder analysis reveals how stakeholders relate to each other, how they develop relationships and how they organise themselves for quality coffee production through land management and climate change adaptation. The stakeholder analysis also allows for a rich representation activities and processes of quality coffee production beyond the coffee farm level as well as roles and links of multilevel stakeholders of the coffee sector of quality for quality coffee production.

1.3.3 Sampling frame and sample size

The general sampling procedure of the study involved multilevel sampling. First, sub-districts (31 Kebeles) were listed and ranked based on the amount of coffee production in the last 20 years. Subsequently, four of the highest coffee producing sub-districts (*kebeles*) (Konga, Sede Kokea and Udesea) were selected on purpose (Minten et al, 2014). At the next lower level, villages (*sub-kebeles*) of the selected sub-districts were used to stratify households and the sampling frame of the household survey was made-up of the list of households in each *villages.* After the establishment of the sampling frame in each villages, the final stage of sampling was carried out using simple random selection of households to make the sample of respondents. The sample size for study was determined by using the formula of Kothari (2004) expressed as:

$$n_0 = \frac{z^2pq}{e^2} \qquad (1)$$

Where, n_0 is the sample size for the infinite population, *z* is the selected critical value of desired confidence level, *p* is the estimated proportion of an attribute that is present in the population, 1- *q* = *p* and e is the desired level of precision. Thus, the sample size was:

$$n = \frac{1.96x1.96xo.5.0.5}{0.05x0.05} = 384 \qquad (2)$$

However, since we have a finite population size, which is 4,309 households for the four sub districts (Konga, Konkea, Sede and Udesa), we corrected the sample size in equation 2, following Cochrane (1967) as follows.

$$n = \frac{no}{1+(\frac{no-1)}{N}} \qquad (3)$$

$$n = \frac{384}{1+(\frac{384-1)}{4309}} \qquad n = \frac{384}{1.09} \qquad n = 352 \qquad (4)$$

Finally, the sample was proportionally allocated to the sub-districts (*kebeles*) as indicated in the following table.

Table 2: Sampling and sample size of the study

Sub-district (*Kebele*)	Total HHs	Coffee production type		Total
		Conventional coffee farmers	Quality coffee farmers	
Konga	1219	67	35	102
Sede	1051	56	17	73
Kokea	1318	64	44	108
Udesa	721	45	24	69
Total	**4309**	**232**	**120**	**352**

1.4 THESIS OUTLINE

The thesis consists of the introduction and six chapters. Chapter 2 presents the theoretical and conceptual frameworks of the study. Chapter 3 contributes to the understanding of the effects of quality coffee production on local land use and land cover of the study area over the last three decades. Coffee farmers' perceptions and meteorological evidence of local climate change in the study area is discussed in chapter 4. The focus is a comparative assessment of the perceived and observed changes in the local climate, and the association of the perceived local climate change and with quality coffee production. Lessons learned from Chapter four were used in Chapter five to examine impacts of quality coffee production on adaptation to climate change by smallholder coffee producers. The focus of this propensity score matching study was to assess the difference between the conventional and quality coffee producers in terms of climate change adaptation practices. Chapter 6 looks into the role of actors in quality coffee production. A stakeholder analysis on the role of actors of coffee value chain in quality coffee production and implications for climate change adaptation was undertaken in Chapter 6. The farmers and other stakeholders identified climate change to be an important factor affecting quality and quantity of coffee harvests identified climate change. The final Chapter (seven) discusses the major findings of the thesis, and outlines the main conclusions drawn from the findings. It also draws out the policy implications and highlights issues for future research.

REFERENCES

Alambo, F. I. and Yimam, H. A. (2019). *Elderly Care and Social Support Systems among the Gedeo of Southern Ethiopia : Socio-cultural Contexts , Forms , Dynamics and Challenges*. *18*(3).

Ayele, G., Hayicho, H. and Alemu, M. (2019). *Land Use Land Cover Change Detection and Deforestation Modeling : In Delomena District of Bale Zone , Ethiopia*. 532–561.

Bacon, C. M., Méndez, V. E., Gómez, M. E. F., Stuart, D., and Flores, S. R. D. (2008). Are sustainable coffee certifications enough to secure farmer livelihoods? The millenium development goals and Nicaragua's Fair Trade Cooperatives. *Globalizations*, *5*(2), 259–274.

Baker, P. (2015). *Global Coffee Production and Land Use Change Global Coffee Production and Land Use Change*. (September 2014).

Beshah,B., Kitaw, D. and Dejene, T. (2013). Quality and Value Chain Analyses of Ethiopiancoffee. *Journal of Agriculture and Social Research*, *13*(2), 35–41.

Bewket, W. and Abebe, S. (2013). *Land-use and land-cover change and its environmental implications in a tropical highland watershed , Ethiopia Land-use and land-cover change and its watershed , Ethiopia*. *7233*. https://doi.org/10.1080/00207233.2012.755765

Borrella, I., Mataix, C. aand Carrasco-Gallego, R. (2015). Smallholder Farmers in the Quality Coffee Industry: Opportunities, Constraints and the Businesses that are Making it

Possible. *IDS Bulletin*, Vol. 46, pp. 29–44. https://doi.org/10.1111/1759-5436.12142

Bunn, C. (2015). *Modeling the climate change impacts on global coffee production. Pages: 20-30. PhD thesis*. 196. Retrieved from http://edoc.hu-berlin.de/dissertationen/bunn-christian.

Bunn, C., Läderach, P., Ovalle Rivera, O. and Kirschke, D. (2015). A bitter cup: climate change profile of global production of Arabica and Robusta coffee. *Climatic Change*, *129*(1–2), 89–101.

CEPF. (2012). Eastern Afromontagne Biodiversity Hotspot. Ecosystem Profile Summary, Available online http://www.cepf.net (accessed September 2019).

Cochran, W.G. (1977). *Sampling Techniques*, 3rd edn. Wiley. New York.

Central Statistical Agency(CSA). (2017).*Population Projection of Ethiopia for All Regions At Wereda Level from 2014 – 2017*. Addis Ababa, Ethiopia.

Creswell, J. W. (2012). Educational research: planning, conducting, and evaluating quantitative and qualitative research (4th Ed.) Pearson

Crotty, M. (1998). The foundation of Social Research: Meaning and Perspectives in Research Process. Sage Publications. London

Daviron B. and Ponte, S. (2007). The Coffee Paradox: Global Markets, Commodity Trade and the Elusive Promise of Development - *The World Economy*, *30*(6), 1031–1032.

Degefa, S. (2016). Home garden agroforestry practices in the Gedeo zone , Ethiopia : a sustainable land management system for socio-ecological benefits. *Socio-Ecological Production Landscapes and Seascapes in Africa*, (January 2016), 28–36.

Doty,B., Grajeda,E., Phillips,P and Shresth, A.(2011).Vulnerability to Climate Change: Applying the livelihood vulnerability index in Trinidad and Tobago." Geoforum

Fischer, L. B., and Newig, J. (2016). Importance of actors and agency in sustainability transitions: A systematic exploration of the literature. *Sustainability (Switzerland)*, *8*(5).

Flick, U. (2002). *An Introduction to Qualitative Research*. Second ed, SAGE Publication, London.

Gray,D.E. (2004).Doing Research in the Real World. SAGE Publications London

Hailu, Y., Tilahun, B., Kerebeh, H., and Tafese, T. (2018). *Agricultural and Resource Economics : International Scientific E-Journal Agricultural and Resource Economics : International Scientific E-Journal*. *4*(4), 20–30.

Harvey, C. A., Saborio-Rodríguez, M., Martinez-Rodríguez, M. R., Viguera, B., Chain-

Guadarrama, A., Vignola, R., and Alpizar, F. (2018). Climate change impacts and adaptation among smallholder farmers in Central America. *Agriculture and Food Security*, *7*(1), 1–20.

Hesse-Biber, S. and Leavy, P. (2017). *The practice of qualitative research* (2nd ed.). Thousand

Hettig, E., Lay, J., and Sipangule, K. (2016). Drivers of households' land-use decisions: A critical review of micro-level studies in tropical regions. *Land*, *5*(4).

Hylander, K., Nemomissa, S., Delrue, J. and Enkosa, W. (2013). Effects of coffee management on deforestation rates and forest integrity. *Conservation Biology*, *27*(5), 1031–1040.

International Coffee Organization. (2015). Sustainability of the coffee sector in Africa. International Coffee Council 115th Session 28 September ─ 2 October 2015 Milan, Italy. ICC 114-5 Rev. 1 26 August 2015.

Iscaro, J. (2012). The impact of Climate Change on urban settlements in Colombia. *Global Majority E-Journal*, *5*(1), 33–43.

Jaramillo, J., Muchugu, E., Vega, F. E., Davis, A., Borgemeister, C. and Chabi-olaye, A. (2011). *Some Like It Hot : The Influence and Implications of Climate Change on Coffee Berry Borer (Hypothenemus hampei) and Coffee Production in East Africa*. *6*(9).

Jassogne, L., van Asten, P. J. A., Wanyama, I. and Baret, P. V. (2013). Perceptions and outlook on intercropping coffee with banana as an opportunity for smallholder coffee farmers in Uganda. *International Journal of Agricultural Sustainability*, *11*(2), 144–158.

Jena, P. R., Chichaibelu, B. B., Stellmacher, T. and Grote, U. (2012). The impact of coffee certification on small-scale producers' livelihoods: A case study from the Jimma Zone, Ethiopia. *Agricultural Economics (United Kingdom)*, *43*(4), 429–440.

Jha, S., Bacon, C. M., Philpott, S. M., Rice, R. A., Méndez, V. E., and Läderach, P. (2011). *A Review of Ecosystem Services , Farmer Livelihoods , and Value Chains in Shade Coffee Agroecosystems*. https://doi.org/10.1007/978-94-007-1309-3

Kodama,Y. (2007). *New Role Of Cooperatives In Ethiopia : The Case of Ethiopian Coffee Farmers Cooperatives*. (March), 87–108.

Kothari C.R.(2004). *Research Methodology: Methods and Techniques.2nd* ed. New Age International Publishers.Jaipur, India

Kuhn,T.S.(1962).*The structure of scientific revolutions*. Chicago: University of Chicago Press.

Läderach P.; Lundy M.; Jarvis A.; Ramírez J.; Pérez P.; and Schepp, K. (2010), "Predicted impact of climate change on coffee-supply chains". In Leal Filho, W. (ed) The Economic, social and Political Elements of Climate Change, Springer Verlag, Berlin

Lambin, E. F. and Meyfroidt, P. (2011). *Global land use change , economic globalization , and the looming land scarcity*. *108*(9). https://doi.org/10.1073/pnas.1100480108

Lambin, E. F., Turner, B. L., Geist, H. J., Agbola, S. B., Angelsen, A., Folke, C., … Veldkamp, T. A. (2001). *The causes of land-use and land-cover change : moving beyond the myths*. *11*, 261–269.

Leavy, P. (2017).Research Design: *Quantitative, Qualitative, Mixed Approaches,Art-basde and Community –based Participatory Approaches.The Guildford Press, London.*

Lincoln, Y.S.,Lynham, S. A. and Guba, E. G. (2011). Paradigmatic controversies: Contradictions,And emerging confluences revisited. In N.K.Denzin and Y. S. Lincoln (Eds.), *The SAGE handbook of qualitative Research* (4^{th} ed., pp. 97–128).

Legesse, A., Teferi, B., Baudouin, A. (2013). Indigenous agroforestry knowledge transmission and young people ' s participation in agroforestry prac- tices : The case of Wonago Woreda ,. *Acta Geographica-Trondheim,* (26).

Ludi, E., Amsalu, W. A., Chiuri, W., Haller, T., Mbeyale, G., and Mhando, D. (2011). Sustainable livelihoods for coffee producers in East Africa: Is producing quality coffee a way out of poverty? *Research for Sustainable Development: Foundations, Experiences, and Perspectives*, *6*, 505–524.

Lundy, M., and Ramirez, J. (2011). *Predicted impact of climate change on coffee - supply chains*. (January). https://doi.org/10.1007/978-3-642-14776-0

Mcsweeney, C., Office, M. and New, M. G. 2010 *The UNDP Climate Change Country Profiles Improving the accessibility of Observed and Projected Climate Information for Studies of Climate Change in Developing Countries*. (June 2014).

Meskela, T. and Teshome, Y. (2014). From economic vulnerability to sustainable livelihoods: The case of the Oromia coffee farmers cooperatives union (OCFCU) in Ethiopia. *International Food and Agribusiness Management Review*, *17*(SI), 103–108.

Meyfroidt, P.(2013). Globalization of land use: distant drivers of land change and geographic displacement of land use, Environ Sustain http://doi.org/10.1016/j.cosust.04.003

Minten, B., Dereje, M., Engeda, E., and Kuma, T. (2019). *Coffee value chains on the move : Evidence from smallholder coffee farmers in Ethiopia*. (July).

Minten, B., Tamru, S., Kuma, T., and Nyarko, Y. (2014). *Structure and performance of Ethiopia ' s coffee export sector*. (June).

Moat, J., Williams, J., Baena, S., Wilkinson, T., Demissew, S., Challa, Z.K., Gole, T. W. and D. A. . (2017b). *Coffee Farming and Climate Change in Ethiopia: Impacts, Forecasts, Resilience and Opportunities. – Summary. The Strategic Climate Institutions Programme (SCIP)*. 37.

Mojo, D., Fischer, C., and Degefa, T. (2015). Social and environmental impacts of agricultural cooperatives: Evidence from Ethiopia. *International Journal of Sustainable Development and World Ecology*, *22*(5), 388–400.

Mulugeta and Mebrate.(2017). Production and Ecological Potentials of Gedeo's Indigenous Agroforestry Practices in Southern Ethiopia. J*ournal of Resources Development and Management*, 30, 2422-8397

Negash, M. (2007). Trees management and livelihoods in gedeo's agroforests, ethiopia. *Forests Trees and Livelihoods*, *17*(2), 157–168.

Nkonya, E., Pender, J., Kaizzi, K. C., Kato, E., Mugarura, S. and Ssali, H.(2008). Linkages between land management, land degradation, and poverty in sub-Saharan Africa: The case of Uganda. In *Research Report of the International Food Policy Research Institute*.

Ovalle-Rivera, O., Läderach, P., Bunn, C., Obersteiner, M., and Schroth, G. (2015). Projected shifts in Coffea arabica suitability among major global producing regions due to climate change. *PLoS ONE*, *10*(4), 1–13.

Pender, J., Place, F., and Ehui, S. (2006). Strategies for Sustainable Land Management in the East African Highlands: Conclusions and Implications. *Strategies for Sustainable Land Management in the East African Highlands*, 377–415.

Perfecto, I., Vandermeer, J., and Philpott, S. M. (2014). Complex Ecological Interactions in the Coffee Agroecosystem. *Annual Review of Ecology, Evolution, and Systematics*, *45*(1), 137–158.

Ponte, S., and Gibbon, P. (2005). Quality standards, conventions and the governance of global value chains. *Economy and Society*, *34*(1), 1–31.

Rahn, E., Liebig, T., Ghazoul, J., Asten, P. (2018). Agriculture , Ecosystems and Environment Opportunities for sustainable intensi fi cation of co ff ee agro-ecosystems along an altitudinal gradient on Mt . Elgon , Uganda. *263*, 31–40.

Riisgaard, L., Bolwig, S., Ponte, S., du Toit, A., Halberg, N., and Matose, F. (2010). Integrating poverty and environmental concerns into value-chain analysis: A strategic framework and practical guide. *Development Policy Review*, *28*(2), 195–216.

Ruben, R., Fort, R., and Zúñiga-Arias, G. (2009). Measuring the impact of fair trade on development. *Development in Practice*, *19*(6), 777–788.

Ruiz Meza, L. E. (2015). Adaptive capacity of small-scale coffee farmers to climate change impacts in the Soconusco region of Chiapas, Mexico. *Climate and Development*, *7*(2), 100–109.

Schensul, J. J., LeCompte, M. D., Nastasi, B. K., and Borgatti, S. P. (1999). Enhanced ethnographic methods: Audiovisual techniques, focused group interviews, and elicitation techniques. In M. D. LeCompte and J. J. Schensul (Eds.), Ethnographer's toolkit (Vol. 3). Walnut Creek, CA: Sage. i:10.1016/j.gloenvcha.2014.04.015

Schroth, G., and Ruf, F. (2015). *Farmer strategies for tree crop diversification in the humid tropics . A review To cite this version : HAL Id : hal-01234798 Farmer strategies for tree crop diversification in the humid tropics . A review*. https://doi.org/10.1007/s13593-013-0175-4

Shaw G.R.,Dixon D.P and Jones III J.P.(2010).Theorizing our World In: Gomez, B and Jones III, J.P(eds). Research in Geography: A critical introduction.pp.9-25 Blackwell Publishing

Woldu, Z., Belew, D., and Benti, T. (2015). *The Coffee-Khat Interface in Eastern Ethiopia : 5*, 149–169.

CHAPTER TWO………………………………………………………………………………

LITERATURE REVIEW AND CONCEPTUAL FRAMEWORK

2. Literature Review and Conceptual Framework of the Study

This chapter presents a review of related literature and discusses the emphasis, strengths and gaps in the literature related to land use change and climate change adaptation practices by smallholders. Then after, theoretical and conceptual frameworks of the study are presented.

2.1 LITERATURE REVIEW

2.1.1 QUALITY COFFEE PRODUCTION, LAND USE AND CLIMATE CHANGE ADAPTATION

Coffee production is a land resource-based industry that is known to cause deforestation, biodiversity loss, soil degradation, and depletion and pollution of limited water resources (Frank et al., 2011; Bacon et al., 2014). In many cases, coffee is produced by farmers with low levels of knowledge on sustainable land use and management (Neilson and Pritchard, 2009; Borrella et al., 2015). In addition, coffee is a highly climate sensitive crop requiring very particular biophysical conditions. Climate change is predicted to reduce the overall areas suitable for coffee cultivation by 50 per cent, and it is already affecting the quality of yields by changing precipitation patterns and increasing pest and disease pressures due to rising temperatures (Jaramillo et al., 2009; Bunn et al., 2014). Coffee production is therefore facing impacts of climate change, while simultaneously contributing to the changing climate by exploitative land management and trade practices. The coffee sector is 'double exposed' to both the biophysical adversities and structural bottlenecks like market imbalances and policy flaws.

Regardless of low returns in volatile global markets and changing climatic conditions, the economic significance of coffee for farmers and producing countries is crucial, ranging from 17 to 80 per cent of total foreign exchange earnings (Gereffi et al., 2014). The influence of coffee production on land use in coffee producing areas is therefore inevitable given the economic significance of coffee for producers matched with the prevailing global demand for the product. However, coffee production does not have to be incompatible with sustainable land management and biodiversity conservation. Studies show that afforestation of degraded land areas in coffee production, combined with improved farming, harvesting and processing practices, can increase biodiversity, improve ecosystem services, and make coffee producing communities more adaptable to climate change (Rahn et al., 2013; Bacon et al., 2014; Borrella et al,. 2015).

Land use systems are shaped by many factors operating at multiple scales. These include interactions between humans and environmental processes; global and regional environmental and market patterns for cash crops; institutions, technologies and cultural practices that influence land uses; and feedback among drivers and impacts of land use and land cover change (LULCC). LULCC is a cause and consequence of social-ecological processes because humans drive land use decisions at local to national scales, and in turn LULCC has consequences for climate change and its impacts, ecosystem service provisioning, and environmental degradation (Lambin et al, 2001). LULCC is also a result of management interventions such as reforestation, change in agricultural production systems, which prompt further land use decisions and actions.

As in the case of many other agricultural commodities, activities involved in the coffee sector are embedded in the totality of socio-ecological systems. In many developing countries, there is heavy reliance on natural resources for livelihoods that results in land degradation. This is particularly true for smallholder farming systems, which are crucial for the livelihoods of the majority of the population and the national economies (Hurni, 2000). Land degradation is mainly attributable to land mismanagement, such as intensive agricultural practices and deforestation, and driven by underlying forces such as weak implementation of policies, national and international market demand for cash crops. These reasons are often related to the trade-offs between immediate human needs and ensuring long-term continuation of ecosystem services (Admasu et al, 2014).

Evidences suggest that adoption of sustainable land management (SLM) by smallholder farmers is determined by factors specific to the context of farming. For example, Wollni et al. (2010) showed that membership in farmer groups had a positive and significant effect on adoption of these practices. In Eastern Africa, Kassie et al. (2013) found that social network variables, particularly membership to producer organizations, were positively and significantly correlated with investment in SLM technologies. These technologies include conservation tillage, soil and water conservation, cereal-legume intercropping, and the use of manure, chemical fertilizer, and the application of improved seed and cereal-legume crop rotation. Such studies found that group membership and stakeholders' partnership foster the adoption of soil and water conservation, cereal-legume intercrops and use of animal manure. Therefore, one approach for successful SLM is through coordination and organization of stakeholders and enhancing farmers' networks with other stakeholders.

Improving the socio-ecological conditions of coffee production is an old quest, yet one that has not achieved great success (Daviron and Ponte, 2005). The increasing demand for quality coffee, which is setting the stage for a new era of quality-oriented production due to saturated markets of commodity coffee should in theory also have positive impacts on land use, biodiversity, and resilience to climate change (Borrella et al., 2015). Quality coffee production has implications to climate change adaptation through sustainable land management (Ponte and Gibbon, 2005). Sustainable land management that involves coffee and quality-maintaining farming practices could be determined by decisions and actions by stakeholders along the coffee value chain. Smallholders' land management practices are therefore not just confounded by farm level efforts but also by other stakeholders along the coffee value chain; it depends on many factors such as farmers' organizations like cooperatives.

Quality coffee refers to single-origin and highest-grade coffee, organically and shade grown coffee which claims significant price premiums in the market and differentiated by its superior flavor and standards for production and trade (Jha et al., 2011). Daviron and Ponte (2007) developed a typology of quality in coffee that refer to the different activities in the coffee value chain. These are material, symbolic and in-person quality. Material attributes are nothing but measurable attributes that are inherent to the product while it is independent from the identity of buyers/sellers. These attributes are often measured through senses (smell, taste, vision, hearing, touch). Symbolic quality attributes are those, which are not measurable through human senses. These attributes play vital role in the political economy of the coffee sector. Symbolic attributes are linked to the specific brands or establishments and copyrights. Moreover, in-person service refers to the relation between the employees and the consumer. Farmers and producing countries sell coffee for its 'material quality' attributes, while consuming country operators downstream create and appropriate value by selling the 'symbolic' and 'in-person service' attributes of coffee.

In sum, quality coffee production is a geographically embedded socio-ecological production process of cultural environments, which are expected to change within a new coffee value chain

(Taylor 2015). It comprises on-farm activities like increasing the biodiversity of farms through intercropping, increasing shade trees on farms, and introducing natural fungicides and insecticides. Thus quality coffee production also has implications for climate change adaptation through sustainable land management. These improvements should also have positive impacts on land use and resilience to climate change. This offers a new research area, as quality coffee can be produced with high levels of integrated and knowledge-based land management.

2.1.2 Stakeholders in quality coffee production

Stakeholder is anyone with power, interest and importance in the performance of a system, and may be positively or negatively affects and/or is affected by that system (Bezabih et al, 2020). In this sense, stakeholders in natural resource management context refer to the individuals or groups who are involved in the decision-making process and actions for sustainable natural resource use (Grimble and Wellard, 1997), or who affect the decisions and actions, and their interests are influenced by the outcome of the decisions (Zeleke et al, 2006). Stakeholders can be grouped into primary and secondary (Duguma, 2017). For this study, the primary stakeholders are those directly involved in the coffee sector, from producers and to consumers, the secondary stakeholders influence decisions and actions of the primary stakeholders by setting rules, or controlling access to resources or to markets, e.g. government officials or policy makers. These secondary stakeholders can empower smallholder farmers as quality coffee production depends on the capacity of farmers to produce quality coffee with high levels of knowledge on land use and management in the changing climate.

Originating from the field of management, stakeholder analysis has been applied in development and environmental studies. For example, Lelea et al (2014) stated that stakeholder analysis enables us to identify actors and their roles, the core processes (input supply, production, processing, marketing and consumption) and institutional linkages (materials, fund and knowledge flows) in natural resource management. Stakeholder analysis is a tool to identify and describe multiple uses and users of resources where there are nebulous property rights, and crosscutting interests of stakeholders in the resources (Grimble and Wellard, 1997). Hence, stakeholder analysis (in line with the political ecology perspective discussed in section 2.2) can be used to gain understanding into the role of stakeholders in quality coffee production and its implications to sustainable land management and adaptation to climate change.

With regard to stakeholder characteristics, stakeholders' power and interest are the two basic attributes to characterize, classify and assess their roles in natural resources management (Grimble and Wellard, 1997). The notion of power is central here as the production of the lived environments is actively co-constructed, contested and remade via complex socio-ecological relations. Power refers to the degree of influence of a stakeholder on decision-making in quality coffee production. Identifying actors that have the largest influence on the way humans and their environment are produced over time is critical (Taylor, 2015). The question of interest to this study is how the required physical (seedlings, soil, and fertilizers), technical (infrastructure, irrigation, and tools), social (networks, knowledge) and financial (investments, credit) inputs are incorporated into the value chain of quality coffee, and what effects it has on land use and climate change adaptation (Gereffi et al.,2014).

Fungo et al (2013) illustrate the dominance of district level stakeholders in decision-making processes in Ethiopia. These key stakeholders synergistically make great contributions, where they assumed functions of support in SLM including advisory and training services, and could influence smallholders' decision in quality coffee production. Coffee farmers often receive advice from district offices to carry out certain SLM measures (e.g. planting legume trees and shade management) or to refrain from certain actions (e.g. in the form of laws and by-laws such as no cultivation of some trees like eucalyptus near coffee trees). As local stakeholders, they bear the direct impact of decision by other stakeholders, but they have little opportunity to participate in the decision-making process.

While stakeholders play vital roles in sustainable land management, their attributes and interactions have not been studied adequately, and stakeholder analyses in quality coffee production are largely lacking (Lange et al, 2015). For example, Nkonya et al. (2008) and Pender et al (2006) highlighted that the study of stakeholders and activities in sustainable land management for cash crop production like coffee beyond farm level context has received little attention. Hence, a bigger picture of role of stakeholders in quality coffee production is missing. Overall, evidence is patchy and limited to the role of stakeholders in sustainable land management as well as on their power, interest and the core functions for quality coffee production.

2.1.3 COFFEE PRODUCTION IN ETHIOPIA

Ethiopia is the origin and centre of genetic diversity of the Arabica coffee plant, and endowed with immense potential in the form of organic and shade-grown coffee (Mojo et al, 2015), and it has considerable potential to sell a specialty coffees (Nure, 2008). Even though recent and reliable data is lacking, coffee production systems include forest (5%), semi-forest (35%), garden (50%), and plantation coffee (5%) (Kufa, 2012). Another study by Hundera et al (2013) indicated three major traditional coffee-production systems within the coffee areas in Ethiopia; (1) the forest coffee (FC) system, (2) the semi-forest coffee (SFC) system and (3) the semi-plantation coffee (SPC) system. This study adopted the second classification, considering the nature of coffee management systems in Yirgacheffe.

Forest coffee is grown in the wild under natural forest cover and it is gathered by farmers from trees with minor tree maintenance. Semi-forest coffee is also grown in forest conditions, but there is some limited maintenance by farmers, mostly annual weeding. The semi-plantation involves modification of the forest similar to the SFC system, but more intensively, and including the systematic planting of coffee seedlings, often locally improved coffee berry disease–resistant varieties. Farmers often intercrop the coffee trees with other crops or trees in the form of agroforestry, which is typical in the study area. Plantation coffee is grown on large commercial farms, private as well as state farms where modern production practices such as irrigation, modern input use, mulching, stumping, and pruning are often applied.

Coffee has been cultivated, traded and consumed for centuries and still plays a central role in the local and national economy of Ethiopia (Moat et al., 2017). It is an important commodity in terms of both export earnings and generating income for smallholder farmers in Ethiopia and for the country's economy at large (ICO, 2015). Since coffee production and harvesting are labour-intensive, it provides an important source of rural employment, for both men and women. Nearly a fifth of the population depends on coffee for their livelihood, where about 5 million smallholders produce 95% of total production in a low input-output production system (Meskela and Teshome, 2014). It contributes up to 50% of the country´s export and more than 25% of the country's foreign exchange earnings (Jha et al., 2011). The production system of coffee also enhances appropriate land management and conservation of natural resources like forest and biodiversity resources (Shumeta et al., 2012). Therefore, coffee is considered as one of the key subsectors of the economy in terms of its potential to raise agricultural production and increase both smallholder's income and government revenue.

During the last few decades, the world coffee market has evolved into a highly specialised and complex global chain involving a wide range of actors that interact in order to satisfy an even wider range of market demands (Petit, 2007). The Ethiopian coffees are being sold at high premiums, as speciality coffee of single origin. In this sense, fine quality coffees from different origins in Ethiopia are kept separate from each other and sold with their regional names, e.g. Yirgacheffe coffee (Minten et al., 2019). Ethiopia's role in the global value chain lies not in the volume of its exports but in the fine quality of its coffees (Ponte and Daviron, 2005**).**

The major challenges of coffee production in Ethiopia are lack of competitiveness (low yield and productivity), inconsistency in quality and supply, weak public-private partnership, and weak market information system and low value addition (Alemseged and Yeabsira, 2014). The participation of smallholder coffee farmers (who are key actors in the coffee sector) in coffee value addition activities is minimal. Furthermore, smallholder coffee farmers are concentrated in remote rural areas, where limited infrastructure and market information typically brings about inefficiencies in terms of production, logistics and transaction costs (Bastin and Matteucci, 2007). As a result, small-scale coffee producers have rudimentary, low input-output agricultural and coffee harvesting practices, low incomes, weak organisations and weak bargaining power.

Although Ethiopia has a reputation of high quality coffee due to its branded varieties of coffee, most of the coffee farmers in Ethiopia are not capable of getting the benefits connected with production and marketing of a finest quality product. In spite of huge potential for collective production of coffee in Ethiopia, the average yield per hectare remains very low at 0.72 metric ton per hectare (ICO, 2015). There are some factors for this 'paradox'. First, there is competing land use particularly with Khat (*Cata edulis*), a plant with mild narcotic effects, with coffee for farmlands in different areas of the country particularly in the Hararghe area. Many farmers prefer Khat because it is more profitable, drought resistant as compared to coffee and then brings a consistent income. Second, the farm management system of coffee and the agronomic practices are traditional, as coffee producing farmers do not get adequate extension services. Lastly, there is low level of public investment in agriculture, inadequate attention to the coffee sector as the major export-earning crop in different agricultural policy frameworks and weak institutional framework; and there is no clear policy designed for the coffee sector. This clearly shows the 'double exposure' of coffee farmers to both structural and policy challenges on one hand and environmental adversities on the other hand. These problems cannot be alleviated without collaborative actions and decisions of stakeholders across the coffee sector.

Despite these challenges, there are opportunities through which the coffee sector of Ethiopia can have enhanced contribution to the economy of the country. Due to the suitable biophysical conditions (Ludi et al, 2010), Ethiopia can sustainably produce and supply fine specialty coffee, with potential of producing all coffee types of the various world coffee growing origins (Jena et al, 2011). In addition, Ethiopia is not just an important producer and exporter of Arabica coffee but also a heavy consumer, which might be an opportunity for alleviating market problems. Ethiopians are the highest coffee consumers in Africa and coffee is deep-rooted in Ethiopian culture. Hence, the Ethiopian coffee production system is deeply embedded in the socio-cultural settings of coffee producers. Thus, the Ethiopian coffee sector is witnessing both challenges and opportunities to have significant contribution in improving both the biophysical conditions and the coffee-based livelihoods.

2.1.4 Stakeholders in quality coffee production and their roles in Ethiopia

According to Duguma (2017), the Ethiopian coffee value chain comprises stakeholders that can be grouped into primary and secondary, but the categorization cannot be exclusive. For example, farmers are both producers and consumers of the coffee. Quality coffee production can be seen as enterprise and involves different actors along the value chain. The coffee value chain in Ethiopia consists of the core processes (input supply, production, processing, marketing and consumption) and institutional linkages (fund, knowledge and technology flows and market linkages).

Amamo (2014) conducted research on coffee production and marketing in Ethiopia. The research indicated that developing strong linkage between the value chain actors is very important to increase production and productivity. Value chain actors play important roles in quality coffee production in many ways. Specifically, stakeholders other than the coffee farmers play an effective role in supporting coffee farmers in quality maintaining activities, and by supplying the price information, capital, and transportation that small-scale farmers often lack (Kodama, 2014). For example, cooperatives as representative of coffee farmers would have a higher bargaining power by way of pooling its members' resources, than a farmer in the coffee market. The government agencies including the Ethiopian Coffee and Tea Development and Marketing Agency (ECTDMA) also play decisive roles in quality coffee production and provide various types of support for coffee farmers like material input supplies and market access. The research institutes include the national and regional coffee research centres and universities, and they are responsible for undertaking systematic studies and support policy makers make informed decisions. Although the support from donors and NGOs has been limited as compared to supports from other actors some donors including USAID and World Food programme, have been supporting Ethiopian coffee farmers in maintaining the coffee quality.

2.2 THEORETICAL FRAMEWORK OF THE STUDY: POLITICAL ECOLOGY

Global environmental change, market and economic changes as well as the flow of resources, people and information are principal processes that have impacts on socio-ecological processes and systems. A common denominator for climate change and land use change literature is that environmental crises are going to exacerbate poverty and systems in developing countries are highly feeling adversities of these changes (Dalia et al, 2016). Though land use and land cover changes are local and place specific, their impacts collectively add up to global environmental changes (Lambin et al, 2006), with the potential for multidirectional effects of change including feedback loops that often characterise land system change (Lambin and Meyfroidt, 2011). Land use change is one major component of global environmental change with adverse effects on climate change, biodiversity and livelihoods.

However, land use changes at all spatial scales are not only, usually, influenced by local factors but also by long-distance flows of inputs, products, people, information and counter-flows between these distant places (Lenschow et al,2015). The notion of land use change describes the various causes and processes of land use and land cover change that places or regions go through due to socioeconomic and/ or biophysical drivers. For example, a land use change from forest coffee to semi- forest and subsequently to semi-plantation and plantation production system driven by the demand for quality coffee in the global market highlights the notion of land transition in coffee production system (Adane and Bewket, 2021). This represents intensification, i.e., producing more for the global market by changing in management practices. Nonetheless, there is persistent spatial decoupling of local land uses from distant drivers of land use change.

The increased integration of smallholder coffee farmers into global markets under unequal power relations may affect decisions and actions of coffee farmers on land use and climate change adaptation. Particularly the demand for quality coffee, and connections of coffee farmers to exporters and consumers has led to the creation of many distinct coffee markets based on qualities (Borrella et al, 2015), representing interactions between distant systems and agents of land use change. The global and national demand for coffee, and standards for production influence land use decisions and outcomes at local levels (Hernandez-Aguilera et al., 2015). This suggests the need for theoretical approaches to capture connections and interactions that involve multilevel stakeholders and factors of land use and climate change adaptation.

In response to this, political ecology can be used to understand the ways decisions and actions of the 'land manager', particularly rural land users in developing countries are shaped by economic and political policies (Blaikie and Brookfield, 198; Escobar, 1995). It can be used to look into the decisions that communities make about the natural resources in the context of politicized environment under economic pressure and societal regulations. It also focuses on how unequal power relations in and among stakeholders and societies affect the natural environment in policy and market contexts. In this study, a perspective of political ecology places emphasis on the roles and linkages of multilevel stakeholders of the coffee sector, how power relations in the coffee sector exist, and thereby how the coffee farmer perceives the role of these stakeholders in land use and climate change adaptation for quality coffee production. While plurality of disciplinary background characterizes political ecology (Bryant and Baily, 1997), this study was linked to it through the following three theoretical principles.

First, political ecologists deconstruct and review the "Malthusian single-factor narrative," which takes up the idea that land degradation is the result of only population pressure and poverty (Blaike, 1985). Instead, they argue that land degradation is not only an inevitable consequence of population growth but also it attributes to other factors that are context-specific policy flaws and socio-economic constraints. Therefore, political ecology approach challenges neo-Malthusian arguments about population pressure and ecological limits by demonstrating how ecological decline is not caused by only population pressure but rather is closely linked to political-economic pressures on resource consumption. This would point to the need to examine the linkages between demand-driven quality coffee production on the one hand and land management and climate change adaptation practices on the other hand.

Second, political ecology is a perspective to examine the linkages between local environmental issues and multilevel political-economic processes and activities. Thus, political ecology has drawn attention to the inter-relationships between socio-economic power relations and their ecological impacts. For example, smallholder farmers would not undermine their natural resource base through destructive farming techniques due to ignorance, or even by choice, but due to the marginalization by national and global scale politico-economic forces (Blaikie, 1985). Rather, they might in fact possess useful information about local conditions and narratives desirable for environmental sustainability. In a similar vein, within the coffee sector there are socially and economically differentiated stakeholders and factors ranging from individual coffee farmers to regional and national institutions. In connection with this, this study assesses the roles and linkages of stakeholders along with their power and interest in quality coffee production.

The third issue that has been explored by political ecology and linked to this study is the ways in which knowledge about nature is mobilized and contested socio-politically. Such knowledge include ecological representations of nature and 'local' or 'indigenous' knowledge that often combine understandings of physical processes with the values and beliefs of the local community about these physical processes and resources. In other words, particular kinds of ecological knowledge which are usually intertwined with values and beliefs are used to justify natural resources management and development priorities (Escobar, 1995). It is used to analyse the complexity of social and environmental changes that are attributed to intersecting and conflicting economic, social, and ecological processes operating at different spatial and social scales. Therefore, how beliefs and values as well as worldviews of stakeholders in quality coffee production determine their adaptation to climate change and land use was addressed based on this line of argument. Hence, the political ecology was adopted as theoretical perspective for this study to assess the perceptions of coffee farmers on local climate change and effects of the coffee production system on land management and climate change adaptation practices.

2.3 CONCEPTUAL FRAMEWORK OF THE STUDY

2.3.1 THE THREE INTERACTING SPHERES

Coffee production goes beyond the production of coffee for the market and is driven by internal factors like attitude, beliefs and values of producers. It includes the ability of people to navigate the changing climate, engagement in land management, establish relationships with stakeholders and dealing with opportunities and risks (Daviron and Ponte, 2007). In this study, these complexities were approached through the three spheres framework for understanding and identifying the effects of quality coffee production on land use and climate change adaptation (O'Brien and Sygna, 2013). These spheres are political, practical and personal, as depicted in Figure 1. Each sphere has its own characteristics that contribute to or inhibit quality coffee production and associated land use and climate change adaptation.

The practical sphere: quality coffee, land use and climate change adaptation

Challenges in land use regime occur due to change in objective dimensions (strategies, activities and technical responses) of stakeholders (Ramankutty and Coomes, 2016). For example, the global demand for quality coffee has its own effect on land use practices in coffee producing areas. The distant factors affecting land use include a growing concentration of global commodity value chains, foreign investments in land and large-scale land acquisitions by foreign actors, and the emergence of niche commodities destined for high-income markets (Rueda and Lambin, 2013). In this sense, as the global market becomes more integrated due to the flow of people, information and commodities, it will have high signal on decisions and actions on land use practices in distant production areas through different technical responses (Lambin and Meyfroidt, 2011). Of particular interest is global agricultural commodities like coffee that link smallholder producers from the south to consumers in the north in the context of global value chains. Therefore, the consequent rise in demand of agricultural output is expected to increase pressure on natural resources and associated technical response in the form of different land use and adaptation practices for coffee production.

In general, the practical sphere aligns with the intent of this study to understand how quality coffee production driven by the global and national demand influences land use and management and how it affects the ability to effectively adapt to climate change. Improving the practices of coffee farming, harvesting, processing and storage, introducing resilient varieties, and replanting the indigenous tropical forest canopy are practically oriented strategies that aim to tackle land degradation and climate variability in coffee production areas.

The personal sphere: values and perceptions on climate change

The personal sphere constitutes the subjective dimensions of land use and climate change adaptation in coffee production. These dimensions include worldviews, values and beliefs of stakeholders on quality coffee production and its implication for land use and climate change adaptation practices. Worldviews are the assemblage of values and beliefs about how society functions and should be organized and they frame how environmental changes are perceived (O'Brien, 2010). The term values has been used to refer to a wide array of concepts, including interests, moral obligations, wants and goals of individuals and communities (Moat et al., 2017). Values represent an interior and subjective dimension of decisions and actions of individuals and societies as well as the rationalization of decisions and actions (O'Brien, 2009). Values for this study refers to intrinsically governing principles or qualities important to understanding and responding to climate change and undertaking land management actions. Hence, value systems play important roles in responding to climate change, both in terms of mitigation of greenhouse gas emissions and adaptation to changing climate conditions.

What the effects of climate change mean to those affected importantly determines how to respond to climate change impacts. The reason to consider the values and worldviews in climate change adaptation arises from several angles (O’Brien, 2009). For instance, values are interior or subjective ability of human actors to adapt to climate change, which quietly differ, from the objective ability, and discounting these differences can lead to the underestimation or overestimation of the adaptive capacity of an entity. Values underlie people’s perspectives from which they adapt to the changing climate in subjective and different ways. For example, unlike plants, people do not directly adapt to the changing climate; instead they adapt (or not) to their perceptions and interpretation of such changing patterns. Whereas debates about climate change focus on assessments and measures of the costs of goods, services, and technologies to reduce future impacts, they seldom take into account the differential subjective values of individuals, societies, and cultures.

The personal sphere is directly aligned with one of the intent of this study, that is to assess how stakeholders within the coffee sector perceive socio-ecological changes in quality coffee production. Thus, in terms of values and worldviews, climate change receives different meanings and interpretations by different individuals and groups. The two points of departure of this study with regard to land use are 1)distant factors of land use regime shift in quality coffee producing areas are inadequately addressed, and 2) the subjective human dimension of drivers of land use are lacking in most studies. In consonance with this, one of the intentions of this study was to assess to what extent the demand for quality coffee affects smallholder produces' land use and management practices, and how the value and beliefs of smallholder farmers determine land management practices.

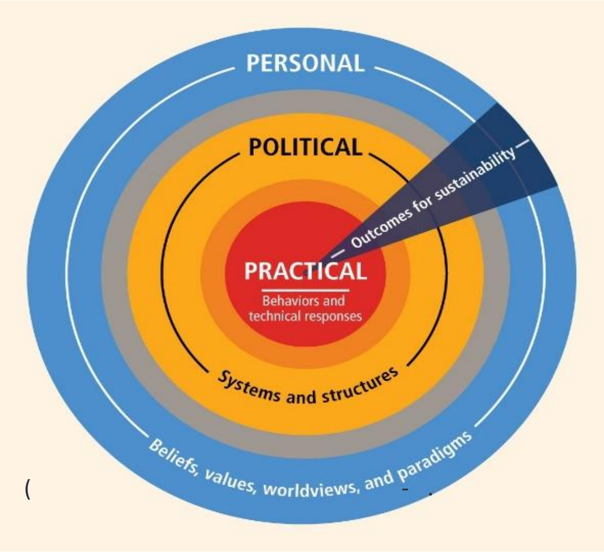


Figure 1: The three interacting Spheres Framework (O'Brien and Sygna,2013)

The political sphere: the role of stakeholders in the coffee sector

The political sphere refers to systems and structures, mainly policies and institutions that guide stakeholders' roles and linkages for a system. A stakeholder is a person or group of persons/ institutions who have a stake in a certain socio-ecological system. Bryant and Biley (1997) pointed out that the notion of power and interest is essential in the study of the role of stakeholders in the politicized environment. Power is the ability of an actor, or a group of actors, to control their own resources and others' interactions within the environment (Lange et al, 2015). The interests of powerful stakeholders, such as the government agencies, are imposed on those of more marginalized groups, such as the local community in resources management activities. The worldview and beliefs of powerful stakeholders on resource use could influence policy, strategies and the practical domains of coffee production, and in turn, coffee production would have effects on the socio ecological system of coffee production.

The coffee sector is faced with a dilemma where the demand for quality can only be met by enabling coffee farmers to produce under conditions that no longer marginalize them, since the process of upgrading production to quality coffee requires development of skills, practices, and knowledge that they do not have (Gereffi et al., 2014; Borrella et al., 2015). Therefore, the political sphere, which influences and is influenced by the personal sphere (worldviews and values), should be taken into account to address coffee cultivation as a complex socio-ecological process. Furthermore, financial returns to coffee farmers, public investment, new infrastructure and processing facilities establish a particular land use-regime or create a scenario for land use change. The political sphere is directly aligned with the role of stakeholders in quality coffee production in improving management of socio-ecological systems.

A key aspect of the three spheres framework is that the decisions and actions of actors within the political sphere are influenced by their subjective beliefs, values and worldviews, which may be in conflict with those of other actors (O'Brien and Sygna 2013). There is therefore a need to acknowledge these factors and how they influence actors within the political sphere in order to understand the practical dimensions of quality coffee production through land management and climate change adaptation. In this spirit, this study explored how stakeholders in the coffee sector were linked and interact with each other for quality coffee production.

2.3.2 Value chain: Concepts and dimensions

The term value chain refers to the full range of activities that are required to bring a product (or service) from conception through the different phases of production to delivery to final consumers and disposal after use (Riisgaard et al., 2010). Hence, a value chain describes the overall value-adding activities that are required to transform inputs into outputs, and a range of technical, financial and business service providers supports it (Gereffi, 2014). Furthermore, a value chain exists when all of the actors in the chain operate in a way that maximizes the generation of value along the chain. According to Grote and Winter (2009), through value chain approach, we may : (a) examine the core processes or value chain functions such as input supply, production, processing, marketing and consumption; (b) describe key value chain stakeholders, their interactions, power and interest within the value chain, and (c) evaluate supporting environments; i.e., policy and socio-economic contexts of the value chain .

More recently, the concept of value chains has been applied to cash crop production and processing that involve natural resources management practices (Dekens and Bingi, 2014; GEF-IFAD, 2015; Swinnen and Kuijpers, 2019). In the coffee sector, there are many benefits associated with taking a "value chain approach" to explore land use decisions and climate change adaptation actions because land use change and climate change affect stakeholders beyond the production fence lines, and calls for collaborative actions and decisions by stakeholders along the value chain (Waskow et al., 2013). For example, stakeholders other than producers can support coffee producers in adaptation and land management activities. As coffee value chains emphasis is on product differentiation (Daviron and Ponte, 2007), there is a growing willingness to pay for high quality coffee; and the demand for quality coffee is increasing with its implications to on-farm coffee management activities including land management and climate change adaptation.

Climate change adaptation and land use in the context coffee value chains is a relatively new, yet important, area of research, with majority of adaptation studies still focusing on on-farm adaptation practices. The value chain for coffee is particularly helpful in understanding the role of stakeholders in quality-maintaining practices in general and in sustainable land management in particular, due to the ecological significance of coffee production (Riisgaard et al., 2010). Quality coffee is an outcome from actors and efforts along the coffee value chain, and the enabling environment like institutional structures and markets, as coffee is a cash crop.

In line with the political ecology framework, the value chain is an appropriate approach to explore the roles of quality coffee production on land use and climate change adaptation through the two main dimensions, i.e., governance and upgrading. Governance and upgrading are important dimensions of value chains (Gereffi, 2014; Gereffi and Luo, 2015; Gibbon et al, 2008; Webber and Labaste, 2009). These are indicators of the role of value chain and its stakeholders in socio-ecological systems in general and in natural resources management activities for cash crop production in particular (Poole and Donovan, 2014). As such, options and interventions for improving the role of stakeholders in the coffee sector for natural resources management could be identified by taking into account the governance and upgrading systems of the coffee value chain.

The concept of governance is central to the value chain approach, which is used to refer to stakeholders' interactions and co-ordination of activities in the chain. This coordination is achieved by setting and enforcement of product and process parameters to be met by stakeholders (Humphrey and Schmitz, 2000). Gereffi (2014) identified two broad categories of governance structures namely, 'producer-driven' and 'buyer-driven' for global commodity chains. While producer-driven chains are common in capital- or technology-intensive industries controlled by upstream actors, downstream actors and labour-intensive sectors (Stamm, 2014) control the buyer-driven chains. The governance structure of many global agricultural commodities from developing countries (in which coffee is a typical example) is buyer–driven, where there is asymmetrical power relations in the coffee value chain with its effects on land use and adaptation practices for quality coffee production. Coffee production is also recognized for its stark social inequalities among stakeholders (Neilson and Pritchard, 2009). Buyers in the North retain as much as 75 per cent of the value, while the producers in the South are left with five to ten per cent of the market value of coffee (FAO, 2013).

Therefore, governance in the value chain can be understood as the power to define who and who does not participate in the chain, the setting of rules of inclusion, assisting chain participants to achieve standards set, and monitoring of performance. There is also differentiated power and interest among the different stakeholders along the value chain. A stakeholder analysis, which was undertaken to assess the role of stakeholders in quality coffee production in this study also operationalizes this dimension of the value chain. The production improvements called for by a buyer-driven demand for "quality coffee" require that both natural and social processes of coffee production are understood, and incorporated into decision-making by stakeholders across the value chain. Upgrading, in the value chain approach, refers to the paths stakeholders can follow to improve production processes and products. According to Webber and Labaste (2009), upgrading can be process upgrading; i.e., increasing efficiency, achieving standards and certifications of products, and/or product upgrading. Product upgrading refers to improving product quality such as through use of new variety for niche markets like quality coffee. Furthermore, there are functional upgrading which is operating at a new level in the value chain, and inter-chain upgrading which refers to moving the production system out of a chain into a new one.

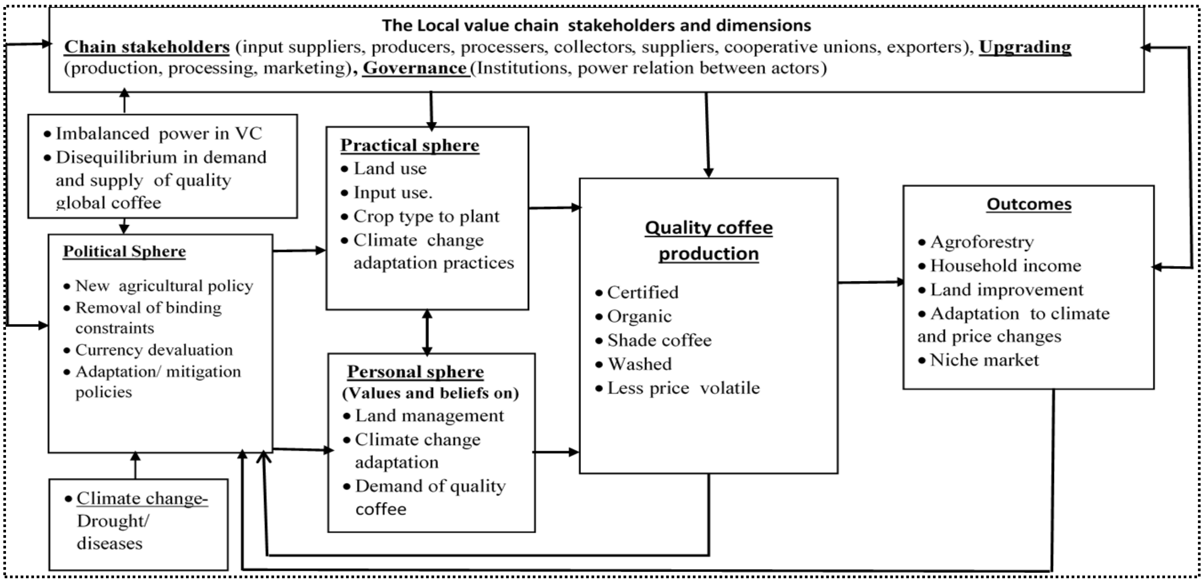


Figure 2: Conceptual Framework of the Study (developed based on literature review)

Process and product upgrading seem in line with the production of differentiated coffee; i.e., quality coffee for the coffee market, in contrast to the conventional coffee. Daviron and Ponte (2005) developed a typology of quality into material, symbolic and in-person service (see Section 2.1.4.3). These aspects of quality are attributable to the different upgrading activities in the coffee value chain. For example, some of quality coffee are distinguished by production standards, such as shade-grown, organic certified, and coffee with intellectual property rights based on their region of origin (Duguma, 2017). Therefore, while producers can improve value added to a certain degree by improving the ‘material’ quality of coffee, they will have to make efforts to natural resources management activities in the form of sustainable land management and climate change adaptation actions. On the other hand, coffee producers have much less control and access over other (‘symbolic’ and ‘in-service’) attributes dominated by actors downstream and where most value is added in the chain (Petit, 2007).

Whilst most studies conducted so far focus on the commodity coffee and related issues in smallholder producers, the socio-economic and environmental impacts of quality coffee production by smallholder producers have not been adequately covered by research (Kwast, 2010). Quality coffee markets that offer premium price for quality coffee improves both local livelihoods and agro-ecological conditions in the producing areas. Central to quality coffee production is coffee farm management and how the different stakeholders contribute to supporting coffee farmers in their quality coffee production activities.

REFERENCES

Adane, A. and Bewket, W. (2021). Effects of Quality Coffee Production by Smallholders on Local Land Use and Land Cover in Yirgacheffe, Southern Ethiopia. *Journal of Land Use Science*, *16*(2), 205-221.

Adimassu, Z., Kessler, A. and Stroosnijder, L. (2014). Farmers' Strategies to Perceived Trends of Rainfall and Crop Productivity in the Central Rift Valley of Ethiopia. *Environmental Development, (11), 123–140.*

Alemseged, A. and Yeabsira,Z (2014). Coffee export business in Ethiopia: Business start-up and operational manual. ECEA, Addis Ababa. 112

Amamo, A. A. (2014). Coffee Production and Marketing in Ethiopia. *European Journal of Business and Management*, *6*(37), 109–122.

Bacon, C. M., Sundstrom, W. A., Flores Gomez, M. E., Ernesto Mendez, V., Santos, R., Goldoftas, B. and Dougherty, I.(2014.) Explaining the "hungry farmer paradox": Smallholders and fair trade cooperatives navigate seasonality and change in Nicaragua's corn and coffee markets. Global Environmental Change, 25, pp.133–149

Bastin,A. and Matteucii,,N .(2007). Financing Coffee Farmers in Jimma Zone, Ethiopia: Challenges and Opportunities. International Conference on Rural Finance Research. Rome, Italy 19-21 March 2007

Bezabih, M., Abera, D., Adie, A., Lefore, N. and Jones, C. (2020). Analysis of stakeholders' roles and relationships in the feed value chain in Ethiopia. ILRI Discussion Paper 39. Nairobi, Kenya: ILRI.

Blaikie, P. and Brookfield, H. (1987). Land degradation and society. London: Methuen.

Blaikie, P., (1985). The Political Economy of Soil Erosion in Developing Countries, Longman Development Series, London

Bolwig, S., Gibbon, P., and Jones, S. A. M. (2009). The Economics of Smallholder Organic Contract Farming in Tropical Africa. *World Development*, *37*(6), 1094–1104.

Borrella, I., Mataix, C., and Carrasco-Gallego, R. (2015). Smallholder Farmers in the Speciality Coffee Industry: Opportunities, Constraints and the Businesses that are Making it Possible. *IDS Bulletin*, 46, 29–44

Bright, A. D., Cordell, H. K., Hoover, A. P., and Tarrant, M. A. (2003). *A Human Dimensions Framework : Guidelines for Conducting Social Assessments*.

Bryant,R.L. and Baily,S.(1997). Third World Political Ecology. Routlegde, London.

Bunn, C. (2015). *Modeling the climate change impacts on global coffee production. Pages: 20-30. PhD thesis*. 196. Retrieved from http://edoc.hu-berlin.de/dissertationen/bunn-christian. (accessed on 15.06.2015)

Bunn, C., Laderach,P., Ovalle Rivera, O. and Kirschke ,D.(2014). A bitter cup: climate change profile of global production of Arabica and Robusta coffee. Climatic Change, 129(1-2), pp.89–101.

Dalia,D.,Vera.,K.,Arttu,M.,Maija N. and Sun,Q.(2016). Is there a role for power relations in climate vulnerability and ecosystem service discourses? Final report of the Working Group 3 in the Helsinki University Centre for Environment workshop in 2016

Daviron, B. and Ponte, S. (2007). The Coffee Paradox: Global Markets, Commodity Trade and the Elusive Promise of Development - *The World Economy*, *30*(6), 1031–1032.

Dekens, J., and Bingi, S. (2014). *Agro-Value Chain Finance and Climate Adaptation: the role of the banking sector climate resilient value chains and food systems briefing note series* |. (June). Retrieved from www.iisd.org/gsi

Duguma, T. (2017). Value Chain Analysis of Ethiopian Coffee (Coffea arabica). *Archives of Current Research International*, *11*(1), 1–15.

Escobar,A.(1995).Encountering Development: The Making and Unmaking Of The Third World: Princeton University Press Princeton, New Jersey

FAO . (2013). FAO Statistical Yearbook, World Food and Agriculture.

Frank, E., Eakin, H. and López-Carr, D. (2011). Social identity, perception and motivation in adaptation to climate risk in the coffee sector of Chiapas, Mexico. Global Environmental Change, 21(1), pp.66–76

Fungo, B., Kamugisha, R., Wagoire, W. W., Scientist, R. And Tessema, B. G. (2013). *Significance of Social Networks in Sustainable Land Management in Central Ethiopia* *and Eastern Uganda*. *African Crop Science Journal*, (3), 735-749

GEF-IFAD. (2015). *Promoting a Value Chain Approach to Climate Change Adaptation in Agriculture in Ghana*. https://www.tetrapak.com/sustainability/environmental-impact/a-value-chain

Gereffi, G. (2014). A Global Value Chain Perspective on Industrial Policy and Development in Emerging Markets. *Duke Journal of Comparative and International Law*, *24*, 433–458.

Gereffi, G. and Luo, X. (2015). Risks and Opportunities of Participation in Global Value Chains. *Journal of Banking and Financial Economics*, *2*(4), 51–63.

Gibbon, P., Bair, J. and Ponte, S. (2008). Governing global value chains: An introduction. *Economy and Society*, *37*(3), 315–338.

Grote, U. and Winter, E. (2009). *Value Chain Analysis Methodologies in the Context of Environment and Trade Research Table of Contents*.

Grimble, R. and Wellard, K. (1997). *Stakeholder Methodologies in Natural Resource Management : a Review of Principles , Contexts , Experiences and Opportunities*. *Agricultural Systems*,*55*(2),173-193

Hernandez-Aguilera, J. N., Gómez, M. I., Rodewald, A. D., Rueda, X., Anunu, C., Bennett, R., … van Es, H. M. (2015). Impacts of smallholder participation in high-quality coffee markets: The Relationship Coffee Model. *Agricultural and Applied Economics Association and Western Agricultural Economics Association Annual Meeting*. http://ageconsearch.umn.edu/bitstream/205650/1/RCM_AAEA_2015_7_27_6255.pdf

Humphrey, J. and Schmitz, H. (2000). Governance and Upgrading in Global Value Chains. *Paper for the Bellagio Value Chain Workshop*, (April).

Hundera, K., Aerts, R., Fontaine, A., Van Mechelen, M., Gijbels, P., Honnay, O., & Muys, B. (2013). Effects of coffee management intensity on composition, structure, and regeneration status of Ethiopian moist evergreen afromontane forests. *Environmental Management*, *51*(3), 801–809.

Hurni, H. (2000). Assessing sustainable land management. Agricultural Ecosystem Environment. (81) 83–92.

Jaramillo, J., Chabi-olaye, A., Kamonjo, C., Jaramillo, A., Vega, F. E., Poehling, H., and Borgemeister, C. (2009). *Thermal Tolerance of the Coffee Berry Borer Hypothenemus hampei : Predictions of Climate Change Impact on a Tropical Insect Pest*. *4*(8), 1–11

Jena, P. R., Stellmache, T. and Grote, U. (2012). The Impact of Coffee Certification on Small-Scale Producers' Livelihoods: Evidence from Ethiopia. *Agricultural Economics*, *43*(49), 429–440.http://ageconsearch.umn.edu/bitstream/126720/2/IAAE paper-2012.pdf

Kassie, M., Zikhali, P., Pender, J., and Köhlin, G. (2010).The Economics of Sustainable Land Management Practices in the Ethiopian Highlands. Journal of Agricultural Economics, 61(3), 605–627

Kodama, Y. (2014). *New role of cooperatives in Ethiopia : the case of Ethiopian coffee farmers cooperatives*. (April).

Kufa, T. (2012). Recent coffee research development in Ethiopia, Presentation at the "Ethiopian Coffee Export Conference: Strengthening the Legacy of Our Coffee", November 8-9, 2012, Hilton, Addis Ababa

Kwast, H. (2010). *The coming specialty coffee supply crisis*. (August 2010), 1–69.

Lelea, M.A., Roba, G.M., Christinck, A. and Kaufmann, B.(2014). Methodologies for stakeholder analysis – for application in transdisciplinary research projects focusing on actors in food supply chains. German Institute for Tropical and Subtropical Agriculture (DITSL). Witzenhausen, Germany.

Lambin, E. F., Geist, H., and Rindfuss, R. R. (2006). *Introduction: Local processes with global impacts BT - land-use and land-cover change: Local processes and global impacts*.

Lambin, E. F., and Meyfroidt, P. (2011). *Global land use change , economic globalization , and the looming land scarcity*. *108*(9). https://doi.org/10.1073/pnas.1100480108

Lambin, E. F., Turner, B. L., Geist, H. J., Agbola, S. B., Angelsen, A., Folke, C., … Veldkamp, T. A. (2001). *The causes of land-use and land-cover change : moving beyond the myths*. *11*, 261–269.

Lenschow, A., Newig, J., and Challies, E. (2015). Globalization ' s limits to the environmental state ? Integrating telecoupling into global environmental governance telecoupling into global environmental governance. *Environmental Politics*, *00*(00), 1–24.

Lange, A., Siebert, R., and Barkmann, T. (2015). *Sustainability in Land Management: An Analysis of Stakeholder Perceptions in Rural Northern Germany*. 683–704.

Maertens, A., Barrett, C.B. (2012). Measuring Social Networks‟ Effects on Agricultural Technology Adoption. American Journal of Agricultural Economics, 95(2), 353–359

Meskela, T., and Teshome, Y. (2014). From economic vulnerability to sustainable livelihoods: The case of the Oromia coffee farmers cooperatives union (OCFCU) in Ethiopia. *International Food and Agribusiness Management Review*, *17*(SPECIALISSUEB), 103–108.

Minten, B., Dereje, M., Engida, E. and Tamru, S. (2019). Tracking the Quality Premium of Certified Coffee: Evidence from Ethiopia. *World Development*, *101*, 119–132.

Moat, J., Williams, J., Baena, S., Wilkinson, T., Gole, T. W., Challa, Z. K., … Davis, A. P. (2017). Resilience potential of the Ethiopian coffee sector under climate change. *Nature Plants*, *3*. https://doi.org/10.1038/nplants.2017.81

Neilson, J. and Pritchard, B.,(2009). Value Chain Struggles, Institutions and Governance in the plantation districts of South India First., Oxford: Wiley-Blackwell.

Nkonya, E., Pender, J., Kaizzi, K. C., Kato, E., Mugarura, S. and Ssali, H.(2008). Linkages between land management, land degradation, and poverty in sub-Saharan Africa: The case of Uganda. In *Research Report of the International Food Policy Research Institute*.

Nure, D. (2008). Mapping quality profiles of Ethiopian coffee by origin. In Adugna, G., Bellachew, B., Shimber, T., Taye, E., Kufa, T. (Eds). Coffee diversity and knowledge, Ethiopian Institute of Agricultural Research, Addis Ababa, Ethiopia: 317227

O'Brien, K. (2009). *Do values subjectively define the limits to climate change adaptation ?* 164–180.

O'Brien, K. and Wolf, J. (2010). *A values-based approach to vulnerability and adaptation to climate change*. *1*(April).

O’Brien, K. and Sygna, L. (2013). Responding to Climate Change: The Three Spheres of Transformation. *Proceedings of Transformation in a Changing Climate*, (June), 16–23.

Pender, J., Place, F., and Ehui, S. (2006). Strategies for Sustainable Land Management in the East African Highlands: Conclusions and Implications. *Strategies for Sustainable Land Management in the East African Highlands*, 377–415.

Petit, N. (2007). Ethiopia’s coffee sector: A bitter or better future? *Journal of Agrarian Change*, *7*(2), 225–263.

Ponte, S. (2002). *The ‘ Latte Revolution ’? Regulation , Markets and Consumption in the Global Coffee Chain*. *30*(7), 1099–1122.

Poole, N. and Donovan, J. (2014). Building cooperative capacity: the specialty coffee sector in Nicaragua. *Journal of Agribusiness in Developing and Emerging Economies*, *4*(2), 133–156.

Rahn, E., Läderach, P., Baca, M., Cressy, C., Schroth, G., Malin, D., Van Rikxoort,H. and Shriver, J.(2013. Climate change adaptation, mitigation and livelihood benefits in coffee production: where are the synergies? Mitigation and Adaptation Strategies for Global Change, pp.1–19

Ramankutty, N., and Coomes, O. T. (2016). *Land-use regime shifts : an analytical framework and agenda for future land- use research*. *21*(2).

Riisgaard, L., Bolwig, S., Ponte, S., du Toit, A., Halberg, N., and Matose, F. (2010). Integrating poverty and environmental concerns into value-chain analysis: A strategic framework and practical guide. *Development Policy Review*, *28*(2), 195–216.

Rueda, X., and Lambin, E. F. (2013). Linking Globalization to Local Land Uses : How Eco-Consumers and Gourmands are Changing the Colombian Coffee Landscapes. *World Development*, *41*, 286–301.

Stamm, A. (2004): Value chains for Development Policy: Challenges for the policy and the promotion of economic development, Materialien zum Handel, GTZ, Eschborn.

Shumeta, Z., Urgessa, K. and Kebebew, Z. (2012). Analysis of Market Chains of Forest Coffee in Southwest Ethiopia21 (3):357-370.

Swinnen, J., and Kuijpers, R. (2019). Value chain innovations for technology transfer in developing and emerging economies: Conceptual issues, typology, and policy implications. *Food Policy*, (83), 298–309.

Taylor, M. (2015). The Political Ecology of Climate Change Adaptation. Livelihoods, agrarian change and the conflicts of development, London, New York: Routledge, Earthscan.

Waskow, D., Jacoby Jonathan, Ocharan, J., de Messieres, S., GLucksman, S., Fischer-Mackey, J., … Woodward, S. (2013). *Value Chain Climate Resilience*. 1–41.

Webber, C. M., and Labaste, P. (2009). Building Competitiveness in Africa’s Agriculture. In *Building Competitiveness in Africa’s Agriculture*.

Zeleke, G., Kassie, M., Pender, J. and Yesuf, M. (2006). *Stakeholder Analysis for Sustainable Land Management in Ethiopia (SLM)*: Assessment of Opportunities, Strategic Constraints, Information Needs, and Knowledge Gaps. (January).

CHAPTER THREE …………………………………………………………………………..

EFFECTS OF QUALITY COFFEE PRODUCTION BY SMALLHOLDERS ON LOCAL LAND USE AND LAND COVER IN YIRGACHEFFE, SOUTHERN ETHIOPIA

Asnake Adane and Woldeamlak Bewket

Journal of Land Use Science, *16*(2), 205–221. https://doi.org/10.1080/1747423X.2021.1893844

3. Effects of Quality Coffee Production by Smallholders on Local Land Use and Land Cover in Yirgacheffe, Southern Ethiopia

Abstract

Environmental factors and human activities drive land use and land cover (LULC) changes at different spatial and temporal scales. The objectives of the study are to identify LULC types that have undergone changes due to quality coffee production, and assess smallholders' perceptions of the LULC changes associated with their coffee production practices in Yirgacheffe coffee area, southern Ethiopia. Yirgacheffe is known for forest coffee and natural forests that comprise the livelihood of smallholders. The study used Landsat satellite images of 1988, 2003 and 2018 to examine the LULC change. In addition, household surveys and focus group discussions were carried out to assess land management practices in the study area. The findings show that forest coffee (FC) cover decreased at a rate of 1.02% per year in the 30-year time, which was mostly changed to semi-forest and semi-plantation coffee cover. The study area has also experienced an increase in semi-plantation cover (0.07% per year), semi-forest coffee (0.9% per year) over the study period, showing a gradual decrease in vegetation cover. This also suggests that a major driving force for the local LULC change is the increasing demand for coffee in the global and national market, as evident from the increasing trend of coffee export from Ethiopia. Survey data show that quality coffee producers were more likely to undertake land management practices than the conventional producers. The study indicates that quality coffee production drives coffee agroforest conversion while it has effects on land management practices by smallholders. Reducing the current heavy dependence of the local economy- as well as the national economy- on coffee as the single most important commodity is likely to enhance sustainability of the coffee agroforests in the area.

Keywords: Quality coffee, smallholders, land use change, Yirgacheffe, Ethiopia

3.1 INTRODUCTION

Land use and land cover change broadly refers to modifications of the terrestrial surface of the Earth. It is driven by complex and interacting biophysical and socioeconomic factors operating at different scales of space and time (Lambin et al, 2001; Rahn et al., 2018). This is shown by many studies (e.g. Hailu et al, 2018; Hettig et al,2016 ; Woldu et al, 2015). For example, Hettig et al (2016) found that a combination of factors including soil suitability, terrain and distance to market significantly affected land use decisions in tropical coffee production areas . Other studies noticed upward shift of coffee production over time due to climate change in Ethiopia (Bunn et al, 2015). In addition to local biophysical and human factors, farmers’ land use decisions are also influenced by decisions and actions of other actors along the value chain of a coffee as a commodity. For some land users such as quality coffee producers, choices and decisions of global actors can influence local-scale land use decisions.

Ethiopia is one of the major coffee producing countries (Baker, 2015), and coffee plays a pivotal role in Ethiopian economy; it is the livelihood of more than 20% of the economically active population and contributes more than 25% of the country's foreign exchange earnings (Maskala and Teshome, 2014). In particular, as Ethiopia’s role in the global coffee market lies mainly on the fine quality of its coffee (Daviron and Ponte, 2007), its Qualitycoffee enjoys a high global demand in the global market. Haggar et al (2013) stated that the global demand for quality coffee affects land use decisions on coffee farms and thereby land use patterns and management options in Ethiopia.

Quality coffee refers to a single-origin and highest-grade, organically produced coffee, differentiated by its superior flavour and it claims price premiums (Minten et al, 2018; Ponte and Gibbon, 2005). Its production is a land resource-based activity and hence has different effects on land, forest and biodiversity resources (Daviron and Ponte, 2007). It also involves material variables (i.e. tools, cultivars, water and nutrients), structural variables (i.e. institutions and markets), and subjective factors, such as individual and shared values and beliefs. One such quality coffee producing areas is Yirgacheffee in Ethiopia, which produces quality coffee(as a variant of quality coffee) that fetches premium prices in the global market (Degefa, 2016). For this study, quality coffee is a type of quality coffee produced mainly for the global market by smallholders in Yirgacheffe.

Studies on effects of quality production on land use and management show mixed results. For example, Pender et al (2006) reported improvements in land management and land use in the highlands of central Kenya due to coffee production. In Uganda, adoption of organic land management practices and perceived improvements in resource and livelihoods were attributed to coffee and banana production (Nkonya et al., 2008). In contrast, there are other studies that found cash crop production to be negatively associated with sustainable land use practices (Hylander et al, 2013; Jassogne et al, 2013; Woldu et al., 2015). Hence, the effects of quality production on land use practices are site specific, despite there are global drivers to quality coffee production and associated land use change (Denu et al,2016; Gole,2015). Rueda and Lambin (2013) also stated that the main driver of LULC change in general is peoples' response to economic opportunities like demand for commodities facilitated by institutional factors.

There are many studies on LULC change in coffee producing areas of Ethiopia claiming that LULC change is generally due to proximate causes, such as expansion of agriculture, and underlying drivers like population growth, markets and cultural factors (Denu et al, 2016; Duguma et al, 2017; Kassa et al, 2016;Kebede et al., 2019; Kebede,2018; Wubie et al, 2016). In particular, it is evident that increasing yield and quality by gradually replacing forest coffee systems with intensified coffee plantations affects forest biodiversity in many coffee-producing areas of Ethiopia (Gole and Senbeta, 2008; Senbeta and Denich, 2006). However, there is no strong research evidence on distant factors for land use change in coffee producing areas (Friis, 2017; Nielsen et al, 2015). Thus, the trade-offs between increasing yield and quality driven by global demand and forest loss are not adequately researched and understood (Hylander et al, 2013). Indeed, none of the above-mentioned studies have focused on understanding effects of quality coffee production (as a spearhead of distant factors) on LULC change and hence there is dearth of information on effects of quality coffee production on local scale land use and land cover. Furthermore, the processes motivating land use decisions are very important and they are affected by land users' values and beliefs (Lambin et al, 2006). In Ethiopia, there is no study as far as we know it on the interaction between LULC change and land users' perceptions, values and belief systems.

The general objective of this paper is to assess LULC change associated with quality coffee production in Yirgacheffe area, Ethiopia. The specific objectives are to: (i) quantify LULC change between 1988 and 2018; (ii) understand effects of quality coffee production on land use and management practices; and (iii) assess perceptions and management practices of the smallholder producers in quality coffee production in the study area. The remainder of the paper is organized as follows. The second section describes materials and methods, and the third section presents results. Section 4 presents discussions. Conclusions and future research needs are presented in section 5.

3.2 RESEARCH METHODOLOGY

3.2.1 METHODS

The study is based on interpretation of satellite remote sensing images and socioeconomic data generated through household survey and field observation. While remote sensing provides a large spatio-temporal framework for LULC change detection, household survey and field observation provide insights into the more subtle human dimensions related to drivers and processes of LULC change (Jiang, 2003). The LULC change can be quantified by analysing satellite images. Surveys and interviews with local residents and stakeholders are crucial for understanding processes of changes that was missed in satellite images (Ambinakudige and Choi, 2009). This affirms that supplementing interpretation of remote sensing images with survey methods can improve understanding of extent of LULC change including its drivers and processes of change (Shrestha, 2000).

3.2.2. REMOTE SENSING IMAGE ANALYSIS

We used Landsat TM images to detect LULC change because of its free accessibility, while it has a good spectral and temporal resolution and moderate spatial resolution (Mihai, 2007). Three cloud free satellite remote sensing images: Landsat TM image for 1988, Landsat ETM+ for 2003 and Landsat 8 OLI/TIRS for 2018, with path/row 156/68 were downloaded from the USGS at http://www.earthexplorer.usgs.gov. We selected these years based on the following rationale. The 1988 image was taken because it was after 1989 that changes like establishment of market centres in rural areas to make local markets more competitive and promote quality coffee production were undertaken (Daviron and Ponte, 2007). The 2003 image was taken because quality coffee production was recognized in 2002 (Minten et al , 2018); and the 2018 image was taken to assess the recent status of coffee cover. The images used are of the same season (January and February) to minimize seasonal reflectance variations and hence reduce image misclassification.

The Landsat images were then layer stacked into single image for each year (Sarkar, 2018) and six band images (1- 5, and 7) were produced. Radiometric calibration was undertaken in ENVI (Environment for Visualizing Images) 5.3 software to convert digital numbers (DNs) into a more meaningful units of reflectance and hence to generate high quality scenes of the images. Atmospheric correction was also performed to minimize the atmospheric disturbances of signals reaching the sensors, and thereby to obtain accurate ground radiance from the target (Mihai et al, 2007). The images were then geo-referenced, and were projected into UTM Zone 37N and WGS 1984 datum; and image subsets were clipped for the study area, i.e, Yirgacheffe district.

The 1987 large-scale aerial photograph (1:50,000) was obtained from the Ethiopian Mapping Agency (EMA) and scanned in A3 format with resolution of 1200 dpi and radiometrically corrected to 8 bit resolution with grey scale; and, mono registration and orthorectifcation were performed in ERDAS IMAGINE 2014. The aerial photos were overlaid on a topographic map (1:50,000) which were also obtained from the EMA. Ground Control Points (GCPs) were collected based on the scanned and processed aerial photographs, with average 0.47 Root Mean Square Error, and had been used as a reference data for the 1988 and 2003 Landsat image classifications and accuracy assessment. In doing so, 250 samples for each LULC category were collected from aerial photos and Google Earth images; and 1250 reference points were collected, of which 850 and 400 were used for training samples and accuracy assessments, respectively. These samples were stored in Excel (csv format) and then imported into QGIS 3.16 to convert to shape files.

Supervised image classification with random forest algorithm was performed using Quantum Geographic Information system (QGIS 3.16) to prepare each land use class. Compared to the traditional and basic algorithms like maximum likelihood classification, random forest is one of the machine-learning algorithm that provides high accuracy results. The higher accuracy of RF was attributed to its ensemble manner in which several classification trees are trained on subsets of the training data (Abdullah et al,2019). A Random forest algorithm creates numerous decision trees for each pixel. Each of these decision trees votes on what the pixel should be classified, and the land cover class that receives the most votes is then assigned as the land use class for that pixel.

Since random forest's performance significantly depends on the predictor variables and training data quality, we included multiple types of auxiliary data, biophysical and spectral variables, both continuous and categorical, to improve classification performance and discrimination between LC classes. In addition to the six reflective Landsat bands (bands 1–5 and 7), we used Green Vegetation Index (GVI) since they are capable of discerning vegetation from bare features (Kolios and Stylios, 2013). In order to further enhance the representation of vegetation, we extracted the Normalized Difference Vegetation Index (NDVI). As multicollinearity affects the cofficients and p-values, but it does not influence the predictions (Hair et al,2019), and we attempted here to make only predictions of distribution of the coffee cover and not to interpret the regression coefficients of variables , while acknowledging the lowered level of overall predictive ability. As such, we may not need to check for it. Assuming that human activity and the artificial environment are linked to the existence of a road network, we derived distance from the road network layer based on the Euclidean distance function for each image (Gounaridis et al., 2016).

While the training samples for the 2018-image classification were obtained from a GoogleEarth high-resolution imagery downloaded via the open layers plugin for QGIS version 3.16, the aerial photographs were used for classification of the 1988 and 2003 images. Training points and predictor variable data were collated in a database. The set of predictor variables was extracted for each training polygon. Each training sample contained the information about every potential predictor variable as well as about the LULC classes based on the information from the polygons, and the classification process was implemented using the Random Forest in Olfeo toolbox in QGIS 3.16. Frequent field visits, and consultations with farmers and local experts were also performed to augment the image classifications. Finally, five main LULC classes were identified; forest coffee, semi-forest coffee, semi plantation, and grassland and built up areas (Table 1).

Accuracy assessment was performed to evaluate the degree of accuracy of the image classification. The accuracy assessment of 1988 and 2003 classifications were undertaken based on reference data from aerial photographs. The reference data for 2018 image classification were collected from Google Earth images of 2018, and from the field by using a hand held Global Positioning System (GPS). As it has already been mentioned, 400 reference points were used, and assigned proportionally to the size of each LULC class (FAO, 2016). Error matrices were generated for the maps; and the producer's, user's and overall accuracies were computed. While producer's accuracy is the number of correctly classified pixels in each class divided by the number of pixels classified in that class, the user's accuracy is a measure of correctly classified pixels in each class divided by the number of training samples in that class (Sarkar,2018). Overall accuracy is the total number of correctly classified pixels divided by the total number of sample points.

Table 1: Description of LULC classes identified in Yirgacheffe, southern Ethiopia

LULC type	Description
Forest coffee	Coffee area with natural forest dominated by native trees of 5 meters height and above; it includes the agroforest systems and canopy cover of 40% and above, with trees like *Birbira* (*Milita de ferruginea*), *Wanza* (*Cordia africana*), *Warka (Ficus vasta*), and *Sholla* (*Ficus sycomours*) and others like coffee and enset (*Ensete ventricosum*).
Semi forest coffee	Land cover with a canopy coverage of < 40% and consisting of mixed native shrubs of between 3–5 m height, and emerging tree seedlings in the understory are removed annually; the upper canopy is selectively thinned; and coffee seedlings are planted (Hundera et al., 2013).
Semi-plantation	Land under coffee production with very limited number of trees as shade, mainly managed by smallholders. This involves conversion of the forest similar to the semi forest coffee system, but more intensively, with systematic planting of coffee seedlings, improved coffee production system, and enset and annual crops.
Grassland	Areas covered with grass and small shrubs; used for communal grazing and covered with grass on seasonal basis.
Built-up areas	Land covered by urban centres and other man-made structures like coffee processing areas, small market centres, roads and settlements.

LULC changes between the periods considered were then detected from the classified images using the image difference formula (Mihai et al, 2007); i.e. $I = S_2 - S_1$; where I is the change detection, S_2 is the second image classification (latter year), and S_1 is the first image classification (earlier year). Change matrices were generated using cross tabulation in ArcGIS Spatial Analyst tool to assess from-to conversion among the LULC classes. Conversion map that shows gains, losses and persistence of LULC types for each period were computed.

3.2.3. Household survey

From a preliminary field visit, two different groups of coffee farmers were identified: quality and conventional coffee farmers. Quality coffee farmers are designated by the district coffee development department as certified organic producers, accredited to export their coffee product directly to roasters, and they possess landholding sizes of 2 ha and above; albeit not much greater than 2 ha as indicated in Table 6. Conventional farmers do not have these characteristics, and production not labelled as quality coffee. The vast majority of coffee producers in the study area are conventional; out of 4,309 farmers, only 120 were quality coffee producers. All of these 120 were included in the household survey sample.

To select a representative sample from the conventional group, we used the list of conventional coffee farmers from the district office. We took 232 samples (which is ~5.5%) from 4,189 farmers, using a systematic random sampling procedure. The overall number of survey participants was therefore 352. The household survey was conducted with household heads using a structured questionnaire and face-to-face interviews that took place from December 2018 to March 2019. The survey captured general information about respondents' household characteristics and demographics, and views on effects of quality coffee production on land use change, change in land area under coffee, and land management practices associated with coffee production. We also included questions about the global demand for coffee. The quantitative data generated by the household survey were analysed using percentages, cross tabulations and χ^2 tests to determine the association between type of coffee production, and farmers' views on the drivers of LULC change and land management practices.

3.2.4. Qualitative Data Collection

Focus Group Discussions (FGDs), key informant interviews and field observation were used to collect qualitative data. Four FGDs were conducted with 7-10 participants of different ages, men/women, quality, and conventional coffee farmers. The diversity of participants was maintained by consulting local experts. The FGDs were guided by checklists, and topics discussed included issues related to quality coffee production, land use decisions and land management practices. In-depth interviews were undertaken with extension workers and district experts using a checklist of questions about the effects of coffee production on land use and management practices. Field observation was undertaken on the sites of coffee production. In addition, secondary data from the district office were collected on the role of selected actors in coffee production.

Audio-recorders and digital cameras were used to gather oral and visual data. The audio-records were transcribed, interpreted and analysed. Analysis of the qualitative data involved coding, pinpointing to underlying concepts, building themes and explaining overarching themes about the settings of coffee production and land management practices.

3.3 RESULTS

3.3.1 IMAGE CLASSIFICATION

Table 2 shows results of accuracy assessment of the image classification. The user's accuracy of individual classes ranges from 86% for semi-forest coffee (SFC), semi-plantation coffee (SPC) in 1988, and built up area of 2003 to 95% for forest coffee (FC) in 2018. The producer's accuracy ranges from 88% for semi-plantation coffee (SPC) in 1988 to 95% for built up areas in 2003 and forest coffee in 2018.

A greater user's accuracy than producer's accuracy in most land use classes indicates a significant agreement between the map data and classified data (Sarkar, 2018). The overall accuracy was 88%, 89% and 92% for the 1988, 2003 and 2018 maps, respectively, and further analysis is possible (Rwanga and Ndambuki, 2017). The classified maps of the three years are shown in figure 3 and areas of the LULC classes are summarized in Table 3. The following section describes these results.

Table 2: Error matrix for the three image classifications

LULC types	1988		2003		2018	
	User's accuracy	Producer's accuracy	User's accuracy	Producer's accuracy	User's accuracy	Producer's accuracy
Forest coffee	0.93	0.91	0.88	0.89	0.95	0.89
Semi-forest coffee	0.86	0.89	0.88	0.91	0.92	0.96
Semi plantation coffee	0.86	0.88	0.92	0.89	0.88	0.88
Grassland	0.88	0.89	0.91	0.93	0.89	0.91
Built up areas	0.87	0.89	0.95	0.86	0.87	0.94
Overall accuracy	0.88		0.89		0.92	

3.3.2 LAND USE AND LAND COVER CHANGE

Period 1: 1988-2003

During this period, there was a significant decrease in forest coffee (FC) cover and an increase in semi-forest coffee (SFC) cover and semi-plantation coffee cover. Forest coffee represents the largest share (59.4%) in 1988, but declined with time being converted to semi forest and semi-plantation coffee cover. In particular, there is a decrease of forest coffee from 21,313.4 ha (59.4%) in 1988 to 13,054.3 ha (36.4%) in 2003.

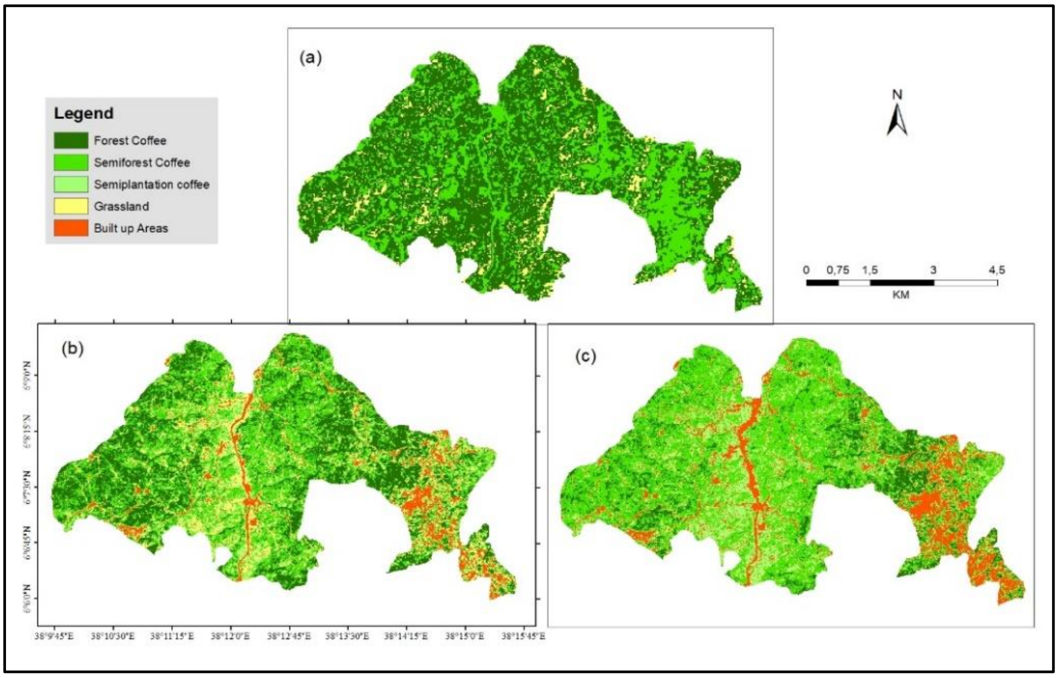


Figure 2: LULC of Yigracheffe in 1988(a), 2003(b) and 2018(c)

In contrast, semi-forest coffee expanded from 12,063.2 ha (33.6%) in 1988 to 21,199.7 ha (59.1%) in 2003. The increase in semi forest coffee cover can be attributed to the intensive coffee management practices over the 15-year time. The semi-plantation coffee cover showed a steady increase from 3.6 ha (0.01%) to 250.2 ha (0.7%) in coverage in this period. Consultations with experts and documents also indicated quality coffee production in the form of semi-plantation coffee in Yirgacheffe commenced in 2002. The total coffee cover increased from 33,380.2 ha (93.1%) in 1988 to 34,502.1 ha (96.2%) in 2003. This corresponds to the finding of Bunn et al (2015) which indicated expansion of coffee cover in Ethiopia, evidently stating that coffee yield decreased while production increased in the last three decade.

Regarding non-coffee land cover, while grassland cover decreased from 2,478.9 ha (6.9%) in 1988 to 1185.2 ha (3.3%) in 2003, built up areas, that include mainly roads and rural settlements, increased from 6.7 ha to 175.7 ha over this period. The greater decrease in grassland (1292.9 ha) and a slight increase in built up areas (169 ha) in this period that indicated the conversion of grassland to coffee coverage. The increase in built up areas is attributable to the expansion of settlements and roads spurred by population growth, which could in turn contributed to expansion of the semi-plantation coffee in the subsequent decades.

Table 3: LULC change in Yirgacheffe between 1988, 2003 and 2018

LULC types	1988		2003		2018		Annual change (1988-2018)	
	Area (ha)	% share	Area (ha)	% share	Area (ha)	% share	Area (ha)	% share
Forest coffee	21,313.4	59.4	13,054.3	36.4	10,388.5	28.6	-364.2	-1.02
Semi-forest coffee	12,063.2	33.6	21,199.6	59.1	21,450.3	60.5	313.1	0.9
Semi plantation	3.6	0.01	250.2	0.7	720.9	2.0	23.9	0.07
Subtotal	33,380.2	93.1	34,502.1	96.2	32,565.6	91.1	-27.4	-0.08
Grassland	2,478.1	6.9	1,185.2	3.3	2,985.2	8.3	16.2	0.1
Built up area	6.7	0.02	175.7	0.5	320.4	0.6	10.5	0.03
Subtotal	2,484.8	6.9	1,360.9	3.8	3,305.6	8.9	27.4	-0.08
Grand Total	35,865	100	35,865	100	35,865	100		

The change matrix (Table 4) over this period (1988-2003) depicted a remarkable increase in semi-forest coffee coverage (9,136.5 ha), with an annual rate of increase of 609.1 ha over the fifteen-year period. However, part of this was converted to forest coffee (1,882.7 ha), grassland (1,122.2 ha), semi-plantation coffee (179.4 ha) and built up areas (98.2 ha). Substantial shrinkage in forest coffee cover (8,258.9 ha) was also observed, with rate of 550.6 ha/year over this period. In addition, it gained area from built up area (0.4 ha), semi forest (1,882.7 ha) and grassland (745.6 ha). Asked about the gain from built up areas (atypical finding), key informants stated that some coffee processing stations (as built up areas) have been relocated to other areas due to environmental reasons, and those locations have been reforested since the 1990s.

The semi plantation coffee gained cover from forest coffee and semi forest coffee of 69.1 ha and 179.4 ha, respectively, and increased from 3.6 ha to 250.6 ha over this period. While grassland gained cover from forest (20.7 ha) and semi-forest coffee (1,122.2 ha), other parts of it were lost to forest (745.6 ha) and semi forest coffee (1,660.9 ha). Overall, grassland experienced remarkable loss over this period (decreased by 1,292.9 ha). Similarly, the built-up areas gained cover at the expense of forest coffee (41.2 ha), semi-forest coffee (98.2 ha) and grassland (29.5 ha) and thereby increased from 7.0 ha to 175.3 ha during this period.

Table 4: LULC change matrix between 1988 and 2003

LULC types	FC	SFC	SPC	GLD	BLA	Total-1988
Forest coffee(FC)	10,425.8	10,756.6	69.1	20.7	41.2	21,313.4
Semi-forest coffee (SFC)	1,882.7	8,780.7	179.4	1,122.2	98.2	12,063.2
Semi plantation (SPC)	-	1.6	1.9	0.1	-	3.6
Grassland(GLD)	745.6	1,660.8	-	42.2	29.7	2,478.1
Built up area(BLA)	0.4	-	0.2	-	6.4	7.0
Total- 2003	13,054.5	21,199.7	250.6	1,185.2	175.3	35,865

Period 2: 2003-2018

In this period, Table 3 shows that forest coffee cover further decreased from 13,054.3 ha (36.4%) in 2003 to 10,388.5 ha (28.9%) in 2018, and semi-forest coffee increased from

21,199.6 ha (59.1 %) to 21,450.3 ha (59.8 %). Semi-plantation increased to 720.9 ha (from 250.2 ha in 2003), mainly at the expense of forest and semi-forest coffee. This is partly due to the increasing demand of differentiated coffee that has stimulated intensification of coffee production since 2002. From the non-coffee covers, grassland and built up areas increased, i.e. from 1,185.2 ha (3.3%) in 2003 to 2,985.1 (8.3 %) in 2018 for grassland and from 175.7 ha (0.5%) in 2003 to 320.4 (0.9%) in 2018 for built up areas.

The LULC change matrix (Table 5) during this period indicated that area of semi-forest coffee was converted to forest coffee (2,259.3 ha), semi-plantation (606.7 ha), and grassland (2,221.13 ha) and built up area (30.8 ha). The most important contributor to the increased semi plantation coffee cover, which is a quality coffee production, is the semi forest coffee coverage (606.7 out of the 720.9 ha).

Grassland cover gained area mainly from semi-forest coffee (2,221.3ha) and simultaneously parts of it were changed into forest coffee (383.7 ha), semi plantation coffee (17.5 ha) and built up area (14.2 ha). A significant conversion of semi-forest coffee into grassland (2,221.3 ha) in this period highlights another path of forest degradation. Built up areas increased from 176.1 ha to 320.2 ha, gaining area from forest coffee (107.5 ha) and semi forest coffee (30.8 ha) that could be due to the expansion of settlement, roads, and rural schools and health centres. A network of roads may result in the expansion of human activities such as infrastructural development and urban expansion along with the removal of vegetation cover.

Table 5: LULC change matrix of between 2003 and 2018

LULC types(ha)	FC	SFC	SPC	GLD	BLA	Total-2003
Forest coffee(FC)	7,649.2	5,133.3	42.1	122.2	107.5	13,054.3
Semi-forest (SFC)	2,259.3	16,081.5	606.7	2,221.3	30.8	21,199.6
Semi plantation (SPC)	97.5	40.3	54.4	54.7	3.9	250.5
Grassland(GLD)	383.7	182.9	11.2	586.9	14.2	1,185.1
Built up area(BLA)	-	17.5	-	-	163.9	176.1
Total- 2018	10,388.7	21,450.3	720.9	2,985.1	320.2	35,865

From 1988 to 2018

As it can be seen from Figure 3, forest coffee decreased at 1.02%/year and semi forest coffee cover increased at 0.9%/year (figure 3a). Semi plantation coffee, grassland and built-up area showed only slight increases at rates of 0.07%, 0.1% and 0.03% per year, respectively. Besides, the semi-forest coffee cover increased remarkably by gaining area mainly from forest coffee, which went down substantially over the study period. The land covers of semi-plantation coffee, grassland and built up areas increased (figure 3b).

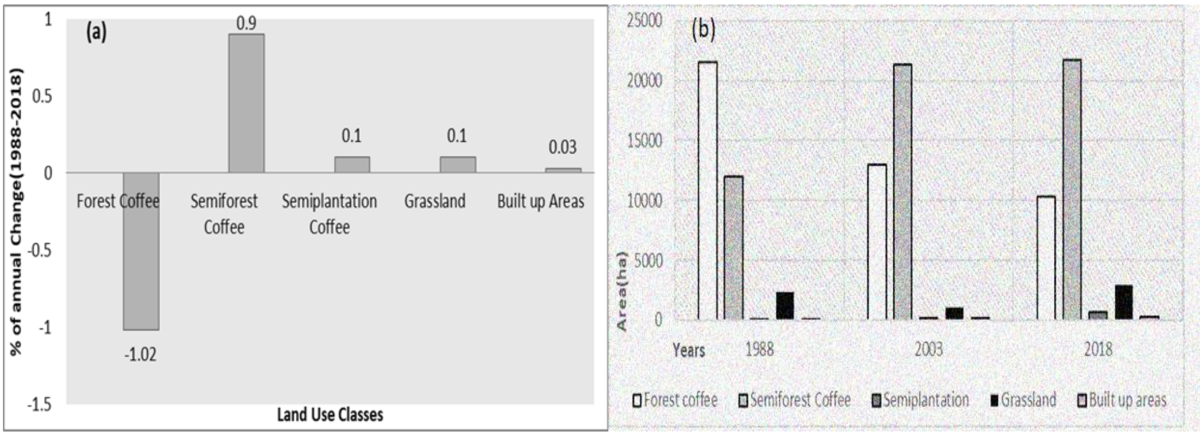


Figure 3: Annual rate (a) and patterns (b) of LULC change in Yirgacheffe (1988-2018)

Table 6 also shows that the difference between quality and conventional coffee production in terms of both yield and production amount is statistically significant. As shown in the Table, quality coffee farmers have higher production amount in the last 5 years than the conventional producers, with significant statistical difference ($t=21.5$, $p<0.001$). The average coffee yield in the last 5 years was also higher for quality coffee producers than the conventional producers with statistically significant difference ($t=9.7, p<0.001$), while there is statistically significant difference in landholding size($t=19.7, p<.000$).

Theoretically, scarcity of land and commodification are driving factors for intensification indicated by increased yield (Lambin et al,2001). In this vein, the quality coffee farmers with larger farm size than the conventional producers had higher yield. This implies that commodification of quality coffee production has been more intensified and resulted in conversion of forest coffee in to semi-forest and semi-plantation coffee over the study period.

Table 6: Average production and yield of coffee in the study area in the last 5 years

Variables	Quality coffee (Mean + SD)	Conventional coffee (Mean+ SD)	*t*	*Sig.*
Average production (Quintal)	15.2+6.0	4.7+3.9	21.5*	.000
Average Coffee Yield (KG/ha)	7.48+ 2.57	5.08+1.98	9.7*	.000

*Significant at 0.05 level of confidence

The results of the change detection (1988-2018) are presented for the five classes in figure 5. The figure reveals that many of the forest coffee areas in the 1988 have been converted into semi forest and semi plantation cover over the study period. Similarly, linear features on the map also indicated that the road networks including the highway (that largest linear feature traversing the study area from north to south). This implies that the expansion of roads and infrastructures contributed to the intensification of coffee production through the conversion of forest and semi-forest coffee covers into semi-plantation coffee.

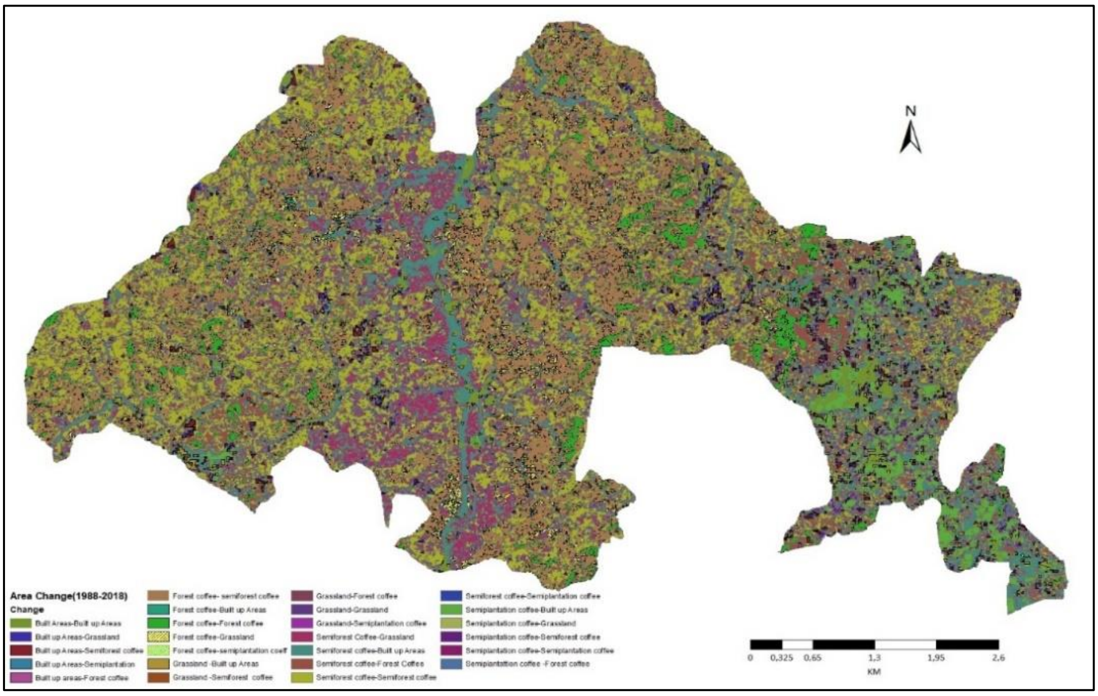


Figure 4: Land use/cover Conversion map of the study area (1988-2018)

3.3.3 LAND USERS' PERCEPTIONS OF LULC CHANGE

As shown in Table 7, about 37% of all respondents acknowledged that there had been an increase in quality coffee coverage over the last two decades, while a significant proportion (33.2%) of respondents did not recognize any change in quality coffee coverage in the study area. Among the quality coffee producers (n=120), about 49% perceived an increase in quality coffee coverage, whereas about 40% of conventional coffee producers reported no change in the quality coffee cover in the area. The Chi-square test also indicated significant difference between respondents of the two groups in terms of perception of land area change under quality coffee production (χ^2 =17.5, p < 0.001).

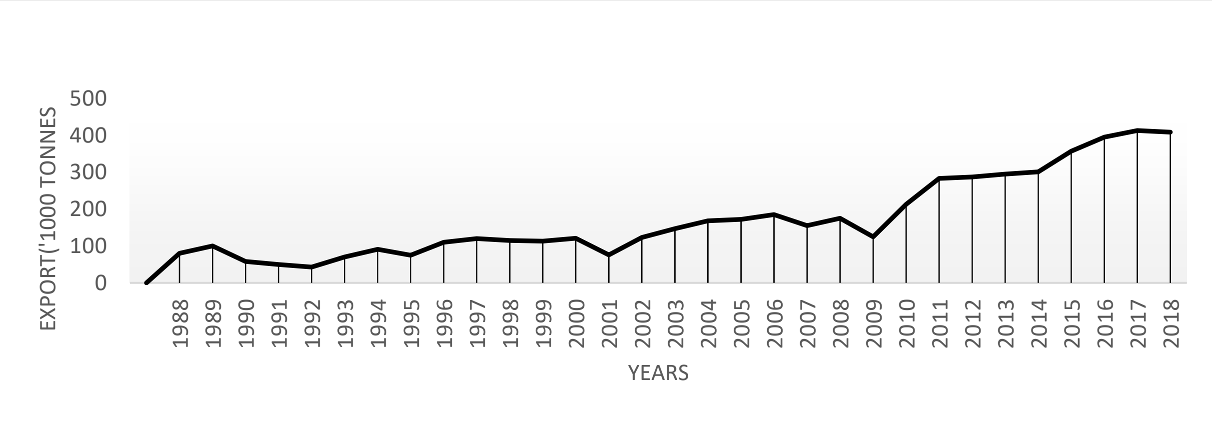
Table 7: Farmers' perceptions on quality coffee cover change (% of respondents)

Perceptions		Coffee production type		Total	
		Conventional (n=232)	Quality(n =120)	(N=352)	χ^2
Change in quality coffee cover	Decrease	16.8	18.3	17.3	17.5*
	No change	40.1	20.0	33.2	
	Increase	30.2	49.2	36.6	
	I do not know	12.9	12.5	12.8	
Causes of quality coffee cover change	Global demand	21.1	71.7	38.4	89.1*
	Domestic policies	45.3	10.0	33.2	
	National demand	28.9	16.7	24.7	
	Others(HH demand)	4.7	1.7	3.7	

*significant at $\leq$0.05 level of significance

About 72% of the quality coffee producers who perceived a change in area under quality coffee mentioned the increase in global demand of the coffee as a driver of LULC change. In contrast, only about 21% of the conventional coffee producers who perceived increases in land cover of quality coffee believed this was the reason for the land use change. The Chi-square test also revealed significant difference between respondents of quality coffee producers and conventional coffee producers in terms of perception on drivers of LULC in Yirgacheffe (χ^2=89.1, p< .001). Discussions with district experts revealed that the Ethiopian coffee sector felt the collapse of the International Coffee Agreement (ICA) in 1989 since coffee is a global commodity, although smallholders were believed to have a limited relationship to the global coffee market (Pender et al, 2006). Therefore, coffee farmers were encouraged to increase coffee yield and quality using different schemes of certification like organic produce.

Other reasons mentioned for the LULC change by the conventional coffee producers include domestic policies (46% of respondents) and national demands (29%).The same reasons were mentioned by only 10% and 17% of quality coffee producers, respectively. The influence of increase in local demand can indeed be significant, and could be a good opportunity for Ethiopian coffee market in case of global price fluctuations, as about 55% of the annual coffee production in the country is consumed domestically (Minten et al, 2018).



Source: FAOSTAT (2019)

Figure 5: Trend of quality coffee export from Ethiopia (1988-2018)

Figure 5 also indicated that the increasing trend of quality coffee export from Ethiopia over the 30 years of time. This could be the response to the global demand for quality coffee in the global market, and drive the land use change in many coffee producing areas of Ethiopia. This concords the perceptions of smallholder farmers (particularly the quality coffee producers) on the global demand for quality coffee as a driver for land use decisions and ensuing land use change in coffee producing areas.

3.3.4 Quality Coffee Production and Land Management

The main activities related to coffee production were assessed considering their potential to land management. The main benefit of implementing these land management practices is expected to be higher and more stable coffee yields, increased system resilience, therefore, enhanced the coffee livelihoods, and reduced production risk. In this section, we summarize findings from a field survey on specific land management practices undertaken by the conventional and quality coffee producers.

As shown in Table 8, about 68% of quality coffee producers reported that they undertook terracing as a main land management practice while a smaller proportion of conventional coffee producers (42%) implemented this practice. The Chi-square test also confirmed that there was significant difference between the two groups (χ^2=21.55, p<.001). The proportion of quality coffee producers constructing soil bunds on their coffee farms was larger (92%) than the conventional coffee producers (82%), with statistically significant difference (χ^2 = 5.99, p = 0.014). About 77% and 75% of quality coffee and conventional coffee producers practised mulching, respectively.

Table 8: Land management practices by smallholder coffee producers (% of respondents)

SN	Land management practices	Response	Coffee farmers (%)		χ^2	*Sig.*
			Conventional	Quality		
1	Terracing	Yes	42.2	68.3	21.55**	.000
		No	57.8	31.7		
2	Soil Bunds	Yes	77.6	88.3	5.99*	.014
		No	22.4	11.7		
3	Mulching	Yes	75.4	76.7	0.066	.797
		No	24.6	23.3		
4	Manure application	Yes	31.5	23.3	1.66	.197
		No	68.5	76.7		
5	Compost application	Yes	18.7	69.2	11.43**	.000
		No	81.3	30.8		
6	Intercropping	Yes	82.5	62.9	14.30**	.000
		No	37.1	17.5		
7	Annual crop rotation	Yes	83.0	46.6	16.30**	.000
		No	53.4	18.0		

*and ** significant at 0.05 and 0.01 level of significance.

Moreover, some 23% of quality and 31% of conventional coffee producers applied manure, respectively, with statistically no significant difference ($\chi^2 = 1.66$, $p = 0.197$). The proportion of quality coffee and conventional coffee producers intercropping coffee with annual crops were 63% and 83%, respectively. The Chi-square test indicated a significant difference existed in application of intercropping coffee with annual crops ($\chi^2 = 14.3$, $p<.001$). This confirms results of the LULC change analysis indicating that quality coffee production is a driver of intensification, shifting from mixed production to single (coffee) production.

While 69% of the quality coffee producers reported using compost on their coffee farms, fewer (19%) of the conventional coffee farmers used this land management practice, showing a significant statistical difference ($\chi^2 = 11.43$, $p< 0.001$). This was confirmed by field observation on how farmers prepare compost from mixing cattle urine, dung, ash, coffee husks, and leaves of *enset (E. ventricosum)* to produce organic coffee (Figure 6). About 83% and 52% of conventional and quality coffee producers implemented annual crop rotation, respectively, and the difference was statistically significant ($\chi^2 = 16.30$, $p < 0.001$). The low level of annual crop rotation for quality producers than for conventional coffee producers may be due to the intensification of production by quality producers.

Figure 6. Composting (2x2X1.5 m volume) by a quality coffee farmer

3.4 DISCUSSION

The LULC change analysis revealed a general trend of changes from forest coffee to semi-forest coffee as well as from forest and semi-forest to semi-plantation cover. In particular, the semi plantation coffee cover showed a high increase followed by semi forest coffee; whereas forest coffee cover showed a significant decline over the study period. These findings corroborate results of previous studies (Hylander et al, 2013; Gole and Senbeta, 2008; Senbeta and Denich, 2006) which reported that the traditional coffee production and management was replaced by intensive form of management in Ethiopia. This involves an effort to increase coffee productivity through the conversion of forest coffee into semi-forest coffee and then to semi-plantation system by way of removing competing undergrowth and canopy trees, leading to the loss of forest biodiversity. Farmers open up the canopy by thinning shade trees, and clearing the under-storey vegetation to increase coffee yield.

The remarkable increase of semi-plantation coffee cover could be due to the increasing global demand of quality coffee, as coffee is a global commodity, and subsequent increasing trend of quality coffee export over the study period. This highlights that the increasing demand of quality coffee in the global market influences smallholders' land use decisions and practices of land management. This agrees with several studies (Ambinakudige and Choi, 2009; Rueda and Lambin, 2013) that mentioned that global coffee markets have influences on land use decisions and practices by smallholders. Furthermore, while smallholders reflected a commonly held view on marked LULC change, variations were noticed between quality/quality and conventional coffee producers in terms of the drivers for the change. Quality coffee producers attributed the LULC change mainly to global drivers of LULC change, i.e demand for quality coffee in the global market whereas conventional coffee farmers were more likely to recognize domestic coffee market, as Ethiopia consumes about 50% of its annual production. This difference appears due to a closer linkage of quality coffee producers to the global market than the conventional group. This highlights that quality coffee production links smallholders in the remote south to consumers in the north, whilst smallholders are of limited voice in the global coffee market (Pender et al, 2006).

Although there is forest coffee loss due to quality coffee production, survey results indicated that quality coffee producers were more likely to perform some land management practices than the conventional producers. For instance, the quality coffee producers were more likely to uptake terracing, soil bund and compost than the conventional coffee producers. As the quality coffee producers endeavour to increase quality and yield of their coffee, and thereby meet the growing quality standards (e.g. organic), they undertake different land management practices, indicating that quality coffee production might positively influence coffee farm management. This finding agrees with previous studies (Hylander et al, 2013; Schroth et al. 2009), which claimed that quality coffee production contributes to sustainable land management.

3.5 CONCLUSIONS

This study provides evidence of LULC changes in Yirgacheffe district indicating that there were major LULC changes over the study period (1988-2018) showing that forest coffee has largely been converted into semi-forest and semi-plantation coffee cover. Global demand in quality coffee drives LULC changes as quality coffee production in Ethiopia is export oriented, and thereby exacerbate forest degradation with implications on smallholders' livelihoods and ecosystem services of the area. However, quality coffee producers were more likely to undertake land management practices than the conventional coffee producers, which reveals that quality coffee production might encourage land management practices at farm level while it exacerbates forest degradation through the conversion of forest and semi forest coffee to semi-plantation coffee cover at larger spatial scales. The increase of grassland cover (2003-2018) potentially has significant impact on forest degradation in the study area. This needs further study to 'net out' the trade-offs of quality coffee production vi-a-vis sustainable land management and deforestation. It was also found that global demand of quality coffee influences land users' decisions and practices by smallholders. Yet, this needs further study to understand to what extent the increasing demands for quality coffee influences such land use decisions. In terms of methods, this study demonstrates that integrated use of remote sensing image analysis and survey methods can better assess processes of land use change and quantify the changes.

Acknowledgments

We would like to acknowledge the Research Council of Norway for funding the Project 'The role of global value chains in transition to sustainability'. We also extend our sincere thanks to all data collectors, and farmers who took part in the surveys of the study.

REFERENCES

Abdullah, A. Y., Masrur, A., Sarfaraz, M., and Adnan, G. (2019). *Spatio-temporal Patterns of Land Use / Land Cover Change in the Heterogeneous Coastal Region of Bangladesh between 1990 and 2017*. 1–28. https://doi.org/10.3390/rs11070790

Alambo, F. I., and Yimam, H. A. (2019). *Elderly Care and Social Support Systems among the Gedeo of Southern Ethiopia : Socio-cultural Contexts , Forms , Dynamics and Challenges*.

Ambinakudige, S., and Choi, J. (2009). Global coffee market influence on land-use and land-cover change in the Western Ghats of India. *Land Degradation and Development*, *20*(3), 327–335.

Ayele, Y. Ewnetu, Z. Asfaw, Z. (2014). Economic Evaluation of Coffee-Enset - Based Agroforestry Practice in Yirgachefe Woreda , Ethiopia : Comparative Analysis with Parkland Agroforestry Practice. *Journal Sustainable Development*, *5*(27), 72–82.

Ayele, G., Hayicho, H., and Alemu, M. (2019). *Land Use Land Cover Change Detection and Deforestation Modeling : In Delomena District of Bale Zone , Ethiopia*. 532–561.

Baker, P. (2015). *Global Coffee Production and Land Use Change Global Coffee Production and Land Use Change*. (September 2014).

Bunn, C., Läderach, P., Ovalle Rivera, O., and Kirschke, D. (2015). A bitter cup: climate change profile of global production of Arabica and Robusta coffee. *Climatic Change*, *129*(1–2), 89–101. https://doi.org/10.1007/s10584-014-1306-x

Daviron B. and Ponte, S. (2007). The Coffee Paradox: Global Markets, Commodity Trade and the Elusive Promise of Development - *The World Economy*, *30*(6), 1031–1032.

Degefa, S. (2016). Home garden agroforestry practices in the Gedeo zone , Ethiopia : a sustainable land management system for socio-ecological benefits. *Socio-Ecological Production Landscapes and Seascapes in Africa*, (January 2016), 28–36.

Denu, D., Platts, P. J., Kelbessa, E., Gole, T. W., and Marchant, R. (2016). The role of traditional coffee management in forest conservation and carbon storage in the Jimma Highlands, Ethiopia. *Forests Trees and Livelihoods*, *25*(4), 226–238.

FAO. (2016). Map accuracy assessment and area estimation : a practical guide. *National Forest Monitoring Assessment Working Paper*, *E*(46), 69.

FAOSTAT. (2019). Accessed on February 2019 from www:fao.org/faostat//en/#data/.

Friis, C. (2017). *Land-use change in a telecoupled world : the relevance and applicability of* *the telecoupling framework in the case of banana plantation expansion in*. *22*(4).

Gole, T. W. (2015). *Environment and Coffee Forest Forum Coffee : Ethiopia ' s Gift to the World The traditional production*. 2–61. Retrieved from http://www.naturskyddsforeningen.se/sites/default/files/dokument-media/coffee_-_ethiopias_gift_to_the_world_ecff_2015 (accessed on 18.04.2018)

Gole, T. W., and Senbeta, F. (2008). *Sustainable Management and Promotion of Forest Coffee in Bale, Ethiopia*. (August), 44.

Gounaridis,D., Apostolou,A . and Koukoulas,S.(2016). Land cover of Greece, 2010: a semi-automated classification using random forests, Journal of Maps, 12(5), 1055-1062

Hailu, Y., Tilahun, B., Kerebeh, H., and Tafese, T. (2018). *Agricultural and Resource Economics : International Scientific E-Journal Agricultural and Resource Economics : International Scientific E-Journal*. *4*(4), 20–30.

Hair, J.F., Black, W.C., Babin, B.J., Anderson, R.E. (2019). Multivariate Data Analysis. 7th ed. Cengage learning, New York, USA

Haggar, J., Medina, B., Aguilar, R. M., and Munoz, C. (2013). Land use change on coffee farms in southern guatemala and its environmental consequences. *Environmental Management*, *51*(4), 811–823. https://doi.org/10.1007/s00267-013-0019-7

Hettig, E., Lay, J., and Sipangule, K. (2016). Drivers of households' land-use decisions: A critical review of micro-level studies in tropical regions. *Land*, *5*(4).

Hundera, K., Aerts, R., Fontaine, A., Van Mechelen, M., Gijbels, P., Honnay, O., and Muys, B. (2013). Effects of coffee management intensity on composition, structure, and regeneration status of Ethiopian moist evergreen afromontane forests. *Environmental Management*, *51*(3), 801–809. https://doi.org/10.1007/s00267-012-9976-5

Hylander, K., Nemomissa, S., Delrue, J., and Enkosa, W. (2013). Effects of coffee management on deforestation rates and forest integrity. *Conservation Biology*, *27*(5), 1031–1040.

Jassogne, L., van Asten, P. J. A., Wanyama, I., and Baret, P. V. (2013). Perceptions and outlook on intercropping coffee with banana as an opportunity for smallholder coffee farmers in Uganda. *International Journal of Agricultural Sustainability*, *11*(2), 144–158.

Jiang, H. (2003). Stories remote sensing images can tell: Integrating remote sensing analysis with ethnographic research in the study of cultural landscapes. *Human Ecology*, *31*(2), 215–232.

Kassa, H., Dondeyne, S., Poesen, J., Frankl, A., and Nyssen, J. (2016). *transition from forest-*

based to cereal-based agricultural systems : a review of the drivers of land use change and degradation in southwest ethiopia.

Kebede, A. S. (2018). Assessment of Land Use / Land Cover Change Using GIS and Remote Sensing Techniques : A Case Study of Dendi District , Oromiya Regional State , Ethiopia. *Journal of Environment and Earth Science*, *8*(1), 123–128.

Kebede, Y., Baudron, F., Bianchi, F. J. J. A., Tittonell, P. (2019). *Drivers , farmers ' responses and landscape consequences of smallholder farming systems changes in southern Ethiopia*. *5903*. https://doi.org/10.1080/14735903.2019.1679000

Kolios, S. and Stylios, C. D. (2013). Identification of land cover/land use changes in the greater area of the Preveza peninsula in Greece using Landsat satellite data. Applied Geography, (40) 150–160.

Lambin, E. F., Geist, H., and Rindfuss, R. R. (2006). *Introduction: Local processes with global impacts BT - land-use and land-cover change: Local processes and global impacts*. https://doi.org/10.1007/3-540-32202-7_1

Lambin, E. F., Turner, B. L., Geist, H. (2001). *The causes of land-use and land-cover change : moving beyond the myths*. *11*, 261–269.

Legesse, A., Teferi, B., Baudouin, A. (2013). Indigenous agroforestry knowledge transmission and young people ' s participation in agroforestry prac- tices : The case of Wonago Woreda ,. *Acta Geographica-Trondheim*, (26).

Meskela, T., and Teshome, Y. (2014). From economic vulnerability to sustainable livelihoods: The case of the Oromia coffee farmers cooperatives union (OCFCU) in Ethiopia. *International Food and Agribusiness Management Review*, *17*(SPECIALISSUEB), 103–108.

Mihai, B., Savulescu, I., and Sandric, I. (2007). Change Detection Analysis (1986–2002) of Vegetation Cover in Romania. *Mountain Research and Development*, *27*(3), 250–258.

Minten, B., Dereje, M., Engida, E., and Tamru, S. (2018). Tracking the Quality Premium of Certified Coffee: Evidence from Ethiopia. *World Development*, *101*, 119–132.

Nielsen, J. Ø, Friis, C., Otero, I., Haberl, H., Hostert, P., … Haberl, H. (2015). *in land system science From teleconnection to telecoupling : taking stock of an emerging framework in land system science*. (November). https://doi.org/10.1080/1747423X.2015.1096423

Nkonya, E., Pender, J., Kaizzi, K. C., Kato, E., Mugarura, S. and Ssali, H.(2008). Linkages between land management, land degradation, and poverty in sub-Saharan Africa: The case of Uganda. In *Research Report of the International Food Policy Research Institute*.

Pender, J., Place, F., and Ehui, S. (2006). Strategies for Sustainable Land Management in the East African Highlands: Conclusions and Implications. *Strategies for Sustainable Land Management in the East African Highlands*, 377–415.

Ponte, S. and Gibbon, P. (2005). Quality standards, conventions and the governance of global value chains. *Economy and Society*, *34*(1), 1–31.

Rahn, E., Liebig, T., Ghazoul, J., Asten, P. (2018). Agriculture , Ecosystems and Environment Opportunities for sustainable intensi fi cation of co ff ee agro-ecosystems along an altitudinal gradient on Mt . Elgon , Uganda. *263*, 31–40.

Rueda, X., and Lambin, E. F. (2013). Linking Globalization to Local Land Uses : How Eco-Consumers and Gourmands are Changing the Colombian Coffee Landscapes. *World Development*, *41*, 286–301. https://doi.org/10.1016/j.worlddev.2012.05.018

Rwanga, S. S., and Ndambuki, J. M. (2017). *Accuracy Assessment of Land Use / Land Cover Classification Using Remote Sensing and GIS*. 611–622.

Sarkar, A. (2018). Accuracy Assessment and Analysis of Land Use Land Cover Change Using Geoinformatics Technique in Raniganj Coalfield Area , India. *Environmental Sciences and Natural Resources*, *11*(1), 555805. https://doi.org/10.19080/IJESNR.2018.10.555805

Senbeta, F. and Denich, M. (2006). Effects of wild coffee management on species diversity in the Afromontane rainforests of Ethiopia. Forest Ecology and Management 232:68-74.

Shrestha, M. (2000). *Integrating Household and Community Data with Remote Sensing Applications to Detect Land-use and Land-cover Change in Lamjung , Nepal*.

Woldu, Z., Belew, D., and Benti, T. (2015). *The Coffee-Khat Interface in Eastern Ethiopia : 5*, 149–169.

Wubie, M. A., Assen, M., and Nicolau, M. D. (2016). Patterns , causes and consequences of land use / cover dynamics in the Gumara watershed of lake Tana basin , Northwestern Ethiopia. *Environmental Systems Research*, 1–12. https://doi.org/10.1186/s40068-016

Yilma, T. (2001). Coffee-Ensete-Livestock interaction for sustainable livelihood in the Sidama area of southern Ethiopia. *Journal of Agriculture in the Tropics and Subtropics*, *102*(2)

CHAPTER FOUR………………………………………………………………………

COFFEE FARMERS' PERCEPTIONS AND METEOROLOGICAL EVIDENCES IN YIRGACHEFFE, SOUTHERN ETHIOPIA

Asnake Adane[1] and Woldeamlak Bewket[1]

Submitted to a Journal and being reviewed: *Climate Action*

4. **Coffee Farmers' Perceptions and Meteorological Evidences of Local Climate Change in Yirgacheffe, Southern Ethiopia**

Abstract

Climate change has posed formidable challenges to the coffee sector while the extent of impacts experienced and perceived by farmers varies across the livelihoods. The objectives of the study are to investigate coffee farmers' perceptions and meteorological evidences, to make comparative assessment between data from the two sources in Yirgacheffe coffee area, Southern Ethiopia. The study used in-depth interviews, participatory observation and household surveys with coffee farmers stratified into speciality and conventional coffee farmers. Chi-square tests were used to identify the associations between coffee production types and coffee farmers' climate change perceptions. In addition, annual and seasonal patterns of historical data on rainfall and air temperature (1988-2018) were analysed to estimate trends and compare with coffee farmers' perceptions. Mann–Kendall's test and Sen's slope estimator were also used to analyse meteorological data. The findings show that coffee farmers perceived climate change, and recognized increasing temperature, delayed rainy season onset, frequent occurrence of dry spells, and early offset of the rainy season in the study area. The Chi-square tests showed that climate change is more widely perceived in terms of its signals and impacts by specialty coffee farmers than conventional coffee producers. The analyses of meteorological data (1988-2018) also indicate that the mean annual maximum, mean annual minimum and annual mean temperatures increased at rates of 0.01, 0.03 and 0.02^{0}C per year, respectively. Farmers' perception of increasing air temperatures was consistent with the meteorological observations, but that of decreased rainfall was not. Enhancing the knowledge base through coordinated research with local smallholder farmers and scientific knowledge will be important to narrow the existing knowledge gaps between the scientific community and farmers about climate change, and then enhance coffee livelihood sustainability.

Keywords: climate change, coffee farmers' perception, coffee production, Ethiopia, meteorological data, Yirgacheffe,

4.1 INTRODUCTION

Climate change is a global threat that negatively affects both human and natural systems. The negative effects are projected to be most severe for Africa, and it is being manifested by increasing variability of rainfall and rising temperatures (Maddison, 2007; Anyah and Qiu, 2012). In particular, the livelihoods of rural households in sub-Saharan Africa are heavily reliant on their natural resource base and the availability of such resources is dependent on the climate of the region. Africa’s agricultural system is heavily dependent on rainfed, small-scale agriculture, hence it is one of the most exposed regions to climate change impacts (Moore et al., 2012). In the climatically more variable regions of eastern Africa, where coffee productions occur in smallholders based on rain fed agriculture, the impact of climate change is unprecedented (Jaramillo et al., 2011; Bunn et al., 2015).

The study of coffee farmers perceptions on local climate change is crucial for climate sensitive rural livelihoods including coffee production by smallholder coffee farmers. Moreover, the changing spatio-temporal patterns of the individual climatic variables are region as well as local specific, and vary from one area to another (Amiri and Mesgari, 2019) because climate variables vary in time and space, and their spatiotemporal characters depends on spatial and temporal scales. The perceptions on local climate change influences the perceived vulnerability to the effects of climate change that might to exceed that of actual vulnerability posed by the changing climate. However, the majority of the previous studies in climate trend analysis focused on trend detection of the main climate variables such as precipitation and temperature at larger spatial scale. Therefore, studying the spatial and temporal variability of climate variables at local can play important roles in decision-making procedures for agrarian economy (Amiri et al, 2017).

The coffee sector, which is the most important source of foreign exchange earnings and a key source of livelihood to millions of smallholders in many developing countries, is highly vulnerable to climate change. Smallholder farmers, also known as smallholder farmers, manage low productivity farming systems with low yield and quality of production. They often cultivate less than two hectares of cropland and depend on household members for most of the labor and they typically have access to limited resources like land, capital, technological skills, and labor (Maddison, 2007). Studies (eg.,Jaramillo et al., 2011; Rahn et al., 2014) noted that coffee plants are highly sensitive to climate in terms of yield and quality; hence, climate change can have a detrimental effect on local and national economies of many coffee producing countries.

Ethiopia has already experienced remarkable climate change, and the mean annual temperature has increased by 1.3°C between 1960 and 2006, at an average rate of 0.28^{0}C per decade (Mcsweeney et al., 2010). The same study also has indicated increasing temperature in Ethiopia has been most rapid from July to September, at a rate of 0.32˚C per decade. The mean annual temperature has been projected to go up 1.1-3.1ºC and 1.5-5.1ºC by 2060 and 2090, respectively (Moat et al 2017); albeit there are marked microclimatic variations. Climate change has posed a formidable challenge to Ethiopia's agriculture in general and coffee production in particular.

Coffee has an important place in the Ethiopian economy. Coffee production is considered a nationally strategic activity as it contributes up to 50% and more than 25% of the country´s export and foreign exchange earnings, respectively (Minten et al., 2018) and provides livelihood to about 15 million Ethiopians; from which about 5 million smallholders produce 95% of the country's total production. Coffee agroforests also provide significant benefits for biodiversity and local climate systems (Nigatu et al., 2017), although this role is increasingly threatened by the intensification of coffee production systems. Climate change affects coffee production and it has been a setback for coffee producers to meet their livelihood needs (Davis et al., 2012; Moat et al., 2017; Minten et al., 2018).

Coffee crops are highly sensitive to climate change with respect to yield and quality. The effect is severe for Arabica coffee as well as quality coffee that require narrow ecological conditions (Ebisa, 2017; Rahn et al., 2018), such as altitudinal range (1,400-2,200 m asl), annual rainfall (1,500-3,000 mm) with distinct dry and rainy seasons, and annual mean temperature of 15-23ºC. Quality coffee refers to a single-origin and is of highest-grade, organically produced coffee, differentiated by standards (e.g., superior flavour) and claims price premiums (Meskela and Teshome, 2014). Its production involves material variables (e.g. tools, cultivars, inputs), structural factors (e.g. institutions and market), and cultural preferences including values and beliefs (Ponte and Gibbon, 2005). This study also mentioned that consumers have a multidimensional concept of quality, which includes physical variables, but not limited to, also determined by the traditions and experiences of coffee producers.

The type of agricultural production farmers engaged may provide an important context in which people experience climate change, and thus may influence perceptions on climate change. As coffee is a climate sensitive crop, smallholder coffee producers’ perceptions might offer a deeper insight into the manifestations of climate change and its effects in coffee producing areas than other actors in the coffee sector(Altea and Altea, 2019). Perception is the ability to become aware of something/ stimulus (Rogers and Curtis, 2012), and a way of regarding or interpreting something. Human perception of climate change is a prerequisite to adaptation, and it is shaped by varying cognitive structures that emanate from lived experiences (Mugagga, 2017). Farmers’ perceptions of climate change and the adaptive measures they take to address climate variability are crucial for agricultural development and local livelihoods (Grothmann and Patt, 2005).

Many studies in Ethiopia have examined the actual effects of climate change on coffee production (Davis et al., 2012; Gole, 2015); others looked into predicted impacts (Moat et al., 2017; Nigatu et al., 2017); and others studied structural setbacks to the coffee sector, such as paradoxs in the global coffee marketing (Daviron and Ponte, 2005). Overall, these studies focused on biophysical responses and economic valuation of coffee in the face of climate change. Studies on local level climate and the subtle human dimensions of climate change remain inadequate.Hence, the novelity of this study lies on its attempt to investigate the more suble human dimensions, i.e., smallholders’ values, beliefs and perceptions on climate change and compare them with the meteorological evidences.

The general objective of this paper was to assess farmers' perceptions of climate change. The specific objectives were: (i) to understand smallholder coffee producers’ perceptions of local climate change; (ii) to examine effects of quality coffee production on climate change perceptions and (iii) to compare farmers’ perceptions with meteorological observations of rainfall and air temperature. The remainder of the paper is organized as follows. The second section describes materials and methods, the third section presents results, and the section 4 presents discussions. Conclusions and future research needs are presented in section 5.

4.2 METHODS

4.2.1 SURVEY DATA COLLECTION AND ANALYSIS

From a preliminary field visit, two different groups of coffee farmers were identified: speciality and conventional coffee farmers. Speciality coffee farmers are designated by the district coffee development department, and met the following criteria, among the others: (i) coffee is grown with only organic inputs for three years prior to certification; (ii) farmers with detailed records of methods and materials used in coffee production; and (iii) a third-party certifier annually inspects all methods and materials for production. Conventional farmers do not have these characteristics, and their production is not labelled as specialty coffee. The vast majority of coffee producers in the area are conventional; out of 4,309 farmers, only 120 were speciality coffee producers. All of these 120 were included in the household survey for this study.

To select a representative sample from the conventional group, a list of conventional coffee farmers from the district office was used and 232 sample coffee farmers were chosen from the 4,189 farmers (5.5% of the conventional coffee farmers) using a systematic random sampling procedure, and proportionally allocated to the four *kebeles* (sub-districts). The overall number of survey participants was therefore 352. The researcher and research assistants conducted the household survey with household heads using a structured questionnaire and face-to-face interviews that took place from December to March 2018.

The survey questionnaire was designed after review of literature on farmers' perceptions of climate in Ethiopia as well as Africa coffee farmers, and then pretested in the study area to identify potentially unclear questions. Then the questions and methods were tailored to local circumstances of coffee production. The survey data was analysed in the following strands: (i) whether there is climate change in view of coffee farmers' perspectives over the last two decades; (ii) potential differences in perceptions between speciality and conventional coffee producers and (iii) comparison of perceptions of coffee farmers with the meteorological data. The Chi square test was used to determine significance of differences in perception of climate change between the speciality and conventional coffee producers.

4.2.2 Qualitative data collection and analysis

Focus Group Discussions (FGDs), in-depth interviews and field observation were employed to collect qualitative data, as these methods guide us to explore similar questions with all participants, but with the flexibility for asking further questions in order to clarify responses. Four FGDs were conducted with 7-10 participants of different ages, males and females, speciality, and conventional coffee producers. For in-depth interviews, 16 farmers were selected, four from each of the four sub-districts. Interviews with seven experts (one from each of the four sub districts, two from the district and one from the Zone level) were also conducted. The diversity of participants in the FGDs and in-depth interviews was maintained by consulting local experts. They were selected on a purposive sampling procedure, including both males and females aged between 28 and 79, with a good and long-term knowledge of the area. Information about the good knowledge of the respondents about the area was obtained from the local coffee offices. Field observations were undertaken on the sites of coffee production to gather information about the perception of coffee farmers on the local climate conditions in association with coffee production, which was lasted for a month. In addition, secondary data from the district office were collected on the role of select personnel such as district offices in coffee production.

The FGDs and in-depth interviews were guided by checklists and include questions on: (i) How would you describe climate change? (ii) What do you think are the main indications of climate change? and (iii) What are the impacts of the changes on coffee production? (iv) How do you perceive the seasonal and annual variations of rainfall in your area? The interview questions were pre-tested with some participants during the preliminary field visit and some changes were made to fit local circumstances. The interviews were continued until theoretical saturation was reached, there was a repetition in the expression of themes and little new information was expressed (Skovdal and Cornish, 2015). All interviews were conducted in Amharic language, since all the interviewees spoke the language. Audio-recorders and digital cameras were used to gather oral and visual data, and those were transcribed later, interpreted and analysed.

Analyses of the qualitative data involved coding, searching for underlying concepts, building themes and explaining overarching themes about the settings of coffee production and climate change perceptions. Finally, the different themes were related to relevant literature on climate change perceptions and observations.

4.2.3 Meteorological data analysis

Meteorological data for rainfall and air temperature from a nearest station (Dilla at $6^0$20'N and $38^0$20'E, altitude of 1,579 masl, 13 km from the study area) were analysed to compare farmers' perceptions with any measured changes in rainfall and air temperature data. As in many areas in developing countries (Burgan and Aksoy, 2018), Yirgacheffe district is ungauged. With the need to assess the meteorological evidences at local level and compare the evidences with the perceptions of coffee farmers, the study resorted to take data from the nearest meteorological station (Dilla); which is a possible meteorological representation of the study area. Here meteorological records extended from 1988 to 2018 were taken and data pre-processing was undertaken.

The study area (with an area of about 358.65 km^2 and a flat physiographic unit of altitudinal range 1501-2300m asl) is found in a single agro-ecological zone -humid temperate zone (Negash 2007), and there is no other meteorological station in the zone. This shows that there is very sparse distribution of meteorological station in Ethiopia. Also, a meteorological station in a flat physiographic unit and humid climate can represent an area of about 900-3000km^2 (WMO, 2008c). Thus, considering these constraints and the recommendation from WMO, it would scientifically sound to use climate data from one station to compare it with the coffee farmers' perceptions; as the major objective of this study is to have an insight into local meteorological evidence and compare it with coffee farmers' perceptions.

To see the presence of trends in both annual temperature and rainfall data, we used non-parametric Mann–Kendall (MK) test statistic and Sen's estimator test, that are the most commonly used methods for similar purposes (Ayanlade et al., 2017; Sridhar and Raviraj, 2017). Positive (+) values indicate an increase in constituent concentrations over time, while negative (-) values show a decrease (Manfred and Wegener, 2010). The strength of the trend is proportional to the magnitude of the Mann-Kendall Statistic (large magnitudes indicate a high trend). The Z score was computed and the confidence limits of the standard normal Z was equally determined. For a ranked set of observations n, X = x_1, x_3. . . xn, the MK trend statistic S was computed using

The Mann-Kendall statistics "S" was computed by the formula:

$$S = \sum_{i=1}^{n-1} \sum_{j=i+1}^{n} sgn\left(x_j - x_i\right) \quad (1)$$

Where x_j are the sequential data values, n is the data length of the time series, and

$$sgn\left(x_j - x_i\right) = \begin{cases} 1\ if\ \ x_i > x_j \\ 0\ if\ x_i = x_j \\ -1\ if x_i\ < x_j \end{cases} \quad (2)$$

The significance of a trend is calculated by the Z-score using:

$$\begin{cases} \quad o \\ Z = \frac{s-1}{\sqrt{var(s)}}, if\ s > 0 \\ Z = 0, \quad\quad if\ s = 0 \\ Z = \frac{s+1}{\sqrt{var(s)}},\ \ if\ s < 0 \end{cases} \quad (3)$$

When Z value exceeds either of the confidence limit lines, it shows a significant trend at a given significance level.

The Sen's slope estimator (SSE) was employed to estimate the magnitude of the trends in the time series data (Sen, 1968). Thus, if a linear trend exists in a time series, then the true slope of the trend is estimated using a Sen-Theil trend line (Theil, 1950) an alternative to linear regression, in combination with the MK test. The slope (T_i) of all data sets is calculated as:

$$T_i = \frac{x_{j-} x_i}{x-k}, \text{ for } i = 1,2,3\ldots\ldots N \quad (4)$$

where xj and xk are taken as data values at time j and k (j > k), respectively. The median of these N values of T_i is represented as Sen's estimator of slope, which is expressed as:

$$Q_{i=} \begin{cases} T_{\ (N+1)/2,} & if\ N\ is\ odd \\ \frac{1}{2}\left(T_{N/_2} + T_{(N+2)/2}\right), & if\ N\ is\ even \end{cases} \quad (5)$$

Sen's estimator is calculated as Q_{med} = T (N+1)/2 if N appears odd, and it is used as Q_{med} = TN/2 + T(N+2)/2 if N appears even. Finally, Q_{med} was computed by a two-sided test at 100(1 − α) % confidence interval, which is then used to obtain the true slope through the nonparametric test. A positive value of Qi suggests an increasing trend and a negative value of Qi offers a decreasing trend in the time series.

Data pre-processing was undertaken to filter the climate data based on their perceived quality. Aspects of quality particularly accuracy and consistencies were assessed based on the availability of data for a minimum required period. For example, according to the Guide to Climatological Practices (WMO 2008c), for an average to be calculated for a given month, data should be available for at least 80% of the years in the averaging period. This equates to having data available for that month in 24 or more out of the 30 years for a climatological standard normal or a reference normal, and values should not be missed for 3 or more consecutive years. Such data pre- assessment processes were undertaken as data quality control methods. Outliers were detected and rejected for daily maximum and minimum temperatures exceeding ±3 standard deviation.

After quality control, the trend was computed for for annual time scale include annual maximum temperature (ATmax), annual minimum temperature (ATmin) and annual average temperature. Rainfall trends for the four seasons (summer, winter, autumn and spring) were also computed using XLSTAT® 16, and the implications for coffee production were assessed. . The households survey data management and analysis was carried out in SPSS version 27. A thematic analysis including description and classification of data and seeing how concepts interconnect was employed for qualitative information to explain and triangulate the survey results and the meteorological evidences.

4.3 RESULTS AND DISCUSSION

4. 3.1 FARMERS' PERCEPTIONS OF CLIMATE CHANGE

Perceptions of Changes in Rainfall

Approximately the same proportion (86%) of conventional (n=232) and speciality (n=120) coffee producers reported that the climate in Yirgacheffe has changed (Table 1). The Chi-square test did not show significant difference between the two groups (χ^2 = 0.009, p = 0.924). A larger proportion of the speciality coffee producers (88%) mentioned early offset of the rainy season than the conventional coffee producers (64.7%); the difference being statistically significant (χ^2 =22.35, p <0.001). Late onset of the rainy season was mentioned by 85% and 64% of speciality and conventional coffee producers, respectively, with the difference being statistically significant (χ^2 =17.28, p <0.001). The perceptions on late onset and early offset of rainy seasons also confirms the perceived shorter rainy seasons.

Quality coffee farmers were more likely to have better climate change perception due to different enabling conditions. Such enabling conditions reported by local experts were accessibility of information about weather, credit and insurance products, and capacity building packages from the companies (eg. a coffee production and harvesting manual of the Nordic coffee from one of the quality coffee farmer during the fieldwork) and local extension services. The most important capacity building services highlighted were trainings and manuals, enhancing sustainable coffee production through certification of organic and shade grown coffee.

Table 1: Perceived changes in rainfall patterns by coffee farmers

Perceptions	Response	Coffee farmers type (%)		X^2	*P value*
		Conventional	Quality		
I know about climate change	No	13.8	14.2	0.009	0.924
	Yes	86.2	85.8		
Early offset of rainy season	No	35.3	11.7	22.35**	0.000
	Yes	64.7	88.3		
Late onset of rainy season	No	36.2	15.0	17.28**	0.000
	Yes	63.8	85.0		
Early onset of rainy season	No	63.8	85.0	17.23**	0.000
	Yes	36.2	15.0		
Late offset of rainy season	No	71.1	85.0	8.32*	0.004
	Yes	28.9	15.0		
High Frequency of dry spells	No	29.3	24.2	1.04	0.306
	Yes	70.7	75.8		

** and * indicate significance levels at 0.01 and 0.05, respectively.

Although frequent dry spells during the rainy seasons were reported by larger proportion of speciality coffee producers (76%) than the conventional coffee producers (71%), there was no statistically significant difference between the two groups (χ^2 = 1.04, p =0.306). Responses from in-depth interviews also showed that there was certainty among participants that rainfall over their area was decreasing, while the number of rainfall days during the rainy seasons was perceived to have decreased with increasing number of dry spells, and affecting coffee yields and quality.

Eighty seven % of conventional coffee producers perceived rainfall to have decreased in the last 15 years, whereas about 54% of the speciality coffee producers perceived the same trend of rainfall, showing statistically significant difference ($\chi^2 = 81.9$, $p < .001$) (Table 2). On the other hand, while substantial proportion (34%) of quality coffee producers perceived no clear pattern of rainfall change (which is consistent with the measured data), a smaller proportion (13%) of the conventional coffee producers perceived a similar pattern of no clear change. This suggests an association between coffee production type and perceptions on climate change, which is attributable to differential access to climate change information. A district expert mentioned that if quality coffee producers intend to maintain the quality of their coffee production for the global market, they are more likely to engage in different ways of dealing with local climate change. In particular, by virtue of their better contact with extension services, quality coffee producers would seem to have more better insights into their local climate changes and patterns.

Table 2: Perceived trends in rainfall

Perceived Rainfall Trend in the past 15 years	Total % (all sample)	Coffee farmers type%		X^2	Sig.
		Conventional	Quality		
Decreasing	76.1	87.5	54.2	81.9*	0.000
Increasing	5.4	3.0	10.0		
No clear pattern	13.4	2.6	34.2		
No change	5.1	6.9	1.7		
Total	100	100	100		
Rainfall is more decisive than temperature for coffee production		88.9	68.3	14.9*	0.000

* Indicates statistical significance level at 1%.

Seventy six % of all the surveyed farmers' perceived decreasing rainfall in the area. Of the speciality coffee producers, about 88% believed that rainfall was more decisive than temperature for coffee production, while only about 70% of the conventional coffee producers held the same belief, with the difference being statistically significant (χ^2 = 14.9, p< 0.001). Thus, while the most important climate parameter affecting Arabica coffee production is temperature of the warmest quarter in a given year(Jarmillo et al., 2011), farmers in the study area believed that rainfall was decisive for optimal coffee production.

Key Based on in-depth interviews, informant interviewees also reported that there was increasing variability and uncertainty in the rainy season, with a decrease in the duration of the rainy season compared to the past decades. Specifically, participants reported that the spring rains used to start in early to mid-March in the past, but it shifted to April–May in recent years. A coffee farmer from the Konga sub district also recounted that:

> ‘’The climate of this area was conducive for coffee production. For instance, before 20 years, conditions were so good for coffee production, and there was no problem with rainfall. I remember the years of distinct rainy and dry seasons, which is desirable for coffee production. Since the late 1990s, it is no longer like that; rainfall begins very late and ends too early, and then the duration is short as a result the amount and duration is not sufficient for optimal coffee production. No one can predict the duration as well as the timing of the rainy and dry seasons of the harvest years while coffee production requires distinct dry and rainy seasons for its flowering, fructification and harvesting.’’ (Sede sub-district, officer, March 2018).

The farmers’ perception that optimal coffee production requires distinctive wet and dry periods and adequate amount of rainfall is consistent with scientific evidence. For instance, Moat et al (2017b) stated that distinctive dry seasons of particularly 2-3 months followed by a rainy season make up climatic suitability for coffee production and harvesting.

Perceived changes in temperature

As shown in Table 3, a larger proportion of speciality coffee producers (89%) perceived an increase in temperature than the conventional coffee producers (80%), the difference being statistically significant (χ^2=10.0, p= .018). A similar significant difference was found with respect to rainfall changes (see section 3.1.1). The difference in perceptions between the quality coffee and conventional coffee producers reflects a systematic difference in access to information, whether due to biased extension service or trainings to qualify coffee producers. Coffee farmers also stated that temperature has increased. The same was confirmed by local experts who had reportedly observed upslope expansion of coffee production in the study area, as an indicator of local climate change.

Moreover, discussions with district experts generated the following information and indicated increasing temperature in the area.

> ''As for temperature, according to my experience, it is increasing from time to time. Before a decade, during this month [March], it was not very hot as it is now. Many of the tree species shade their leaves due to moisture stress in this month; and the agroforest cover of the area in the same month [March] of nowadays and 20 years ago is quite different; that is sparse today as compared to the past'' (Sede sub-district, officer, March 2018).

The results from the FGDs also reveal the farmers' assertion of increasing temperature. For example, it has been pinpointed that *'as for the last 20 years, there have been increased droughts and unpredictable dry spells.'* (FGD, Konga) *'The temperature has most increased most since recent time*.'(FGD, district experts). Likewise, results from the household survey supported those assertions, as the majority of the farmers reported temperature increased.

Table 3: Perceived changes in temperature

Perceptions	Coffee farmers type (%)		X^2	*Sig.*
	Conventional	Quality		
Temperature increased (in last 20 years)	80.2	89.2	10.0*	0.01
Temperature decreased (in last 20 years)	4.6	3.0		
No clear pattern of temperature change	7.5	4.5		
Undetermined pattern of temperature	7.8	3.3		

*Indicates statistical significance at 0.05 level.

Coffee farmers perceived climate change, especially late onset, early offset of rainfall, and decreasing rainfall with adverse effects on their coffee production in the past decades. Another study has reported similar perceptions by farmers in other coffee producing area of Ethiopia (Davis et al., 2012). Dhanya and Ramachandran (2016) also reported that smallholder farmers they surveyed perceived changes in their local climate regardless of their coffee production type. In our study, however, there appears to exist difference between the speciality and conventional coffee producers. This could be related to the fact that several awareness campaigns on climate change and coffee production were given to the speciality coffee producers in order to maintain the quality of their coffee production. Farmers' perception of climate change would seem associated with the type of coffee production in the study area, suggesting that the nature of agricultural production influences farmers' understanding of local climates.

In general, the household survey and in-depth interviews also highlights that coffee farmers' coffee production type may play an important role in these differentiated perceptions by the speciality and conventional coffee producers. While coffee farmers are generally ecologically minded and they perceive the local climate change, there are different factors affecting their perceptions on the local climate change mainly related to more subtle human dimensions of coffee production and climate change, i.e., beliefs and values about coffee production. Additionally, lack of viable path-dependent institutional structures, market access and support and policy-making procedures could be responsible for variation in the perceptions of climate change between the speciality and conventional coffee farmers. This implies that perception of the issue is strongly determined by beliefs held by individuals about the functioning of the local climate and what would constitute a 'coffee production' and the role of individuals and markets in coffee production systems.

4. 3.2 METEOROLOGICAL EVIDENCE FOR RAINFALL AND TEMPERATURE CHANGES

Trends in rainfall

Trend analysis of the long-term rainfall data shows that winter (December – February) and spring (March – May) rainfalls followed a decreasing trend over time, while summer (June – August) rainfall showed a slight increase (Figure 2, Table 4), all of which were not significant statistically. Autumn (September-November) rainfall displayed an increasing trend, showing a statistically significant increase. There was no statistically significant trend in observed mean rainfall in any season in Ethiopia between 1960 and 2006 (Mcsweeney et al., 2010), while smallholder farmers perceived a decreasing trend of rainfall. Farmers were also mainly concerned with changes in rainfall distribution, which includes intensity, onset and cessation of rainfall, indicating a less distinct rainy season, with significant differences between the coffee production types.

Table 4: Variability and trends in rainfall (1988-2018) in Yirgacheffe

Rainfall (mm)	Mean	Std. deviation	Kendall's tau	P-value (two tailed)	Sen’s slope
Annual	1331.8	107.9	0.084	0.522	0.273
March-May	500.2	104.8	-0.116	0.368	-2.261
June-August	336.1	107.8	0.067	0.613	0.671
December- February	99.4	62.3	-0.144	0.265	-1.64
September-November	406.1	112.2	0.320	0.011*	6.221

*Shows increasing trend at 95% confidence level at 0.05 level.

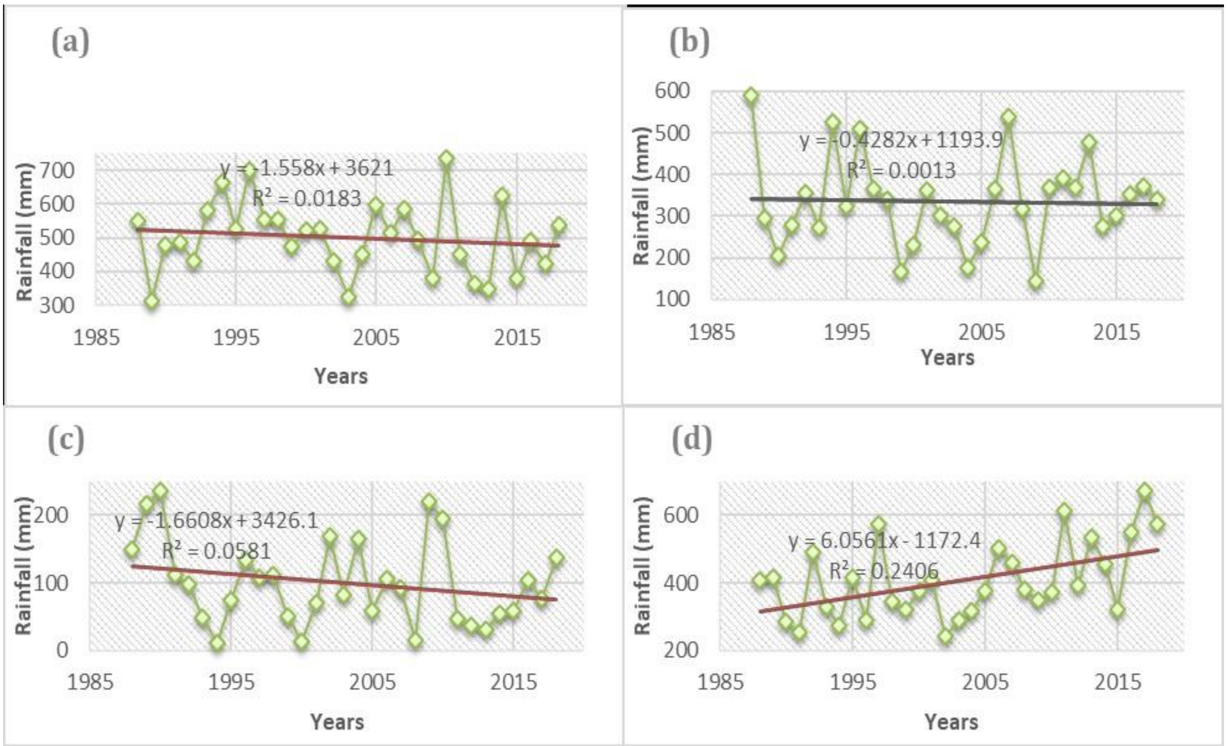


Figure 2: Seasonal variability and trends of rainfall in Yirgacheffe (1988-2018); Average for March-May (a), average for June-August (b), and average for December-February (c) and average for September-November (d)

Temperature trends

Over the observation period (1988-2018), mean annual and minimum temperatures increased, statistically significant (at $p \leq 0.05$) (Table 5). Similarly, Tekleab et al (2013) reported significant increases in annual mean minimum temperature from 1952-2012 in the Abay basin. The maximum temperature did not show a statistically significant change. Overall, the rate of change for annual mean minimum temperature is higher than the annual mean maximum temperature over the study period.

Table 5: Variability and trends in temperature (1988-2018) in Yirgacheffe

Temperature(^{0}C)	Mean	Std. deviation	Kendall's tau	P-value (two tailed)	Sen's slope
Mean maximum	28.0	0.604	0.110	0.39	0.011
Mean minimum	12.8	0.524	0.432	0.001*	0.032
Mean annual	20.4	0.360	0.476	0.000*	0.025

*Indicates statistical significance at 0.05 level.

Figure 3 depicts variability and trends of the mean annual maximum, minimum and annual temperatures. The slopes of linear regression represent the rates of changes in temperature in 0.1°C, 0.3°C and 0.2°C per decade for mean annual maximum, minimum and annual temperatures, respectively. Mean minimum temperature has the highest rate of increase. The faster rate of change in the annual mean minimum temperature than annual mean maximum temperature is in line with trends found by NMA (2007).

As suggested by Peterson et al. (2002), the changes are attributed to the decreasing night-time cooling in Caribean region. In consonance with this, McSweeney et al. (2010) also indicated that the average number of hot nights has increased by 137 whereas the hot days by 73 days per year from 1960 to 2003 in Ethiopia. These results are consistent with the farmers' perceptions that temperature has increased in the area. The trend of mean annual temperature observed in the study area was relatively higher than the historical trend reported at national level. For instance, a warming trend of 0.1°C/decade increase in annual temperature was observed in Ethiopia between 1953 and 1999 (NMA, 2007). Other studies at various spatial and temporal scales have also recognized warming trends in maximum temperature (Degefu and Bewket, 2014; Worku et al., 2019).

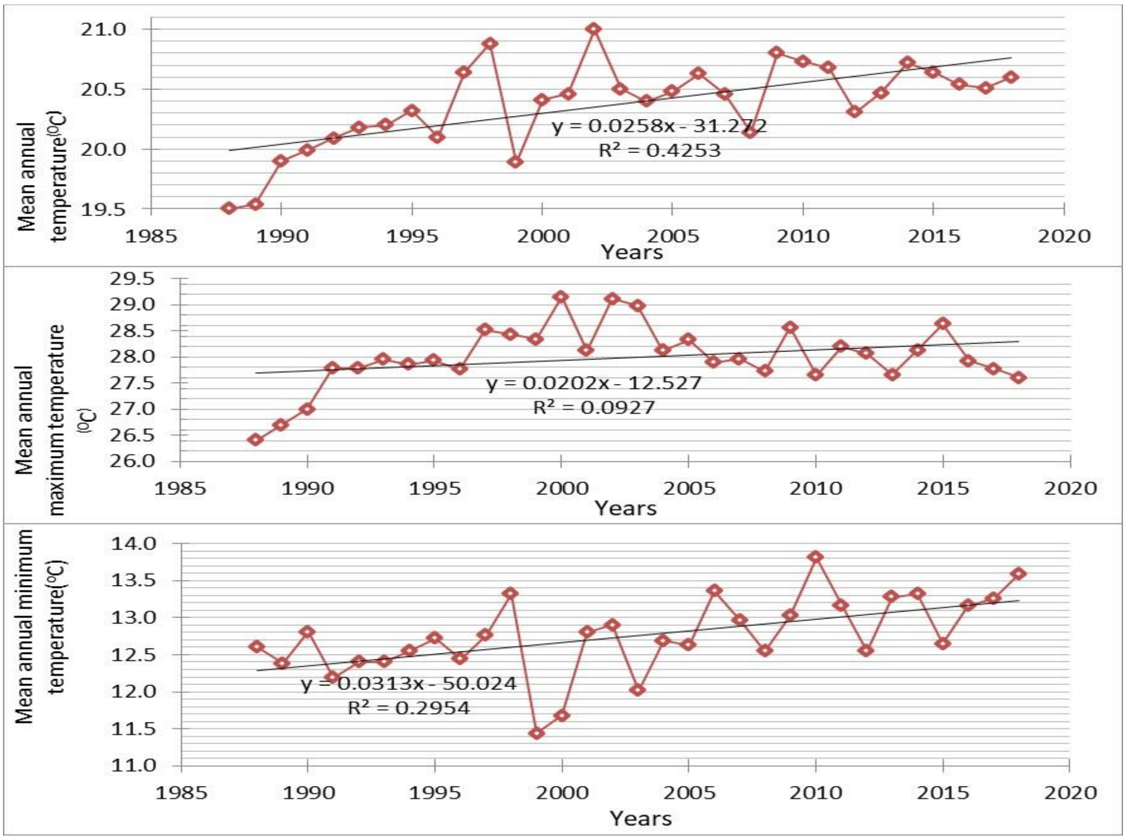


Figure 3: Trends of temperature in Yirgacheffe (1988-2018)

4.3.3 Comparison of farmers' perceptions of climate change and meteorological evidence

Consistent with what Ayanlade et al. (2017) found, the majority of farmers surveyed (i.e., 80% and 89% of the conventional and specialty coffee producers, respectively) noted increasing temperature. Simelton et al. (2013) also reported that farmers' perceptions of increasing temperature was supported by their climate data analysis, showing that farmers they surveyed perceived an increase in temperature. The majority of farmers surveyed in this study perceived that the climate was changing, and their perceptions and recorded data agreed with a significant increase in temperature. Meteorological observations indicated that mean annual maximum and minimum, and annual mean temperatures increased at rates of 0.01, 0.03 and 0.02^{0}C per year, respectively. This suggests that knowledge and observation of local climate by coffee farmers could be used to substantiate and extend scientific evidence, for example, in data-scarce regions such as in most areas of Ethiopia. This would be possible through uncovering the discrepancies and congruencies between coffee farmers' perception and meteorological evidences on the state of local climate; and exploring alternate ways of perceiving, explaining, and responding to the local climate change.

In terms of rainfall, however, the nuanced views of coffee farmers seen on a decreasing trend was not supported by the meteorological data analysis. Measured data indicated different trends for different seasons. Spring rainfall showed a declining trend while autumn and winter rainfalls did not show statistically significant changes. The surveyed farmers did not mention noticing any differences in rainfall trends between the seasons. Asayehegn et al. (2017) also reported that meteorological data did not provide any evidence to support farmers' perceptions of decreasing rainfall in the highlands of Kenya.

A possible explanation for the inconsistencies between farmers' perception and climate data analysis on rainfall could be attributed to their greater concern and detailed observations on shortage of rainfall as a major constraint to optimal coffee production than increasing temperature. Farmers' perceptions are heavily influenced by irregularities in rainfall patterns; i.e. onset, duration and cessation, as they consider rainfall a more decisive factor for optimal coffee production than temperature. In addition, farmers may not have been able to recognize variability in rainfall over a long period. Dhanya and Ramachandran (2016), for example, found that farmers' perception and experiences are affected by emotion and capability to recall climate system; farmers more easily recall a dry period than a hot one.

The perceptions on climate change has implications on perceived impacts of climate change on coffee production. The perceived impacts were negative and coffee farmers mentioned that quality and yield maintaining physiological processes like flowering, fructification and ripening of coffee cherries are affected by unpredictable and the indistinct rainy and dry seasons. The occurrence of diseases and pests was also mentioned as the consequence of climate change. Similarly, Killeen and Harper (2016) mentioned both coffee productivity and quality largely depend on the climate suitability, especially the precipitation and air temperature. Coffee farmers also perceived that climate change resulted in the loss of suitable land for cultivation. Particularly, coffee famers in the study area mentioned that coffee trees are growing better in higher elevation parts of the study area than before 15 and 20 years, while at the same time coffee yield and products in lower physiographic units of the study area are decreasing. This shows that coffee farmers recognized the local level shift in coffee production area. Similarly, Jaramillo et al (2011) stated that the increase in temperature render to production area less suitable or even completely unsuitable for coffee growing and production. These anecdotal evidences from the coffee farmers and district experts on the impact of climate change on coffee production implies that perception on the local climate change has spill-on effect on the perceived impacts of climate change on coffee production, and the subsequent decisions and actions to adapt to the changing climate.

4.4 CONCLUSIONS

The local climate of Yirgacheffe was investigated based on the coffee farmers' perceptions and meteorological evidences during the period of 1988-2018. Meteorological observations indicated that mean annual maximum and minimum, and annual mean temperatures increased at rates of 0.01, 0.03 and 0.02^{0}C per year, respectively. Air temperature and rainfall were analysed using the Mann-Kendall test and compared with coffee farmers' perceptions. The results reveal the importance of coffee farmers' perceptions and local meteorological evidences for site-specific decision-making procedures in coffee producing areas. Moreover, it has been found that selecting different time scales (seasonal and annual) and also different durations in each time scale (such as spring and winter in the seasonal time scale) can help coffee farmers informed decisions on their coffee livelihoods across the study area. The most commonly observed changes in climate include rising temperatures, declining rainfall, and changes in the onset and duration of the rainy season. While the majority of farmers surveyed held a view of local climate change, their perceptions on temperature trends generally reflects recorded data, whereas their perception on rainfall change did not concur the climate data analysis.

The study also highlights while almost both specialty and conventional coffee farmers noticed that the climate of Yirgacheffe has changed and was having effects on their coffee production, disparities exist between the two groups in terms of the views held on climate change. Perceptions held by those in quality coffee production are positively related with the measured data on climate change. The chi-square test indicate that specialty coffee farmers have better understanding of climate change, compared to the conventional coffee producers. This could be due to the fact that quality coffee producers have more interactive relationships with other stakeholders and get different supports for quality coffee production including information about the local climate systems, which is pertinent to coffee production. This implies that quality coffee production enhances accurate perception of smallholders about climate change, particularly due to different enabling conditions such as accessibility of information about weather, credit and insurance products. This suggests that quality coffee production enhances better farmers' perceptions on local climate changes, while contributing to sustainable coffee livelihoods for smallholders. Therefore, it is essential to investigate how coffee farmers with different production types perceive climate change processes and its impacts to have a deeper understanding of site-and-livelihood specific perceptions by the coffee farming communities.

Moreover, as the majority of coffee producers are conventional coffee producers, a policy intervention on conventional coffee producers is imperative to them more informed and aware about the local climate change and make the coffee production more sustainable. This suggests that a need exists to bridge the gap between coffee farmers' perceptions and scientific understanding of the local climate change through capacitating coffee farmers through trainings and extension services. This would also help fine-tune coffee farmers' understanding the local climate change, and create room for manoeuvre to take context-relevant adaptation measures.

Finally, climate change poses a formidable challenge to quality coffee production and quality coffee production determines coffee farmers' perceptions about climate change. Quality coffee production also requires not only understanding of biophysical issues involved but also unfolding the 'more subtle human dimensions' of local climate change. Thus, further research is required to yield in-depth understanding about the notion of values and beliefs on local climate change. Such future research would yield deeper understanding on perceptions of local climate change, and might enhance the science-local knowledge interface for sustainable coffee livelihood. While our study has focused on the perceived and observed local climate change in the context of coffee production, empirically research is needed on the perceived and observed impacts of climate change on coffee production in Yirgacheffe.

Acknowledgments

We would like to acknowledge the Research Council of Norway for funding the Project 'The role of global value chains in transition to sustainability' (Project number 255664). We also extend our sincere thanks to all data collectors and farmers who took part in the surveys of the study.

REFERENCES

Altea, L. and Altea, L. (2019). Perceptions of climate change and its impacts : a comparison between farmers and institutions in the Amazonas Region of Peru. *Climate and Development*, *0*(0), 1–13. https://doi.org/10.1080/17565529.2019.1605285

Amiri,A. M. and Mesgari, M. S. (2019). Spatial variability analysis of precipitation and its concentration in Chaharmahal and Bakhtiari province, Iran. Theoretical and Applied Climatology, 137(3-4), 2905-2914.

Amiri, A. M., Mesgari, M. S. and Conoscenti, C. (2017). Detection of homogeneous precipitation regions at seasonal and annual time scales, northwest Iran. Journal of Water and Climate Change, 8(4), 701-714.

Anyah, R. O. and Qiu, W. 2012 *Characteristic 20th and 21st century precipitation and temperature patterns and changes over the Greater Horn of Africa*. *363*(January 2011), 347–363.

Asayehegn, K., Temple, L., Sanchez, B. and Iglesias, A. (2017). Comparing smallholder farmers' perception of climate change with meteorological data: A case study from southwestern Nigeria. *Weather and Climate Extremes*, *15*(December 2016), 24–33.

Ayele, Y. Ewnetu, Z. and Asfaw, Z. (2014). Economic Evaluation of Coffee-Enset - Based Agroforestry Practice in Yirgachefe Woreda , Ethiopia : Comparative Analysis with Parkland Agroforestry Practice. *Journal of Economics and Sustainable Development*, *5*(27), 72–82.

Burgan, H.I and Aksoy, H. (2018). Annual Flow Duration Curve Model for Ungauged River Basins. Hydrology Research, 49(5), 1684-1695.

Bunn, C., Läderach, P., Ovalle Rivera, O. and Kirschke, D. (2015). A bitter cup: climate change profile of global production of Arabica and Robusta coffee. *Climatic Change*, *129*(1–2), 89–101.

Cochran, W.G. (1977). *Sampling Techniques*, 3rd edn. Wiley. New York.

Daviron, B. and Ponte, S. (2005). The coffee paradox: global markets, commodity trade, and the elusive promise of development. London; New York.

Davis, A. P., Gole, T. W., Baena, S. and Moat, J. (2012). The Impact of Climate Change on

Indigenous Arabica Coffee (Coffea arabica): Predicting Future Trends and Identifying Priorities. *PLoS ONE*, *7*(11), 10–14.

Degefu,M. and Bewket, W. (2014). Variability and trends in rainfall amount and extreme event indices in the Omo-Ghibe River Basin, Ethiopia. *Regional Environmental Change*,14(2), 799–810.

Dhanya, P. and Ramachandran, A. (2016). Farmers ' perceptions of climate change and the proposed agriculture adaptation strategies in a semi arid region of south India. *Journal of Integrative Environmental Sciences*, *13*(1), 1–18.

Ebisa, D. B. (2017). Impacts of climate change on global coffee production industry: Review. *African Journal of Agricultural Research*, *12*(19), 1607–1611.

Gole, T.W. (2015). *Environment and Coffee Forest Forum Coffee : Ethiopia ' s Gift to the World The traditional production*. 2–61.

Grothmann, T. and Patt, A. (2005). *Adaptive capacity and human cognition : The process of individual adaptation to climate change*. *15*, 199–213.

Jaramillo, J., Muchugu, E., Vega, F. E., Davis, A., Borgemeister, C. and Chabi-olaye, A. (2011). *Some Like It Hot : The Influence and Implications of Climate Change on Coffee Berry Borer (Hypothenemus hampei) and Coffee Production in East Africa*. *6*(9).

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

Kothari C.R. (2004). *Research Methodology: Methods and Techniques.2^nd^* ed. New Age International Publishers. Jaipur, India

Legesse, A., Teferi, B. and Baudouin, A. (2013). Indigenous agroforestry knowledge transmission and young people ' s participation in agroforestry prac- tices : The case of Wonago Woreda ,. *Acta Geographica-Trondheim*, (26).

Maddison, D. (2007). *The Perception of and Adaptation to Climate Change in Africa*. (August).

Mcsweeney, C., Office, M. and New, M. G. (2010). *The UNDP Climate Change Country Profiles Improving the accessibility of Observed and Projected Climate Information for Studies of Climate Change in Developing Countries*. https://doi.org/10.1175/2009BAMS2826.1

Meskela, T. and Teshome, Y. (2014). From economic vulnerability to sustainable livelihoods: The case of the Oromia coffee farmers cooperatives union in Ethiopia.

International Food and Agribusiness Management Review, *17*(SPEC), 103–108.

Minten, B., Dereje, M., Engeda, E. and Kuma, T. (2019). *Coffee value chains on the move : Evidence from smallholder coffee farmers in Ethiopia*. (August 2017).

Moat, J., Williams, J., Baena, S., Wilkinson, T., Gole, T. W., Challa, Z. K., … Davis, A. P. (2017). Resilience potential of the Ethiopian coffee sector under climate change. *Nature Plants*, *3*. https://doi.org/10.1038/nplants.2017.81

Moore, N., Alagarswamy, G., Pijanowski, B., Thornton, P., Lofgren, B., Olson, J., … Qi, J. (2012). *East African food security as influenced by future climate change and land use change at local to regional scales*. 823–844.

National Meteorological Agency of Ethiopia (NMA). (2007). Climate Change National Adaptation Programme of Action (NAPA) of Ethiopia, *National Meteorological Services Agency,* Federal Democratic Republic of Ethiopia, Addis Ababa, Ethiopia.

Negash, M. (2007). Trees management and livelihoods in gedeo's agroforests, ethiopia. *Forests Trees and Livelihoods*, *17*(2), 157–168.

Nigatu, D., Tiki, L., Kewessa, G. and Datiko, D. (2017).Traditional Coffee Management Practices and Their Effects on Woody Species Structure and Regeneration in Bale Eco-Region, Ethiopia. *International Journal of Advanced Research*, *5*(6), 591–598.

Peterson, T. C. Taylor, M. A., Demeritte R., Duncombe, D.L., Burton,S., Thompson,F., Porter,A…(2002). Recent changes in climate extremes in the Caribbean region," Journal of Geophysical Research: Atmospheres, 107(D21) p. 4601

Ponte, S. and Gibbon, P. (2005). Quality standards, conventions and the governance of global value chains. *Economy and Society*, *34*(1), 1–31.

Rahn, E., Läderach, P., Baca, M., Cressy, C., Schroth, G., Malin, D., … Shriver, J. (2014). Climate change adaptation, mitigation and livelihood benefits in coffee production: where are the synergies? *Mitigation and Adaptation Strategies for Global Change*, *19*(8), 1119–1137.

Rogers, M. F. and Curtis, A. (2012). *The influence of cognitive processes on rural landholder responses to climate change*.

Sen, P. K. 1968 Estimates of the regression coefficient based on Kendall's tau. *Journal of the American Statistical Association*, (63)324, 1379–1389.

Skovdal, M. (2020). *Qualitative Research for Development : A guide for practitioners Improving programme impact and accountability through qualitative research*.

(January).

Sridhar, S. I. and Raviraj, A. (2017). *Statistical Trend Analysis of Rainfall in Amaravathi River Basin Using Mann-Kendall Test*. *12*(1), 89–96.

Simelton, E., Quinn, C. H., Batisani, N., Dougill, A. J., Jen, C., … Stringer, L. C. (2013). *Is rainfall really changing ? Farmers ' perceptions , meteorological data , and policy implications*. (February), 37–41.

Tekleab, S., Mohamed, Y. and Uhlenbrook, S. (2013). Hydro-climatic trends in the Abay/upper blue Nile Basin, Ethiopia. *Physics and Chemistry of the Earth*, Parts A/B/C, vol. 61-62, pp. 32–42.

Theil, H. (1950). A rank-invariant method of linear and polynominal regression analysis (Parts 1-3), Proceedings of the Koninklijke Nederlandse Akademie van Wetenschappen Series A, vol. 53, pp. 1397–1412.

World Meteorological Organization (WMO).(2008c). Guide to hydrological practices, Hydrology – From measurement to hydrological information, Volume I. 6th Edn. Geneva, Switzerland.

Worku, G., Teferi, E., Bantider, A. and Dile, Y. T. (2019). Observed changes in extremes of daily rainfall and temperature in Jemma sub-basin, upper Blue Nile basin, Ethiopia. Theoretical l and Applied Climatology 135 (3–4) 839– 854.

CHAPTER FIVE…………………………………………………………………………

EFFECTS OF QUALITY COFFEE PRODUCTION ON SMALLHOLDERS' ADAPTATION TO CLIMATE CHANGE IN YIRGACHEFFE, SOUTHERN ETHIOPIA

Asnake Adane[2] and Woldeamlak Bewket[1]

International Journal of Climate Change Strategies and Management: DOI 10.1108/IJCCSM-01-2021-0002

5. **Effects of Quality Coffee Production on Smallholders' Adaptation to Climate Change in Yirgacheffe, Southern Ethiopia**

Abstract

The purpose of this paper was to assess effects of quality coffee production on climate change adaptation using household survey and interview data gathered from coffee farmers in Yirgacheffe, southern Ethiopia. A sample of 352 households, of whom 232 (66%) were conventional coffee producers and 120 (34%) were quality coffee producers. The propensity score model for participating in quality coffee production was estimated using 14 covariates, and the impact of quality coffee production on adaptation to climate change adaptation was examined. The results were augmented with qualitative data collected through Focus Group Discussions (FGDs) and key informant interviews held with randomly selected smallholder farmers. The PSM analysis reveals that quality coffee production positively influences climate change adaptation. This implies that conventional coffee producers would have performed better in adaptation to climate change if they had participated in quality coffee production. The results of group discussions also confirm positive effects of quality coffee production on adaptation to climate change, which also suggests positive spill over effects for sustainable coffee farm management. The study suggests enhancing quality coffee production is essential if a more sustainable and climate change resilient coffee livelihood is envisioned.

Key words: Quality coffee production, climate change adaptation, propensity score matching, Ethiopia,

5.1 INTRODUCTION

The impact of climate change is most severe in Africa, as its food production systems are among the most sensitive due to its extensive reliance on rainfed crops production and droughts are recurrent under natural climate variability (Moore et al., 2012). The African coffee sector, which supports millions of smallholder families and generates the much needed foreign currency to national government is particularly sensitive to climate change impacts (George, 2014; Jassogne et al, 2013). This is particularly the case with the Arabica coffee, which requires very specific environmental conditions for successful production (Ebisa, 2017), including an optimum mean temperature range of between 15º to 23ºC (Davis et al, 2012; Baca et al, 2014).

Ethiopia is the origin and centre of genetic diversity of the Arabica coffee plant, and has a huge natural advantage and potential for quality coffee production in the form of organic and shade-grown coffee (Mojo et al, 2015). Coffee has been cultivated, traded and consumed over centuries and still plays a central role in the local and national economy of the country (Gole et al, 2015). It contributes up to 50% of the country´s export commodity and more than 25% of the country's foreign exchange earnings (Jha et al., 2011). Nearly a fifth of the national population depends on coffee for their livelihoods, where about five million smallholders produce 95% of the total production in a low input-output production system (Meskela and Teshome, 2014). Ethiopia is the first African coffee producer but the second exporter (Daviron and Ponte, 2007), as the domestic consumption represents more than 50% of the total production (Petit, 2007) because of the country's strong coffee-drinking culture.

Ethiopia's role in the global coffee market lies mainly on the fine quality of its coffee; Ethiopian quality coffee enjoys a high demand in the global market (Daviron and Ponte, 2007). Quality coffee refers to a single-origin and highest-grade, organically produced coffee, differentiated by its superior flavour and it claims price premiums (Minten et al, 2018; Ponte and Gibbon, 2005). Different flavoured coffee varieties that have internationally been reputed and marketed at premium prices are being produced in various parts of Ethiopia including Yirgacheffe (Degefa, 2016). For this study, quality coffee is a type of quality coffee produced mainly for the global market by smallholders in Yirgacheffe area.

Coffee production in Ethiopia has also important benefits in adapting to climate change through different coffee production and land management practices. More than 90% of Ethiopia's coffee is de facto organic (Mekuria et al, 2004), and about 45% of the coffee comes from forest and semi-forest areas in which local biodiversity as well as traditional practices are generally maintained (Minten et al, 2018). Even in areas where coffee is produced in gardens, it is grown under large trees such as indigenous leguminous trees (e.g. Acacia trees), highlighting that coffee is a shade loving tree (Meskela and Teshome, 2014). These coffee farm management practices of maintaining forest and indigenous trees have several implications for the coffee-based livelihoods and environmental sustainability.

However, the expanding trend of deforestation for more intensive cultivation to increase coffee production (since forest coffee has low yield) has been reported as a potential threat to environmental sustainability to many coffee producing countries including Ethiopia (Jena et al, 2012). In particular, Petit (2007) remarked that the growing demand for quality coffee is currently becoming more important than in the past as the demand for differentiated coffee is going up, and this influences producer's coffee farm management practices. The notion of quality coffee in this paper refers to a variety of quality coffee that is grown with only organic inputs for three consecutive years prior to certification and this is annually inspected by third party certifiers.

Coffee crops are highly sensitive to changes in climate, which can decrease both the quantity and quality of harvests (Meza, 2015). Obviously, adaptation is one of the strategies to mitigate the negative impacts of the ongoing climate change (IPCC, 2007). As quality coffee production involves various farm management practices, it is likely to have climate change adaptation benefits. However, this has not been studied in any detail in Ethiopia.

Previous studies on coffee in Ethiopia (e.g., Mojo et al, 2015; Minten et al, 2015;Kodama, 2007) are focused on assessment of structural bottlenecks like institutional and marketing issues or biophysical factors related to coffee production, and on modelling current and projected impacts of climate change. This paper therefore attempts to fill in an important knowledge gap by assessing the link between quality coffee production and climate change adaptation benefits by using Yirgacheffe area in southern Ethiopia as a case study site The specific objectives of the study are to: (i) assess factors affecting quality coffee production by smallholders and (ii) examine the effects of quality coffee production on climate change adaptation in Yirgacheffe. The remainder of the paper is organized as follows. Section 2 describes materials and methods, and the third section presents results. Section 4 presents discussions. Conclusions and issues for future research are presented in section 5.

5.2 RESEARCH METHODOLOGY

5.2.1 Survey data collection

Based on consultations with staff of district office and preliminary field visit, two different groups of coffee framers were identified: quality and conventional coffee farmers. Quality coffee farmers, as designated by the district coffee development department, are characterized by (i) coffee is grown with only organic inputs for three years prior to certification; (ii) farmers keep detailed records of methods and materials used in coffee production; and (iii) a third-party certifier annually inspects all methods and materials.

The majority of coffee producers in the study area are conventional coffee farmers; out of 4,309 farmers in the district, only 120 were quality coffee producers. All of these 120 were included in the household survey sample. To select a representative sample from the conventional group, we used the list of conventional coffee farmers from the district office. Then, we took 232 as sample (which is 5.5% of the total) out of the 4,309 farmers, using a systematic random sampling procedure. The overall number of survey participants was therefore 352. The household survey was conducted via face-to-face interview during December and March 2018 with household heads using a structured questionnaire by the researcher and trained research assistants to collect data primarily on: (i) factors affecting farmers' participation in quality coffee production and (ii) coffee farmers' adaptation practices to climate change.

5.2.2 Methods of Quantitative Data Analysis

The propensity score is the probability of treatment assignment conditional on measured baseline covariates(Austin,2011). Propensity score methods are increasingly being used to reduce or minimize the confounding that occurs frequently in observational studies of the effect of treatment on outcomes. It involves pairing treatment and control groups that are similar in terms of their observable covariates (Getnet and Anullo, 2012). If the relevant differences between any two units are captured in the observable covariates, matching methods can yield an unbiased estimate of the treatment impact. Among the matching methods, PSM is suggested when there is a dimensionality problem because of the differences in the nature of the covariates (including measurement scales) that make matching on covariates difficult (Rosenbaum and Rubin, 1985). There are four ways of using the propensity score to reduce confounding: matching on the propensity score, stratification on the propensity score, inverse probability of treatment weighting using the propensity score and covariate adjustment using the propensity score.

Stratification (or subclassification) on the propensity score stratifies the entire sample into mutually exclusive subclasses based on the propensity score. A common approach is to define the subclasses using specified quantiles of the propensity score, then matching the treated and untreated subjects of similar PS. Rosenbaum and Rubin (1985) stated that stratifying on the quintiles of the propensity score eliminates approximately 90% of the bias due to measured confounders when estimating a linear treatment effect. When estimating the ATT, each stratum would be weighted proportionally to the number of treated subjects who lay within that stratum (Rubin and Thomas, 2006). The inverse probability of treatment weights (IPTWs) are used when the distribution of baseline covariates in each treatment group will be the same as the distribution of baseline covariates in the overall unweighted sample. It uses weights based on the propensity score to create a synthetic sample in which the distribution of measured baseline covariates is independent of treatment assignment. The covariate adjustment involves matching that involves regressing the outcome variable on an indicator variable denoting treatment status and the estimated propensity score.

In this study, matching on the propensity score was used to assess the effects of quality coffee production on adaptation to climate change by smallholder coffee producers. It allows us to establish control groups, as it is not possible to assign a household into quality coffee producers and non-quality coffee producer through randomization. Control groups consist of comparable groups of subjects who did not receive the treatment, but have similar observable covariates to those receiving the intervention (the treatment groups). The PSM was used to balance the covariate difference between the speciality coffee farmers and the conventional coffee farmers based on logistic regression. SPSS version 27 and STATA 16.1 were used to analyse the propensity scores, and then to assess the balance of covariates to participate in quality coffee production

The PSM works under the following assumptions (Caliendo and Kopeinig, 2000): (i) it depends on conditional independence assumption (CIA), after controlling for the observable covariates (Z) the potential outcomes are independent of the treatment assignment; (ii) the common support is assumed to be satisfied, subjects with the same Z values have similar probability of being treated, indicated by the propensity scores; and (iii) PSM requires the fulfilment of the balanced scores, i.e. the covariate means of the two groups should be similar after the propensity score matching. The CIA assumption implies that participation decision is based on covariates;

i.e. observable variables that simultaneously influence participation decision (quality coffee production in our case) and performance indicators (adaptation practices). Considering the assumptions mentioned earlier and previous studies (Abebaw and Haile 2013; Francesconi and Ruben 2012), and covariates that are deemed important in quality coffee production, we estimated the propensity score using the logit model to match quality coffee producers with conventional producers. Further details are given below.

Choosing Covariates and Estimating Propensity Score

The selection of covariates to be included in propensity score estimation is an important issue, and proper selection of independent variables is extremely crucial for the validity of propensity score matching. The general principle is that covariates affecting group assignment or outcome variables should be included (Caliendo and Kopeinig, 2005; Rosenbaum and Rubin, 1983). In this study, a set of covariates that are deemed important for both participation in quality coffee production (group assignment) and adaptation practices (outcome) were selected (Table 1). This was based on review of theoretical arguments and literature, and frequent field observation (Austin, 2011; Rubin,2001).

The covariates were categorized into continuous and categorical, for analysis purpose. The selected continuous covariates were age of household head, household size, experience in coffee farming, land holding size, coffee farm size, distance of coffee farms from coffee processing centre, number plots and number of coffee plots. The categorical covariates were education and sex of household heads, access to information, access to credit, and cooperative membership of households and perception of household heads about climate change.

The propensity score was estimated using logistic regression in which the set of covariates was considered as predictors and participation in quality coffee production was used as the dependent variable. The estimated propensity score (PS), for subject e (Xi), (i = 1 … N) is the conditional probability of being assigned to a particular treatment group given a vector of observed covariates x_i (Thoemmes, 2012):

$$Ln\ [\frac{p\ (z=1|x1....xn)/}{1-\ p\ (z=1|x1....xn)}] = \beta_0 + \sum_{j=1}^{P} \beta_j x_j \qquad (1)$$

Where zi = 1 for treatment; zi = 0 for control; xi = the vector of observed covariates for the i^{th} subject. In our case where z = (0, 1) is the indicator of quality coffee production (dependent variable), and then z = 1, if a subject produces quality coffee) and z = 0 if he or she produces conventional coffee; X is the multidimensional vector of observed covariates (explanatory variables).

Table 1. Variables for PSM model in relation to quality coffee producers

Variable	Description of variable	Category	Expected effect
Explained	Participation in quality coffee production	Dummy	
Explanatory			
EDU_HH	Education of the HH head (literate=1,0 otherwise)	dummy	+ve
AG_HH	Age of the HH head(years)	Continuous	+ve / -ve
D_FAR	Distance of plots from pulp centre (km)	Continuous	+ve/-ve
SE_HH	Sex of HH head (% of male)	dummy	+ve
EXP_HH	Experience in Coffee Farming (Years)	continuous	+ve
ACC_INF	Access to information (% access)	dummy	+ve
HH_SIZ	Household size (number)	Continuous	+ve
ACC_CRT	Access to credit	Dummy	+ve
T_LHS	Landholding Size(ha)	Continuous	+ve
COP_MEM	Cooperatives membership	dummy	+ve
N_PLOT	No of plots (number)	continuous	+ve
N_CPLOT	No of coffee plots (number)	continuous	+ve
CO_FARS'	Coffee Farm Size (ha)	continuous	+ve
Perc_CC	Perception about climate change(perceived=1, 0 otherwise	dummy	+ve

Propensity Score Matching

There are different matching methods to check the influence of the choice of the matching algorithm. The first matching method is Mahalanobis-distance matching (MM), which differs from NN by not relying on estimated propensity scores but directly minimizes the Mahalanobis-distance between the covariates (Rosenbaum and Rubin, 1985). The third matching method we consider is genetic matching (GM), which minimizes a generalized Mahalanobis-distance but uses an optimization routine to find an optimal weight for each covariate. The nearest neighbour matching was used in this study due to its simplicity to implement and understand. In the nearest neighbour matching, a subject is first selected at random from the intervention group and subsequently paired with a subject in the control group with the closest propensity score. To ensure good matches, a caliper (maximum allowable distances between to two subjects) was defined, and a caliper of 0.08 (0.2 of the standard deviation of the propensity scores (0.4)) was used for matching (Rubin, 2001). The choice of caliper involves a trade-off: a narrower caliper will yield more similarly matched pairs but may result in a small matched subsample and vice versa. The matching estimator is given as:

$$\tau^{M} = \frac{1}{N^{T}} - \Sigma iET\left\{Y_i^{\,T} - \Sigma iETW_{ij}Y_j^{\,c}\right\} = \frac{1}{N^{T}}\left\{\Sigma iETY^{T} - \Sigma iET\Sigma iETW_{ij}Y_j^{\,c}\right\} \quad (2)$$

Where I, E, T, $N^{c}i$ denote the number of controls matched with observation and define the weights Wij = 1/Nci and Wij = 0 otherwise. M stands for the nearest neighbour matching, and N^{T} denotes the number of units in the quality coffee group. With this, 92 pairs were generated from the PSM for further analysis.

Testing the Balance in Covariates between the Groups

The standardized mean difference is mostly used to check whether balance of the covariates had truly been achieved. The standardized mean difference compares the difference in means in units of the pooled standard deviation. Although there is no universally agreed upon criterion as to what threshold of the standardized difference (d) can be used to indicate good balances, Rubin (2001) suggests that it should be near zero or d<0.2. For continuous covariates, the standardized difference (Cohen's d) was calculated as:

$$d = \frac{M_1 - M_2}{\sqrt{\frac{(n_1-1)SD_1 + (n_2-1)SD_2}{(n_1+n_2)-2}}} \quad (3)$$

where M_1 and M_2 denote the sample mean of the covariate in treated and untreated subjects, respectively, whereas SD_1 and SD_2 denote the sample variance of the covariate in treated and untreated subjects, respectively, and n_1 and n_2 denote the sample sizes of treated and untreated subjects. For the dichotomous covariates, the standardized difference was computed as:

$$d = \frac{(\hat{p}\ intervention - \hat{p}\ control)}{\sqrt{\frac{\hat{p}\ intervention(1-\hat{p}\ intervention)+\hat{p}\ control(1-\hat{p}\ control)}{2}}} \quad (4)$$

where $\hat{p}$ intervention and $\hat{p}$ control denote sample proportion for a dichotomous variable in quality and conventional coffee producers, respectively. The results are presented in Table 2.

Assessment of effects of quality coffee production on adaptation to climate change

The effect of the quality coffee production on adaptation to climate change was assessed in the matched subsample (n=92 pairs). In effect, unbiased comparison between subjects with the same or similar propensity scores from the quality and conventional coffee producers was undertaken. Therefore, subjects from the two groups with the same PS were assumed to be comparable as the covariates were balanced. Hence, if Y_1 denotes the potential outcome (adaptation to climate change) conditional on quality coffee production and Y_0 denotes the potential outcome conditional on conventional coffee production; the effect of quality coffee production Di is given by:

$$D_i = Y_{1i} - Y_{0i} \quad (5)$$

Here 1 refers to treatment and 0 refers to non-treatment

To evaluate treatment effect over the entire population, we find the Average Treatment Effect (ATE)

$$ATE = E\,[D_i\,] = E(Y_1 - Y_0) \quad (6)$$

Beyond the ATE, the average treatment effect for the treated (impact) was estimated as follows

$$ATT = E\,(Y_1 - Y_0/D_i = 1) = E\,(Y_1/\,D_i = 1) - E\,(Y_0/\,D_i = 1) \quad (7)$$

Where, Y_1 is the outcome (adaptation) in the treated condition; Y_0 is the outcome in the control condition; and the D_i indicator variable (treatment status) denoting participation in quality coffee production.

Finally, the odds ratio or marginal probabilities of the occurrence of the outcome (adaptation) were computed for binary outcomes as a measure of treatment effects (Austin and Stuart, 2017).

5.2.3 Qualitative data collection

Focus Group Discussions (FGDs), in-depth interviews and field observation were employed to collect qualitative data; these methods enable exploring questions with participants with the flexibility for asking further questions in order to clarify responses. The qualitative component of this study provides additional data to establish a deeper understanding on adaptation practices by coffee production types. Four FGDs were conducted with 7-10 participants of different ages, men/women, quality, and conventional coffee producers. For in-depth interviews, 16 farmers were selected (four from each of the four sub districts) and interviewed. We also conducted interviews with seven experts (one from each of the four sub districts, two from the district and one from the Zone level offices), as important stakeholders in the coffee sector. The diversity of participants in the FGDs and in-depth interviews was maintained by consulting local experts. They were selected on a purposive sampling procedure, so it included both males and females aged between 28 and 79 with long-term knowledge of the area. Field observation was undertaken on the sites of coffee production for a month. In addition, secondary data from the district office were collected on the role of selected actors such as district offices in coffee production.

The FGDs and in-depth interviews were guided by checklists that included topics on: (i) How they described quality coffee production, (ii) What they believed about the role(s) of quality coffee production in climate change adaptation, and (iii) What they believed adaptation practices as viable in their respective coffee production types. The interview questions were pre-tested with some participants during the preliminary field visit and some changes were made to adjust it to local circumstances. The interviews were continued until saturation was reached; until there was a repetition in the expression of themes and little new information was expressed (Skovdal,2020). All interviews were conducted in Amharic language, since all the interviewees spoke the language. Audio-recorders and digital cameras were used to gather oral and visual data, and those were transcribed, interpreted and analysed. Analysis of the qualitative data involved coding, searching for underlying concepts, building themes and explaining overarching themes about the settings of quality coffee production and climate change adaptation.

5.3 RESULTS

5.3.1 PROPENSITY SCORES

The propensity score was estimated using a logistic regression model of the probability of participating in quality coffee production based on the set of pre-tested covariates for quality coffee production. The distribution of propensity scores is shown in Figure 2. The box plot representation of the propensity scores before and after propensity score matching indicates the degree to which propensity score matching had achieved balancing covariates between the two groups.

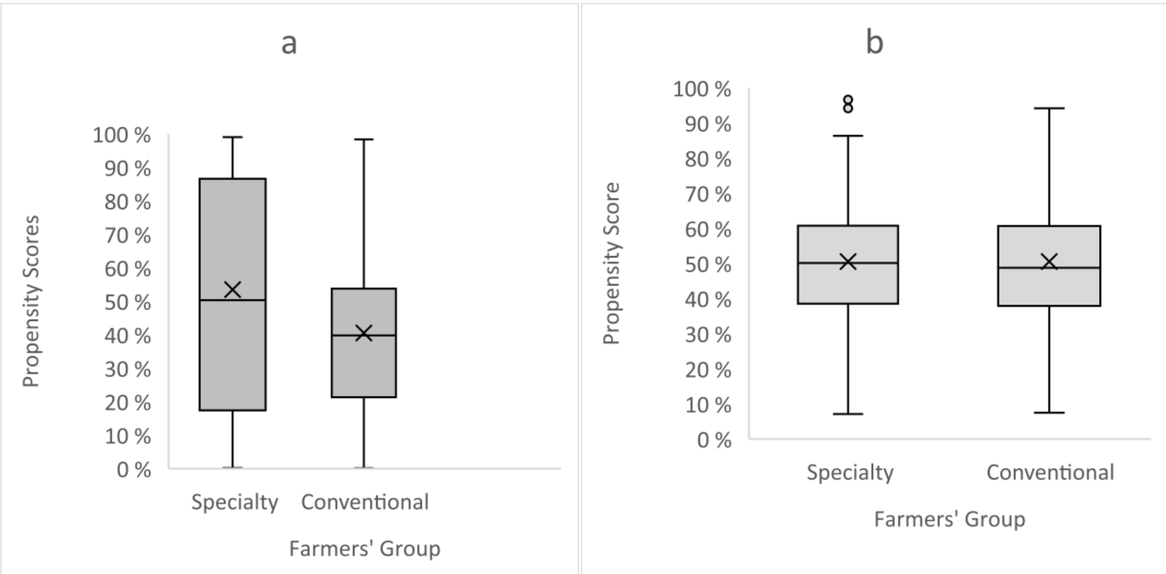


Figure 2. Distribution of the propensity scores before (a) and after (b) matching

Standardized differences of the means were computed for each of the 14 covariates in the sample, and comparable balance was achieved using the propensity score matching (Tables 2 and 3). For the categorical variables, the standardized mean differences (d) before and after matching were computed based on the proportions of the values for each group (equation 4), and summarized in Table 2.

Table 2. Categorical variables balances before and after matching

Covariates	Coffee Group	Before matching		After matching	
		Mean	Standardized Mean difference	Mean	Standardized Mean difference
Sex of the HH head (% of male)	Quality coffee	0.89	0.25	0.98	0.00
	Conventional coffee	0.80		0.98	
Education of the HH head (% of literate)	Quality coffee	0.75	-0.14	0.56	0.04
	Conventional coffee	0.81		0.54	
Access to extension (% access)	Quality coffee	0.52	0.54	0.75	0.04
	Conventional coffee	0.39		0.73	
Access to credit (% of access)	Quality coffee	0.40	0.65	0.60	0.14
	Conventional coffee	0.13		0.52	
Cooperative membership (%)	Quality coffee	0.32	-0.76	0.14	-0.16
	Conventional coffee	0.67		0.20	
Perception about Climate change (%)	Quality coffee	0.92	0.21	0.94	0.02
	Conventional coffee	0.85		0.93	

N.B: Before matching (N=120 for quality, and N= 232 for conventional coffee producers) and after matching (N=92 for each group)

As shown in Table 2, while the values are greater than the absolute value of 0.2 before matching (except for educational level), those values that are less after matching indicate the propensity score matching was successful for further analysis. While all the continuous covariates exhibited a significant difference between the groups and imbalance for comparison (d> 0.2) before PSM, a good balance (d < 0.2) was found after the PSM (equation 3); which indicated effective balancing of the covariates for further analysis (Table 3).

Table 3. Covariates (continuous variables) balance before and after matching the groups.

Covariates	Before propensity matching			After propensity matching		
	Quality Mean (SD)	Conventional Mean (SD)	*Standardized mean difference (d)*	Quality Mean (SD)	Conventional Mean (SD)	*Standardized mean difference (d)*
Age of HH head (years)	40.4 (12.5)	44.0 (13.3)	-.27	39.3 (12.7)	9.3 (13.6)	-0.008
Coffee Farm Size (ha)	2.0(0.3)	0.7 (0.6)	.36	2.0 (0.3)	2.0 (0.4)	0.055
Distance of plots from pulp centre (km)	1.9 (1.7)	2.8 (2.3)	.70	1.9 (1.7)	1.9 (1.6)	-0.010
Experience in Coffee Farming (Years)	21.9(12)	24.8 (12.7)	.80	27.7 (4.9)	27.7 (15.5)	-0.005
Household size (number)	10.5(4.7)	8.4(4.3)	.90	9.5 (4.3)	9.4 (4.4)	0.007
Land holding Size (ha)	2.1(0.8)	0.8 (0.7)	1.1	2.2 (0.5)	2.1 (0.3)	0.011
No of plots (number)	3.2 (1.6)	2.6 (1.5)	.50	3.0 (1.4)	3.0(1.5)	0.009
No of coffee plots (number)	2.4 (1.5)	1.9 (1.0)	.48	2.0 (1.1)	1.9 (1.1)	0.081
Propensity Score*	.5 (0.2)	.3 (0.2)	.49	0.5 (0.1)	0.5 (0.1)	0.06

N.B: Before matching (N=120 for quality, and N= 232 for conventional coffee producers) and after matching (N=92 for each group); SD denotes standard deviation

5.3.2 Effect of Quality Coffee Production on Adaptation to Climate Change

The main adaptation practices related to coffee production were assessed in terms of the Average Treatment Effect on the Treated (ATT). Logistic regression was used to estimate the marginal odds ratio of these adaptation practices as binary outcomes of quality coffee production by smallholders, and summarized in Table 3. The estimated marginal odds ratio for cultivar selection as adaptation practice was 0.53 (95% CI: (0.37, 0.68)). The effect of quality coffee production on the odds of cultivar selection was statistically significant ($p <.001$). This implies that the probability of using cultivar selection by the quality coffee producers would be about 0.53 times greater than the probability that would be if they were conventional coffee producers. This highlight that quality coffee production had a statistically significant effect on the cultivar selection as an adaptation practice. In particular, quality coffee producers recognized the need for new varieties of coffee that produced better yield in the face of climate change, as they mainly work to increase yield and quality targeting the global demand for quality coffee.

The estimated marginal odds ratio for irrigation use was 0.1 (95% CI: (-0.08, .28)), with no statistically significant difference (p =.27). The estimated effect of quality coffee production on mulching was -0.03 (-0.08, .28), with no significant effect (p=.75)). Both groups of coffee farmers mentioned that they used grasses and enset (E.ventricosum) trashes to mulch the ground under coffee plants in order to increase moisture retention and efficiently use the limited available water. Mulching increases infiltration and improves soil moisture, and helps coffee farmers make their coffee production systems more resilient to climate variability. The estimated marginal odds ratio for rainwater harvesting was 0.7 (95% CI: (0.6, .8)); indicating a significant effect of quality coffee production on this adaptation practice (p <.001). This indicates quality coffee farmers are 0.7 times more likely to undertake rainwater harvesting than it would be if all of them were conventional coffee producers. Informal discussions with coffee producers and field observations also confirmed that quality coffee farmers were more likely to undertake rainwater harvesting than conventional coffee producers. Rainwater harvesting was used mainly to mitigate effects of dry spells during the coffee growing season.

The estimated marginal odds ratio for shade management was 0.5 (95% CI: (.38, .68)), with statistically significant effect of quality coffee production on shade management (p <0.001). This means the probability that quality coffee producers undertake shade management was 0.5 times greater than that would be if these farmers were not participating in quality coffee production. In-depth interviews with the sub-district experts also revealed that quality coffee producers practiced shade management more than conventional coffee producers did. Shade trees planted near coffee plants have the ability to block out the sun's direct impact on the plants, and modify the local climate, reducing by up to 5^0C (Bongase,2017). During fieldwork, it was observed that more frequent and modified shade trees existed in the quality coffee famers' farms than in the conventional coffee farmers' farms. For example, while the optimal shade cover for coffee production is 40-50% (Denu et al, 2016), in-depth interviews indicated that coffee farmers did not have awareness about the optimal level of this shade cover.

Shifting coffee seedlings time was another adaptation practice identified in the study area. The estimated marginal odds ratio for shifting coffee seedlings time was 0.5 (95% CI: (.37, .62)), with statistically significant effect of quality coffee production on undertaking this adaptation practice ($p < 0.001$). This indicated that quality coffee farmers were 0.5 times more likely to carry out shifting nursery seasons of coffee seedlings than that would be if they were conventional coffee producers. Focus group discussions with district experts also indicated quality coffee producers were more likely to shift nursery periods of coffee seedlings based on the onset and offset of the rainy season, mainly due to their closer links to extension workers from the local coffee development department and better access to information about demand for quality coffee in the global market.

The estimated marginal odds ratio for crop diversification was -0.3 (95% CI: (-0.42, -.07)). The effect of quality coffee production on the odds of crop diversification was statistically significant ($p = .006$). This implies that quality coffee farmers were 0.3 times less likely to employ crop diversification as adaptation practice than that would be if all of them were conventional coffee producers. Participants from the conventional coffee producers also believed that crop diversification through intercropping and rotation with the coffee plants would help buffer against coffee yield risks caused by climatic adversities, and was considered as an economic way out during thin coffee seasons. It was also confirmed from field observation that conventional coffee growers cultivated multi-cropped coffee farms, particularly comprising enset (*e.ventricosum)*, avocado *(*p. *americana*) and banana (*m.acuminata*). Expectedly, the estimated marginal odds ratio for shifting to other crops in response to worries about the climate sensitivity of coffee plants was -0.06 (95% CI: (-0.21, .09)), showing no statistically significant effect of quality coffee production ($p = .46$). This suggests that the probability quality coffee producers would shift to other crops from coffee production was 0.06 times less than that would be if none of the farmers had participated in quality coffee production. Shifting out of coffee production is not an easy option due to the strong attachment to the coffee cultivation and cultural acceptance of alternative crops in the study area. A coffee development expert from Yirgacheffe district recounted that 'the local community chooses to die with dried coffee tree(s) due to climate change than shifting to other crops'. This implies that coffee production in the study area is not only a matter of economic aspect of livelihoods but it also encompasses cultural aspects shared among the different generations of the local community.

Table 4. Impact of quality coffee production on adaptation practices by smallholders

Adaptation Practices (for quality vs conventional coffee farmers)	Coef.	Std. Err.	z	p>z	[95% Conf. Interval]
Cultivar selection	0.53	.08	6.7	0.000**	(.38,.68)
Irrigation	0.10	.09	1.9	.27	(-.08, .28)
Mulching	-0.03	.08	0.32	0.75	(-.17, .12)
Rainwater harvesting	0.73	.06	11.48	0.000**	(.60, .84)
Shade management	0.53	.07	7.12	0.000**	(.38, .67)
Shifting coffee seedling time	0.50	.06	7.6	0.000**	(.37, .63)
Crop diversification	-0.25	.09	-2.73	0.006*	(-.42, -.07)
Shifting to other crop production	-0.06	.08	-0.75	0.46	(-.21, .09)
Off-farm activities	-0.22	.07	-3.17	0.002*	(-.35, .08)
Migration	-0.30	.09	-3.17	0.002*	(-.47, -.11)
No of pruned coffee trees/ Household/ year	87.4	46.1	1.90	0.05*	(2.8, 177)
Compost applied (m^3/ha)	1.4	.18	7.9	0.000**	(1.1, 1.7)

** and * statistically significant at 0.01 and 0.05 level, respectively

The estimated marginal odds ratio for undertaking off-farm activities was -0.22 (95% CI: (-0.35, .08)), with statistically significant effect of quality coffee production on it (p =.002). This indicated quality coffee producers were 0.22 times less likely to engage in off-farm activities than it would be if none of the farmers were participating in quality coffee production. In other words, conventional coffee farmers were more likely to engage in off-farm activities. FGDs also indicated that smallholders (mainly conventional coffee producers) had resorted to other small-scale businesses such as petty trading and wage employment in construction. The marginal odds ratio for migration was -0.3 (95% CI: (-.47,-.11)), with statistically significant difference between the two groups of coffee producers (p =.002). This implies that the probability to migrate in response to climate change impact for quality coffee farmers was 0.3

less than the probability that would be if all of them were conventional coffee producers; indicating that conventional coffee farmers were more likely to migrate in response to climate change than the quality coffee producers.

The average number of coffee trees per household for quality coffee producers was about 87 trees greater than the average that would be if none of these farmers were participating in quality coffee production at 95% CI: (2.8, 177); with statistically significant difference (p=0.05). This suggests that quality coffee production contributes to pruning old coffee trees that have been reported to be a problem to improve coffee yield and quality in the study area. The average amount of compost applied per household by quality coffee producers was about 1.4 m^3/ hectare greater than the average that would be if none of these farmers were participating in quality coffee production. The difference in application of compost was statistically significant (P<0.001); indicating that quality coffee production improves application of organic inputs like compost to maintain quality of their coffee production.

The conclusion from this section is that most farmers practiced multiple adaptation measures to climate change, which were used in combination at the same time. Quality coffee production has a positive effect on cultivar selection, irrigation, shade management, rainwater harvesting, compost application and pruning old coffee trees as adaptation practices. On the other hand, it has a negative effect on migration, crop diversification, off-farm activities, which were reported to be applied by the conventional coffee farmers.

5.4 DISCUSSION

The results of this study indicate that quality coffee production has positive effects on farm level adaptation to climate change. While almost all of the surveyed farmers undertook different adaptation practices, the impact assessment indicates differences between the two groups compared in terms of extent of use of adaptation practices, which is attributable to quality coffee production. In general, quality coffee producers were more likely to carry out use of new cultivars, rainwater harvesting, shade tree management and shifting nursery seasons for coffee seedlings than the conventional coffee producers. The application of compost and pruning of old coffee trees were also more likely to be carried out by quality coffee producers than conventional producers. The quality coffee producers were more likely to undertake these adaptation practices to maintain quality of their produce in response to the growing demand for quality coffee in the national and global coffee markets.

Both groups of coffee producers undertook irrigation, mulching and shift to other crops with statistically non-significant differences. This might be a reflection of the local circumstance, such as availability water for irrigation and availability of plant leaves and grasses for mulching. Asked about shifting from coffee production to other crops, informants from both groups of coffee producers asserted lack of intention to do so, indicating that coffee production is deeply entrenched in the culture of the local community.

On the other hand, crop diversification, off-farm activities and migration as adaptation options were found to be more likely to be undertaken by the conventional coffee producers than the quality coffee producers. Crop diversification is an integrated management option, which combines coffee production with food crops production, to increase opportunity of the farmers to get subsistence food and sustain their livelihoods. It was learned that since conventional coffee producers had lower cash income to buy food than the quality producers, they tend to produce food crops on their coffee farms. Migration and off-farm activities like local petty trading and daily labour were more likely to be used by the conventional producers because of their lower cash incomes from their coffee farms.

Our findings are generally consistent with findings from earlier similar studies that have reported better on-farm adaptation practices of quality coffee producers than conventional producers (Lin, 2007). Similarly, Burnham and Ma (2016) and Denu et al (2016) concluded that quality coffee production contributes to climate change adaptation. Apparently, quality coffee producers worked to increase quality and yield of their coffee so as to meet the growing quality standards (e.g. organic), and in the process they undertake different adaptation practices.

5.5 CONCLUSION

The study reveals that coffee farmers made a number of adjustments to their farming practices in order to adapt their coffee production to climate change. It also found that a significant association exists between most adaptation practices and quality coffee production. The findings highlight how quality coffee production influences adaptation practices. While off-farm adaptation practices were more likely to be carried out by conventional coffee producers, quality coffee producers were more likely to undertake mostly on-farm adaptation practices to maintain quality of their production for the national and global markets. This indicates that particularly the global demand for quality coffee drives smallholders' decisions to undertake various quality-maintaining activities related to adaptation measures to climate change. While further research is needed to firmly establish connections between climate change adaptation practices and the demand for quality coffee at ''a distance'', this study concludes that the demand for quality coffee in the global market influences adaptation practices by smallholders in coffee producing areas and countries. In terms of methods, this study demonstrates that the propensity score matching method is a useful approach to assess effects of quality coffee production on adaptation to climate change by balancing confounding factors that are deemed important.

Acknowledgments

We would like to acknowledge the Research Council of Norway for funding the Project 'The role of global value chains in transition to sustainability'. We also extend our sincere thanks to all data collectors, and farmers who took part in the surveys of the study.

REFERENCES

Adane, A. and Bewket, W. (2021). Effects of Quality Coffee Production by Smallholders on Local Land Use and Land Cover in Yirgacheffe, Southern Ethiopia. *Journal of Land Use Science*, *16*(2), 205-221. https://doi.org/10.1080/1747423X.2021.1893844

Austin, P. C. (2011).An introduction to propensity score methods for reducing the effects of confounding in observational studies", *Multivariate Behavioral Research*, *46*(3), 399–424.

Baca,M.,Laderach,P.,Haggar,J.,Scroth,G. and Ovalle Revira.O.(2014). *An Integrated Framework for Assessing Vulnerability to Climate Change and Developing Adaptation Strategies for Coffee Growing Families in Mesoamerica. PLoS ONE.*9 (2). e8846

Caliendo, M. and Kopeinig, S. (2005). *Some Practical Guidance for the Implementation of Propensity Score Matching*'.(1588).

Daviron,B. and Ponte,S. (2007). The Coffee Paradox: Global Markets, Commodity Trade and the Elusive Promise of Development.*The World Economy*, *30*(6), 1031–1032.

Davis, A. P., Gole, T. W., Baena, S. and Moat, J. (2012).The Impact of Climate Change on Indigenous Arabica Coffee (Coffea arabica): Predicting Future Trends and Identifying

Priorities", *PLoS ONE*, *7*(11), 10–14.

Degefa, S. (2016).Home garden agroforestry practices in the Gedeo zone , Ethiopia : a sustainable land management system for socio-ecological benefits. *Socio-Ecological Production Landscapes and Seascapes in Africa*, (January 2016), 28–36.

Denu, D., Platts, P., Kelbessa, E., Gole, T. and Marchant, R. (2016). The role of traditional coffee management in forest conservation and carbon storage in the Jimma Highlands, Ethiopia. *Forests Trees and Livelihoods*, *25*(4), 226–238.

Ebisa, D. B. (2017). Impacts of climate change on global coffee production industry: Review. *African Journal of Agricultural Research*, *12*(19), 1607–1611.

George, E. (2014).*The coffee sector in Sub-Saharan Africa*. (March), Ecobank Research 2014

Getnet, K. and Anullo, T. (2012). Agricultural cooperatives and rural livelihoods: evidence from Ethiopia. Ann Public Coop Econ 83: 181-198.

Gregorich, E., Drury, C., Baldock, J. and Greaves, T .(2001). Changes in soil carbon under long-term maize in monoculture and legumebased rotation. Can J Soil Sci 81:21–31

Grothmann, T. (2014). *Adaptive capacity and human cognition : The process of individual adaptation to climate change*. (May). https://doi.org/10.1016/j.gloenvcha.2005.01.002

IPCC (Intergovrnmental Panel for Climate Change) (2007).Climate Change 2007: The Physical Science Basis Contribution of Working Group I to the Fourth Assessment Report of the IPCC

Jassogne, L., van Asten, P. J. A., Wanyama, I. and Baret, P. V. (2013). Perceptions and outlook on intercropping coffee with banana as an opportunity for smallholder coffee farmers in Uganda. *International Journal of Agricultural Sustainability*, *11*(2), 144–158.

Jena, P. R., Chichaibelu, B. B., Stellmacher, T. and Grote, U. (2012).The impact of coffee certification on small-scale producers' livelihoods: A case study from the Jimma Zone, Ethiopia. *Agricultural Economics (United Kingdom)*, *43*(4), 429–440.

Jha, S., Bacon, C. M., Philpott, S. M., Rice, R. A., Méndez, V. E. and Läderach, P. (2011). *A Review of Ecosystem Services , Farmer Livelihoods , and Value Chains in Shade Coffee Agroecosystems*. Campbell W. B. and López Ortíz,S.(Eds), Integrating Agriculture, Conservation and Ecotourism: Examples from the Field,Issues in Agroecology – Present Status and Future Prospectus, Springer Science-Business Media 2011,pp.141-208

Kodama,Y. (2007). *New Role of Cooperatives In Ethiopia : The Case of Ethiopian Coffee Farmers Cooperatives*. (March), 87–108.

Meskela, T. and Teshome, Y. (2014). From economic vulnerability to sustainable livelihoods: The case of the Oromia coffee farmers cooperatives union (OCFCU) in Ethiopia. *International Food and Agribusiness Management Review*, *17*(SPECIALISSUEB), 103–108.

Mekuria, T., Neuhoff, D. and Köpke, U. (2004).The Status of Coffee Procuction and The Potential for Organic Conversion in Ethiopia. *Conference on International Agricultural Research for Development*, 9. http://www.tropentag.de/2004/abstracts/full/293.pdf

Meza, L. E. (2015).Adaptive capacity of small-scale coffee farmers to climate change impacts in the Soconusco region of Chiapas, Mexico. *Climate and Development*, *7*(2), 100–109.

Minten, B., Dereje, M., Engida, E. and Tamru, S. (2018).Tracking the Quality Premium of Certified Coffee: Evidence from Ethiopia. World Development, 101, 119–132.

Mojo, D., Fischer, C. and Degefa, T. (2015). Social and environmental impacts of agricultural cooperatives: Evidence from Ethiopia. *International Journal of Sustainable Development and World Ecology*, *22*(5), 388–400.

Moore, N., Alagarswamy, G., Pijanowski, B., Thornton, P., Lofgren, B., Olson, J., … Qi, J. (2012). *East African food security as influenced by future climate change and land use change at local to regional scales*. 823–844. https://doi.org/10.1007/s10584-011-0116-7

Petit, N. (2007). Ethiopia's coffee sector: A bitter or better future?. *Journal of Agrarian Change*, *7*(2), 225–263.

Rosenbaum, P. R. and Rubin, D. B. (1983).The central role of the propensity score in observational studies for causal effects. *Biometrika*, *70*(1), 41–55.

Rubin, D. B. (2001). Using propensity scores to help design observational studies: Application to the tobacco litigation. Health Services and Outcomes Research Methodology,2, 169-18.

Rubin, D. B. and Thomas, N. (2006).Matching using estimated propensity scores: Relating theory to practice.*Matched Sampling for Causal Effects*, Vol.*52 No.*1, pp.263–281.

Skovdal, M. and Cornish, F. (2015). Qualitative research for development: a guide for practitioners, *Practical Action Publishing*, Rugby, UK.

CHAPTER SIX ……………………………………………………………………

ASSESSMENT OF STAKEHOLDERS' ROLES AND LINKS IN QUALITY COFFEE PRODUCTION IN YIRGACHEFFE, SOUTHERN ETHIOPIA: IMPLICATIONS FOR LOCAL CLIMATE CHANGE ADAPTATION

Asnake Adane[1] and Woldeamlak Bewket[1]

Submitted and Being Reviewed: *Norwegian Journal of Geography*

6. Assessment of Stakeholders' Roles and Linkages in Quality Coffee Production in Yirgacheffe, Southern Ethiopia: Implications for Local Climate Change Adaptation

Abstract

Rapid rates of land degradation and limited instances of genuine collaborations involving the different stakeholders adversely affects environmental and socioeconomic sustainability. The objective of this study was to assess stakeholders' roles and linkages in quality coffee production and its implications for adaptation to climate change in Yirgacheffe, southern Ethiopia. Stakeholder analysis tools, namely the Process Net Map (PNM) and Participatory Analysis Matrix (PAM) were used to identify and characterize stakeholders based on the power and interest criteria, and assess their linkages and roles in quality coffee production. A household survey of coffee farmers (stratified into quality and conventional coffee farmers) was also used to assess levels of satisfaction of coffee farmers with various forms of support provided to them by the stakeholders. The PNM shows that stakeholders possess different degree of power and interest in quality coffee production. While government agencies are more powerful in decisions and actions related to quality coffee production, coffee farmers (though key actors) are less powerful. The links and flows that exist between the stakeholders highlight that quality coffee production is the result of combined efforts of multiple stakeholders along the value chain. Results from the household survey indicated that quality coffee producers were more satisfied with supports received from stakeholders than the conventional coffee farmers. This suggests that quality coffee producers tend to have stronger linkages with stakeholders than the conventional coffee producers. The findings suggest policy interventions that enhance collaborative quality coffee production through capacitating stakeholders in the coffee value chain could be important to make the coffee-based livelihoods sustainable and resilient to climate change.

Key words: quality coffee production, stakeholders, climate change adaptation, Ethiopia

6.1 INTRODUCTION

Coffee production is a key component of the rural economy throughout the tropics, and it is particularly important for smallholders (Finley-Lezcano et al, 2016). Ethiopia is the origin and centre of genetic diversity of the Arabica coffee plant, and endowed with immense potential to produce ‘differentiated’ high-quality coffee, such as organic and shade-grown coffee (Mojo et al, 2015). Coffee has been cultivated, traded and consumed for centuries and still plays a central role in the local and national economy of Ethiopia (Gole, 2015). It contributes up to 50% of the country´s export and more than 25% of the country's foreign exchange earnings, and nearly a fifth of the country’s population depends on coffee for their livelihood, where about 5 million smallholders produce 95% of the total production in a low input-output production system (Meskela and Teshome, 2014).

Ethiopian coffee is sold at high premiums, as single origin in the niche market. Fine quality coffee from different origins in Ethiopia is kept separate from each other and sold with their regional name; e.g., Yirgacheffe coffee (Minten et al, 2019). While some aspects of quality (material quality) can be measured by using the human senses, symbolic quality can be ensured through long-term relationships between actors, or use of private brands or geographical indications that signal the reputation of products (Daviron and Ponte, 2007). The quality of coffee is maintained by inherent and external factors such as, but not limited to, genetic type of the coffee tree, agro-climatic condition (soil type, rainfall, altitude), and coffee production and processing (Bacon,2005; Degefa, 2016).

Quality coffee production comprises on-farm activities like increasing biodiversity of farms through intercropping, increasing shade trees on farms, and introducing natural fungicides and insecticides. It simultaneously involves many nodes and actors along the value chain (Daviron and Ponte, 2007; Riisgaard et al., 2010). This suggests that coffee farming practices and quality maintaining activities could be determined by decisions and actions by actors of varied power and interest along the value chain. Quality coffee is therefore an outcome of actors and efforts along the value chain, and its enabling environment like institutional structure and markets, as coffee is a cash crop (Fischer and Newig, 2016). Value chain analysis for coffee is useful to understand the roles of actors in the entire process.

Many studies exist on quality coffee production in Ethiopia (e.g., Bolwig et al , 2009; Minten et al, 2019; Rahn et al., 2018). However, the focus of most of those studies was about on-farm actors and practices of quality coffee production, with little attention going beyond the farm level context of production (Canevari-luzardo, 2019). Very few studies (e.g. Riisgaard et al,

2010) have addressed how value chain can be integrated into environmental and socio-economic concerns in general, and particularly evidence is scarce on stakeholders' roles and integration within the coffee value chain for quality coffee production and its implications for climate change adaptation. Understanding the nuanced role of actors along the value chain in supporting quality coffee production remains sketchy (Grote and Winter, 2009), and gaps persist to look beyond farm level decisions and practices.

The aim of this study was to examine roles and linkages of stakeholders in quality coffee production, and its implications for adaptation to climate change in Yirgacheffe, southern Ethiopia. Specifically, the study intends to: (i) identify stakeholders and describe their roles in quality coffee production, (ii) assess the linkages between and among stakeholders of quality coffee production, and (iii) assess coffee farmers' perceptions on the role of stakeholders, and (iv) describe implications of quality coffee production for climate change adaptation. The remainder of the paper is organized as follows. The second section outlines the analytical framework of the study. The third section describes materials and methods, and the fourth section presents results. Section 5 presents discussion and conclusions.

6.2 ANALYTICAL FRAMEWORK

6.2.1 Stakeholder Analysis For Quality Coffee Production

A stakeholder is anyone with power, interest and/or importance in the performance of a system, and will positively or negatively affect or is affected by that system (Bezabih et al, 2020; Tesfaye et al, 2020; Zeleke et al, 2006). Stakeholders are often grouped into primary and secondary stakeholders (Duguma, 2017). In our case, the primary stakeholders are those who are directly involved in the coffee sector, from producers to consumers, and the secondary stakeholders are those that influence the sector by setting rules, or controlling access to resources or markets; e.g., government officials or policy makers. Stakeholders are also categorized according to their relative power and interest (Grimble and Wellard, 1997); interest refers to whose needs are the priorities, while power refers to the influence stakeholders will have over the success of a system.

Originating from the field of management, stakeholder analysis has been applied in development and environmental studies. Lelea et al (2014) assert that stakeholder analysis has the capacity to identify actors and their roles, the core processes (input supply, production, processing, marketing and consumption) and institutional linkages (fund flows, knowledge and technology flows and market linkages).The Participation Analysis Matrix (PAM) and Process Net-Map (PNM) are important tools in stakeholder analysis (Bezabih et al, 2020). The PAM can be used when one wants to explore important features of the stakeholders who are involved in the value chain. It is often applied on experts and stakeholders in the downstream part of the value chain. In contrast, net-mapping is an innovative tool to identify important linkages among actors (Lelea et al, 2014). The PNM considers all activities and processes along the value chain, from input supply to end users, and helps to identify the different linkages of stakeholders. In this study, the PNM is used to explore the roles of and relationships between stakeholders, and power and interest of stakeholders in the quality coffee production process.

6.2.2 Value chain analysis

Value chain refers to the overall value-adding activities that are required to transform inputs into outputs, and the range of service providers that support these activities (Gereffi, 2014). Value chain analysis (VCA) is a diagnostic tool to examine actors involved in the chain, their network structures and the core functions involved in bringing a product from its conception to its final consumers. It is used to assess the performance of value chains, including analysis of product flows, information flows and overall chain management, and its environmental concerns like adaptation to climate change. According to Bezabih et al (2020), value chain analysis involves: (a) examining the core processes or value chain functions such as input supply, production, processing, marketing and consumption; (b) describing key value chain actors, their network structures and activities within the value chain; and (c) evaluating the environmental, political and socio-economic contexts of the value chain.

6.2.3 Coffee value chain stakeholders and their roles in Ethiopia

Coffee value chain comprises growing, harvesting, processing, roasting and brewing, and involves various stakeholders. The stakeholders can be categorized into primary and secondary based on type and level of their involvement. The primary stakeholders include, among others, coffee farmers, cooperatives, agro-supply dealers, traders, exporters and consumers, and the secondary stakeholders comprise service providers that include government agencies, research institutes, donors and non-governmental organizations (NGOs). This categorization is obviously not exclusive, as for example, farmers are both producers and consumers of coffee.

Coffee farmers in the production side of the coffee value chain undertake both production and value adding functions. Coffee producers often sell the red cherry coffee on their farm. Coffee cherry collecting and transporting activities are mostly performed by women and most coffee processing employees are women. The coffee sector constitutes a very important source of casual employment for many poor people including women. While coffee collectors play an essential role of bringing coffee from very remote areas to the market, traders buy coffee from collectors or producers and sell to exporters (USAID, 2010). They carry out coffee processing (wet or dry processing) as a value adding activity before they sell it to the exporters.

Cooperatives are important stakeholders in the coffee value chain. They undertake processing activities like washing, pulping, sorting and finally sell it to their respective unions (Shiferaw et al, 2016). Cooperatives create linkages of small producers with processors, exporters and actors in high value markets, and facilitate economic coordination with other enterprises (e.g. financial institutions, input suppliers) and service providers (e.g. extension agents). Cooperatives also have the potential of collective action to aggregate standardized and high quality products from small producers, and consistently supply to high value markets (Kodama, 2007). In general, cooperatives potentially play key roles in integrating coffee farmers into market systems, enhance access to technologies and services, and contribute to more sustainable and climate resilient coffee sector.

The secondary stakeholders are primarily service providers at each node of the coffee value chain. These groups comprise government agencies including the coffee and agricultural offices at different administrative levels. The government agencies are actors that include the federal Ministry of Agriculture, Regional, Zonal, and District level government agencies. This group also includes the Ethiopian Coffee and Tea Development and Marketing Agency (ECTDMA). ECTDMA plays important roles in quality coffee production such as providing various forms of support for coffee farmers like material input supplies and market access. It is also expected to provide targeted and defined financial support as well as technical advice on coffee production and marketing aspects (Shiferaw et al, 2016). It also represents coffee farmers in policy discussions on coffee production.

NGOs and financial sector actors that provide credit and other financial services are also secondary stakeholders in the coffee value chain (Duguma, 2017). Research institutes, which include national and regional level coffee research centres and universities, are expected to undertake systematic studies and support producers as well as policy makers to make informed decisions. Furthermore, as smallholder coffee farmers cannot be expected to directly influence policy decisions, research institutes can also play important roles in advocacy and representation in policy discussions.

6.3 METHODS

6.3.1 Qualitative methods

We used Process Net Mapping (PNM), which is suitable to characterize stakeholders and assess their roles in quality coffee production (Lelea et al,2014). The PNM tool is a participatory approach in which individual actors discuss, understand and visualise important and complex formal and informal linkages, power relations and the goals of each actor in systems they participate (Hauck et al., 2016). The PNM builds on an on-site network visualisation by drawing networks with participants to explore linkages between stakeholders and associated meanings. The PNM was undertaken with purposively selected actors in the coffee value chain, including coffee farmers (Figure 2) between December 2018 and March 2019. A total of 35 respondents participated in the qualitative data collection process (Table 1).

Two PNMs at Zonal and District level, with participants of nine members and lasting for two hours each, were undertaken. Guiding questions for the PNM were developed to define a maximum of commonalities in the questions across the participants and adapt them to the local contexts. Those guiding questions were: (i) who are influential actors in quality coffee production? (ii) What do you think are the roles of actors in quality coffee production? (iii) How would you assess the power and interest of actors and their decisions in quality coffee production? (iv) What do the flows and linkages of materials and information between and among actors pertinent to quality coffee production look like? (v) What are the implications of these flows and links for climate change adaptation?

Table 1. Stakeholders' composition in FGDs and KIIs

Primary stakeholders	Number of interviewees	Secondary stakeholders	Number of interviewees
Agro-input suppliers	3	Government agencies (district, CTDMA offices)	4
Farmers	8		
Cooperative leaders	4	Financial sectors	2
Processors	6	Research institutes	3
Traders	3	Donors and NGOs	2
Exporters	----		
Total	24		11

Note: Participants from all categories of stakeholders are consumers, and hence we took the views of some participants from the vantage point of consumers.

The Participatory Analysis Matrix (PAM) in the form of Focus Group Discussions and Key Informant Interviews was also undertaken with experts and downstream actors of the coffee value chain at Dilla (a Zonal town) with eight participants from different categories of stakeholders. The respondents mainly included experts from government agencies, research institutes, NGOs, and cooperatives unions. The PAM involved three main steps: (i) respondents were asked to identify all actors involved in the coffee value chain and their respective roles (Figure 3). These identified actors were recorded on a flip chart that was prepared for the purpose. (ii) respondents were asked to mention the role of these actors in quality coffee production, and (iii) after completion of the map, respondents were asked to review whether all the stakeholders and their roles in the coffee value chain were included. The discussions were continued until theoretical saturation was reached, where there was a repetition in the expression of themes and little new information was unveiled.

6.3.2. Survey data collection

Household survey was conducted with household heads to compliment the qualitative data. The vast majority of coffee producers in the study area were conventional coffee producers; out of 4,309 farmers, only 120 were quality coffee producers (see Adane and Bewket (2021)) for definitions of conventional and quality coffee). All of the 120 farmers were included in the household survey sample. To select a representative sample from the conventional group, we used the list of conventional coffee farmers from the district office. We took 232 samples (5.5% of the total conventional coffee farmers) by using a systematic random sampling procedure. The overall number of survey participants was therefore 352. The household survey was conducted via face-to-face interview between December 2018 and March 2019 with household heads using a structured questionnaire by the researcher and trained research assistants. The questionnaire was focused on: (i) identifying and characterizing actors in quality coffee production and (ii) perceived roles of value chain actors in the quality coffee production. A summary of the tools and methods of the research are presented in Table 2.

Coffee farmers were asked about their views on other stakeholders' roles and the level of satisfaction with supports they obtained from these stakeholders. Such approaches may be particularly useful to study certain topics, for example, for which stakeholders would like to explain the role of other stakeholders instead of themselves (Wang and Aenis, 2019). The coffee farmers' level of satisfaction with support they obtained from different actors in the value chain was categorized into five: very low (VL), low (L), moderate (M), high (H) and very high (VH), which was adapted from Wonnacott and Wonnacott (1990). From these assessment levels (ALs), weighted average index (WAI) was calculated as follows (Wonnacott and Wonnacott (1990):

$$WAI = [fVH(1.0) + fH(0.8) + fM(0.6) + fL(0.4) + fVL(0.2)] / N \quad (1)$$

Where, WAI = Weighted Average Index; fVH = Frequency of very high satisfaction; fH= Frequency of high satisfaction; fM = Frequency of moderate satisfaction; fL = Frequency of low satisfaction; fVL = Frequency of very low satisfaction; N= number of observations.

The weighted average index (WAI) was then classified into five to rate overall satisfaction levels: 0.01–0.20 for VL, 0.21–0.40 for L, 0.41–0.60 for M, 0.61–0.80 for H, and 0.81–1.00 for VH (Wonnacott and Wonnacott, 1990).

The independent samples t-test was used to compare the levels of satisfaction of the quality and conventional coffee farmers with the supports from the different stakeholders. While supports represent the path of participation of stakeholders in quality coffee production, the level of satisfaction of coffee farmers with these supports would indicate the extent of involvement of the stakeholders.

Table 2. Summary of research tools and approaches used for data collection

Research tools and methods	Type of information and data collected
Process Net-Mapping; FGD and KII guided by checklists	Identifying stakeholders, their relationships (flows and links) in coffee production
Power-Interest Matrix	Analytical categorization of stakeholders, influential actors in quality coffee production
Participant Analysis Matrix (PAM); FGD and KII guided by checklist	Aspects of quality coffee production, stakeholders' roles in quality coffee production
Household survey of coffee farmers	Perceived roles of stakeholders in quality coffee production, households' socio-economic profiles

6.4 RESULTS

6.4.1. ANALYTICAL CATEGORIZATION OF STAKEHOLDERS

Stakeholders in quality coffee production were identified using the Participatory Analysis Matrix (PAM) and subsequent interviews with experts and downstream actors along the value chain. Following Reed et al (2009) participants were asked to list specific stakeholders and give values (1-10, where 10 is the highest) for each stakeholder based on their perceived power (to control what decisions are made on quality coffee production) and interest (prioritization of quality coffee production). This was used to generate a power-interest grid (Fig. 3). The scores of power and interest levels were then categorized into four quadrants, where the first quadrant is occupied by low power/high interest (*subjects*), the second quadrant by high power/ high interest (*key players*), the third quadrant by high power/ low interest (*context setters*) and the last quadrant by low power/ low interest (*crowds*) groups.

Accordingly, coffee farmers and research institutes were the least powerful but of high interest (*subjects*) groups in the quality coffee production. Agriculture development agents (DAs) at the farm villages level, CTDMA, primary coffee producers cooperatives and the district coffee office were the most powerful and high interest actors (*key players*). The district coffee and spices agency is the primary government agency responsible for generating and disseminating good practices of quality coffee production. It is responsible for preparation of manuals for coffee cultivation and production, design and implementation of coffee development strategies and provision of extension services. It also works in collaboration with the Zonal agriculture bureau, particularly in the development of coffee production strategies and policies. Together, these stakeholders facilitate the institutional environment and regulatory services for the coffee value chain as well as quality coffee production in the area.

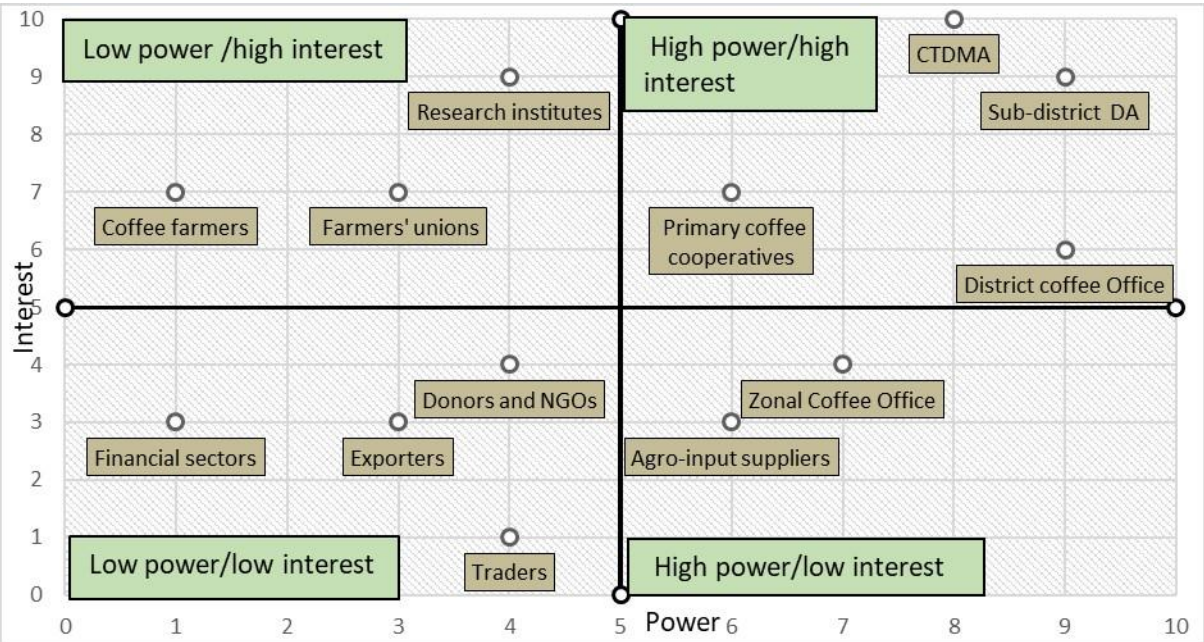


Figure 2. Power-Interest matrix of stakeholders in quality coffee production in Yirgachefe, southern Ethiopia

As stressed by participants in the Participatory Analysis Matrix (PAM), primary coffee cooperatives supported more the quality coffee producers than the conventional coffee producers. For instance, the role of cooperatives with regard to quality coffee production was to build linkages between coffee farmers and buyers/ consumers to improve total coffee production. This is consistent with the findings of Poole and Donovan (2014) and Canevari-luzardo (2019) which asserted cooperatives were better positioned to attract Quality coffee buyers and consumers who were increasingly looking for sustainability behind the products they buy. However, participants of the PNM stated that cooperatives had limited financial and human capacity to facilitate timely procurement of essential inputs for members.

The Zonal coffee office and farmers' union were identified and grouped into actors with high power and low interest (*context setters*) in quality coffee production; while donors and NGOs, traders, exporters and financial sector actors were grouped into the category of the least powerful and lowest interest category. The financial sector actors were not directly present in quality coffee production, but they still had important function by steering finance flows. FGD participants reported that the Zonal coffee office and farmers union seldom followed up the coffee production process; in most cases, unions met farmers only to buy the coffee.

6.4.2. Stakeholders' Linkages/ flows

The PNM and subsequent interviews with coffee farmers and other upstream actors in the coffee value chain identified six groups of actors: input suppliers, government agencies, coffee processors and traders, research institutes, NGOs and coffee farmers (Figure 3). The PNM Participants were asked to rank the influence of these actors (with score value 1 through 6 with 1 being the least influential) and mention their relationships in quality coffee production. Accordingly, government agencies were the most linked in quality coffee production, as reflected by an importance score of six followed by input suppliers (score of 6). Participants in the PNM mentioned that directives and orders on quality coffee production issued by the government agencies to the coffee farmers play a role in the implementation of quality coffee production; albeit there are material and financial constraints for implementation.

On the other hand, coffee farmers were the most connected actors in the network receiving different inputs, while they had low perceived influence, as reflected by a score of three. Results from the FGDs also showed that coffee farmers, as the primary stakeholders of quality coffee production, are aware of many quality-maintaining on-farm practices but would need more material and financial support to implement these practices on a broader basis. Coffee farmers were perceived as less influential stakeholders in quality coffee production despite their key role in the sector, highlighting that they may not be heard or taken seriously in the quality coffee value chain

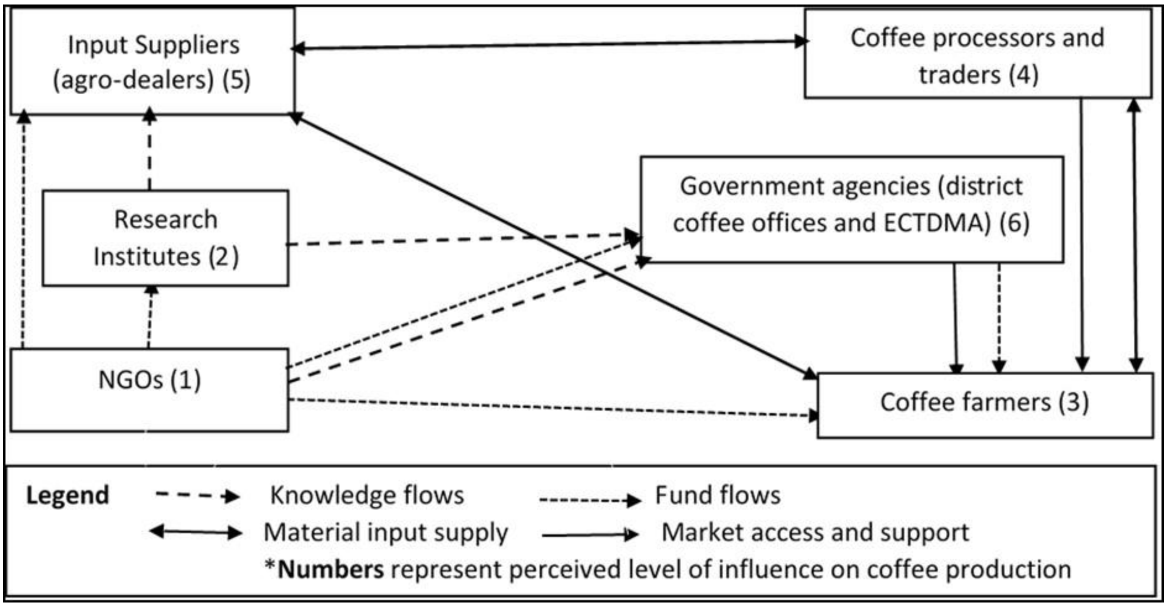


Figure 3. Linkages and flows in the coffee value chain in Yirgacheffe, southern Ethiopia

Participants during the Net-Mapping sessions mentioned that input suppliers provided seedlings, improved farm tools and materials to coffee farmers for quality coffee production. NGOs were perceived as the least influential in quality coffee production (with a score of 1). It was apparent in the PNM sessions that NGOs often addressed small areas, which meant a few farmers only, and their supports discontinued as projects phased out. The PNM also revealed four bundles of linkages/flows in the value chain that represented stakeholders' interactive relationships: material input supply, knowledge and information flows, fund flows, market access and supports (Figure 3). The material input supply includes key activities like providing improved coffee seedlings and new cultivars for coffee producers by agro-dealers and district coffee departments. Knowledge and information flows were considered as linkages in technical knowledge, training and capacity development mainly by research institutes. Fund flows were defined as credit services and incentives for quality coffee production or financing quality coffee production by NGOs, and market access represents transactions involving exchange in the coffee market.

6.4.3. Stakeholders' roles in quality coffee production

The role of primary stakeholders

According to Duguma (2017), the primary stakeholders in the Ethiopian coffee value chain include agro-supply dealers, coffee farmers; cooperatives, traders, exporters and consumers, and the secondary stakeholders comprise service providers that include government agencies, research institutes, donors and non-governmental organizations (NGOs). This categorization is obviously not exclusive, as for example, farmers are both producers and consumers of coffee. Nevertheless, participants of the FGDs believed that coffee farmers had low decision-making power in the coffee sector. This agrees with an assertion by Neilson and Pritchard (2009) that coffee production displays stark social and economic inequalities, where coffee farmers were often marginalized in decision-making processes. Coffee processors are actors engaged in production upgrading through value addition practices. While traders are the major sale outlets for coffee produce, they also play a crucial role in connecting end users and upstream actors along the value chain.

It was apparent from the Participation Analysis Matrix (PAM) that farmers' cooperatives provided some support to coffee farmers. In output markets, cooperatives enhanced collective marketing for farmers to have a higher bargaining power by way of pooling their resources, than an individual farmer in the coffee market. This means cooperatives facilitate linkages of farmers with the downstream actors in the value chain like exporters and roasters. Cooperatives are generally expected to play important roles in supporting coffee farmers in quality maintaining activities, and by supplying price information, capital, and transportation that small scale farmers often lack (Kodama, 2007; Wollni et al., 2010). However, this is not always without challenges. For example, participants of the PAM stated that cooperatives were constrained by several challenges, such as inadequate finance to purchase coffee from the farmers and ensure good price to their produce, and delayed payments (on average for 10 weeks) to the farmers for the produce collected. In contrast, alternative selling channels paid on delivery or shortly thereafter but at lower prices. As a result, many cash-constrained farmers opt to sell through these channels that pay quickly despite their lower rates.

Coffee farmers' perception on the roles secondary stakeholders

The secondary stakeholders comprise service providers that include government agencies, research institutes, donors and non-governmental organizations (NGOs). These stakeholders play important roles in creating enabling environment for quality coffee production. These roles (supports to coffee farmers) were captured using the PNM. The roles played by government agencies were offering extension services, developing standards to guide quality coffee production, offering market access and coordinating quality coffee production. The financial sector actors provided financial services like rural savings and credit, and research institutes support coffee farmers by innovating technologies and preparing manuals for quality coffee production. NGOs, on their part, support quality coffee production through financial loans and trainings on coffee farm management for quality coffee production.

The level of satisfaction of coffee farmers with the supports from stakeholders would signify the role of those stakeholders in quality coffee production by coffee farmers (Wonnacott and Wonnacott, 1990). In this study, the role of secondary stakeholders in quality coffee production was examined by asking coffee farmers to indicate their level of satisfaction with the supports they obtained from the stakeholders. Variations were apparent between quality and conventional coffee farmers in terms of satisfaction by the services obtained from the secondary stakeholders, as shown in Table 3. It is shown (in Table 3) that the weighted average indexes (WAI) of the role of government agencies (like district coffee office and ECTDMA) in developing standards for quality coffee production was statistically and significantly higher for quality coffee farmers than for the conventional counterparts ($t=6.04$, $p<.001$). Similarly, there was statistically significant difference in the level of satisfaction of coffee farmers with market access and support from government agencies ($t=3.7$, $p< .001$). These highlight the higher involvement of government agencies in developing standards for quality coffee production and creating market access to the quality coffee producers than for the conventional coffee farmers. In addition, developing standards for quality coffee production and market support received high (H) and medium (M) assessment levels from the quality coffee and conventional coffee producers, respectively. This was also confirmed by direct field observation of manuals and guidelines developed by the district office in the hands of quality coffee producers.

Table 3. Roles of secondary stakeholders in coffee production in Yirgacheffe, southern Ethiopia

Secondary stakeholders and their roles in quality production	Quality coffee (n=120)		Conventional coffee (n=232)		t-test	Sig.
	WAI	AL	WAI	AL		
a. Government agencies (district agricultural office)						
Providing extension services	0.50	M	0.45	M	1.87	.063
Develop standards that guide quality coffee production	0.61	H	0.46	M	6.04*	.000
Create market access and support to farmers	0.62	H	0.51	M	3.72*	.000
Coordinating quality coffee production	0.49	M	0.47	M	0.75	.451
b. Financial sectors						
Bank credit availability	0.50	M	0.44	M	1.7	.08
Microfinance services (rural savings)	0.55	M	0.37	L	7.14*	.000
c. Research institutes						
Provide technologies on quality coffee production	0.57	M	0.46	M	1.9**	.05
Preparing manuals for quality coffee production	0.52	M	0.48	M	0.98	.324
d. NGOs						
Financial support	0.55	M	0.44	M	0.7	.48
Trainings on quality coffee production	0.66	H	0.42	M	6.3*	.000

WAI = Weighted Average Index, Al= assessment level

** and * indicate significance levels at 0.01 and 0.05, respectively.

There was no statistically significant difference between the two groups of coffee producers in terms of the WAI on extension services (t=1.9, *p*=.06) and promotion of quality coffee production (t=0.8, *p*=.06) by the government agencies. Extension services and coordinating quality coffee production by government agencies received medium (M) assessment rating from both the quality coffee and conventional coffee producers. The WAI for the quality coffee farmers was statistically and significantly higher than the conventional coffee producers in the cases of microfinance services (t=7.14, $p<.001$).

There was no statistically significant difference between the two groups of coffee producers in terms of views on bank credit accessibility (t=1.8, $p=.08$). Microfinance services (loans and savings services) received medium (M) and low (L) assessment levels from the quality and conventional coffee producers, respectively. This suggests that quality coffee producers had better access to loans and credit services from microfinance institutions. On the other hand, interviews and focus group discussions with farmers and experts revealed that financing quality coffee production was generally limited. A Zonal expert mentioned that stakeholders at different levels of the value chain knew little about microfinance services, consistent with previous studies (Kodama, 2007; Shiferaw et al., 2016).

The WAI for provision of knowledge on quality coffee production was statistically and significantly higher for the quality coffee than for the conventional coffee producers (t=1.9, $p=.05$). This suggests that the quality coffee producers received more trainings about quality coffee production than the conventional coffee farmers. Availability of technologies for coffee production and manuals for quality coffee production received medium (M) assessment level from both the quality coffee and conventional coffee producers. There was no statistically significant difference between the two groups of farmers in terms of financial services obtained from NGOs (t=.7, $p=.48$), and financial supports received medium (M) assessment level from both groups of farmers. Trainings on quality coffee production by NGOs showed statistically significant difference (t=6.3, $p<.001$) between the two groups of producers, and it received high (H) and medium (M) assessment levels from the quality coffee and conventional coffee producers, respectively. NGOs provided trainings to promote quality coffee production; however, as mentioned during FGDs, NGOs often addressed small areas and small number of coffee farmers with a top-down approach. This could have ramifications for the continuity of trainings and associated technologies after activities of the NGOs had to phase out.

6.4.4 Implications of quality coffee production for local climate change adaptation

Quality coffee production, which involves stakeholders beyond the farm level, has important implications for climate change adaptation. For instance, trainings provided to farmers about coffee farm management, which means increased awareness and capacity, will have indirect benefits of promoting adaptation to climate change. Similarly, improved varieties of coffee obtained from research institutes could enhance coffee farmers' resilience to climate change impacts. For coffee farmers, information and knowledge are essential to be able to implement adaptation practices, while for government actors and other downstream actors, disseminating information and knowledge to coffee farmers is a requirement. In general, coffee quality maintaining activities on the production end of the value chain would have contributions to enhance resilience of the coffee livelihood to climate change.

Financial services from microfinance institutions and banks, though to a limited extent, apparently have adaptation benefits. For example, Ozor and Nnajib (2011) found that access to credit increased households' income, which enabled them to take risks associated with using adaptation strategies. Coffee farmers' access to input and output markets increases their financial capital, which is also good for climate change adaptation. Coffee farmers were of the view that they are aware of the importance of quality coffee production for adaptation to climate change, but they would need more supports in, among others, financial form to overcome the constraints they are facing. This suggests that financial services foster adaptation practices to climate change and that policy makers should therefore strengthen financial institutions so that they would provide services to the coffee farmers.

Coffee framers will have enhanced adaptive capacity to climate change due to institutional supports from cooperatives and government agencies in the form of extension services i.e., advisory services, trainings and input supplies. For example, advice from district coffee office on agronomic practices for quality coffee production, such as pruning, stumping and cultivar selection were given to the farmers to improve the quality of coffee produced. There were also trainings to farmers on moisture conservation, mulching and agroforestry management. The most important implication to climate change adaptation is through the SLM activities-that are deemed to be important for maintaining the quality of coffee production. Moreover, directives and orders on quality coffee production play a role because coffee farmers often receive orders from the government to carry out certain quality maintaining practices (e.g. planting legumes trees) or to refrain from certain actions (e.g. planting eucalyptus trees which is believed to be undesirable for quality coffee production). All of these would obviously have climate change adaptation benefits, as shown by other studies elsewhere (e.g., Bianco, 2020; Ozor and Nnaji, 2011).

6.5 DISCUSSION

Coffee production play a critical role in the political economy of Ethiopia. It serves as source of cash income for both the local and national economy of the country, and as a livelihood for the many smallholder farmers. This study attempted to examine the role of stakeholders and their links in the land management aspect of quality coffee production using stakeholder analysis. Results on the power- interest analysis of stakeholders revealed that stakeholders vary in the level of power and interest in quality coffee production in Yirgacheffe, southern Ethiopia. While stakeholders have generally varied power and interest in quality coffee production, they have their resultant effects on the decisions and actions of coffee farmers to engage in quality coffee production. The stakeholder analysis matrix also shows that coffee farmers are mere recipient of materials and knowledge from the downstream actors and their room for maneuver for active engagement in decisions and actions in quality coffee production would seem limited, implying that there is asymmetrical power relationship between farmers and downstream actors. This calls for the need to design strategies for empowering coffee farmers, and then ensuring symmetrical power relation within the coffee value chain for sustainable land management and quality coffee production.

Stakeholders have also varied influences and roles in quality coffee production with resultant effects on the decisions and actions of coffee farmers to engage in quality coffee production. The interaction pattern of stakeholders is characterized by the predominance of some stakeholders (e.g., the government agencies) in the network. Government agencies and input suppliers could help more coffee farmers in quality coffee prodcution and sustainable land mangement. The strong variation in power and interest of stakeholders and the perceived roles of stakeholders points to the need to strengthen stakeholders' collaboration to improve sustainable land management for quality coffee production. This finding is consistent with

Bianco (2020) stated that downstream actors in the coffee value chain contribute a lot to quality coffee production.

The study also highlights that stakeholders have helped coffee farmers adopt quality-maintaining activities in coffee production like sustainable land management practices. These sustainable land management practices are also useful to the adaptation efforts to the local climate change. For example, stakeholders support coffee farmers in rainwater harvesting, small-scale irrigation, mulching and shade management that could have contributions to decrease soil carbon, enhance soil moisture holding capacity, and thereby reducing climate-induced coffee production risks. Similarly, Nkonya and Kato (2011) stated that farmers could adapt to climate change by using sustainable land (SLM) practices that also provide local mitigation benefits, reducing the negative effects of climate change at the level of farm, or even beyond. Other studies have also shown that SLM practices enhance adaptation to climate change (Cooper and Coe, 2011). This suggests that through sustainable land management, coffee farmers may increase the resilience of their coffee livelihood to the changing climate.

6.6 CONCLUSION

Quality coffee production is a complex social-ecological system that, in order to function efficiently, requires not only understanding of biophysical issues involved but also the links and interactions between stakeholders. This study explored the interactive relationships among stakeholders in quality coffee production, and the linkages/ flows of material input supply, knowledge, finance and market access. Coffee farmers received different types of support from different stakeholders and endeavored to meet standards of coffee production set by downstream actors in the coffee value chain. The study found difference between quality and conventional coffee farmers in terms of satisfaction levels with the supports received from stakeholders. The quality coffee farmers had generally higher level of satisfaction with the services than the conventional coffee farmers. This suggests that quality coffee production enhances coffee farmers' integration into the coffee value chain. In other words, quality coffee producers were better positioned in the coffee value chain than the conventional coffee producers. The findings also indicate that quality-maintaining activities in coffee production apparently have climate change adaptation benefits.

Finally, the stakeholder analysis shows that different stakeholders have different degrees of power and interest in quality coffee production. While government agencies are more powerful in decisions and actions related to quality coffee production, coffee farmers (though key actors) are less powerful. It is therefore imperative to capitalize on actions and decisions that take into account the differences in power and interests (sometimes conflicting) of these stakeholders in quality coffee production. The links and flows that exist between the stakeholders also highlight that quality coffee production could help enhance stakeholders' collaboration for sustainable coffee production in Yirgacheffe district. Overall, findings of this study suggest that policy interventions that can foster stakeholder collaborations and engagement processes would be important to enhance quality coffee production in the study area, and thereby to contribute to making the coffee-based livelihoods more sustainable and resilient to climate change.

Acknowledgments

We would like to acknowledge the Research Council of Norway for funding the Project, 'The role of global value chains in transition to sustainability' (Project number 255664) and the University of Oslo for hosting the researcher as a guest researcher for six months. We also extend our sincere thanks to all data collectors, all Net-Map participants, and farmers who took part in the survey of the study.

REFERENCES

Adane, A. and Bewket, W. (2021). Effects of Quality Coffee Production by Smallholders on Local Land Use and Land Cover in Yirgacheffe, Southern Ethiopia. *Journal of Land Use Science*, *16*(2), 205-221. https://doi.org/10.1080/1747423X.2021.1893844

Ayele, Y. Ewnetu, Z. and Asfaw, Z. (2014). Economic Evaluation of Coffee-Enset - Based Agroforestry Practice in Yirgachefe Woreda, Ethiopia : Comparative Analysis with Parkland Agroforestry Practice. *Journal of Economics and Sustainable Development*, *5*(27), 72–82.

Bacon, C. (2005). Confronting the coffee crisis: Can Fair Trade, organic, and Qualitycoffees reduce small-scale farmer vulnerability in Northern Nicaragua? *World Development*, *33*(3), 497–511.

Bezabih, M., Abera, D., Adie, A., Lefore, N. and Jones, C. (2020). Analysis of stakeholders' roles and relationships in the feed value chain in Ethiopia. ILRI Discussion Paper 39. Nairobi, Kenya: ILRI.

Bianco, G. B. (2020). *Climate change adaptation , coffee , and corporate social responsibility : challenges and opportunities*. *0*.

Bolwig, S., Gibbon, P. and Jones, S. A. M. (2009). The Economics of Smallholder Organic Contract Farming in Tropical Africa. *World Development*, *37*(6), 1094–1104.

Canevari-luzardo, L. M. (2019). *Value chain climate resilience and adaptive capacity in micro , small and medium agribusiness in Jamaica : a network approach*. 2535–2550.

Cooper, P.J.M. and Coe, R. (2011). Assessing and Addressing Climate-induced Risk in Sub-Saharan Rainfed Agriculture Foreword to a Special Issue of Experimental Agriculture. Experimental Agriculture, 47(2): 179–184

Daviron,B. and Ponte, S. (2007). The Coffee Paradox: Global Markets, Commodity Trade and the Elusive Promise of Development. *The World Economy*, *30*(6), 1031–1032.

Degefa, S. (2016). Home garden agroforestry practices in the Gedeo zone, Ethiopia : a sustainable land management system for socio-ecological benefits. *Socio-Ecological Production Landscapes and Seascapes in Africa*, (January 2016), 28–36.

Duguma, T. (2017). Value Chain Analysis of Ethiopian Coffee (Coffea arabica). *Archives of Current Research International*, *11*(1), 1–15. https://doi.org/10.9734/acri/2017/31486

Finley-Lezcano, J., King, D. and Wang, T. (2016). *Adaptation to Climate Change by Smallholder Coffe Producers in Latin America*. 1–135.

Fischer, L. B. and Newig, J. (2016). Importance of actors and agency in sustainability transitions: A systematic exploration of the literature. *Sustainability (Switzerland)*, *8*(5).

Gereffi, G. (2014). A Global Value Chain Perspective on Industrial Policy and Development in Emerging Markets. *Duke Journal of Comparative and International Law*, *24*, 433–458.

Grimble, R. and Wellard, K. (1997). *Stakeholder Methodologies in Natural Resource Management : a Review of Principles , Contexts , Experiences and Opportunities*. *Agricultural Systems*,*55*(2),173-193

Gole, T. W. (2015). *Environment and Coffee Forest Forum Coffee : Ethiopia ' s Gift to the World The traditional production*. 2–61.

Grote, U. and Winter, E. (2009). *Value Chain Analysis Methodologies in the Context of Environment and Trade Research Table of Contents*.

Hauck, J., Schmidt, J. and Werner, A. (2016). Using social network analysis to identify key stakeholders in agricultural biodiversity governance and related land-use decisions at regional and local level. Ecol Soc 21(2):49. https://doi.org/10.5751/ES-08596-210249

Kodama,Y. (2007). *New Role Of Cooperatives In Ethiopia : The Case of Ethiopian Coffee Farmers Cooperatives*. (March), 87–108.

Legesse, A., Teferi, B. and Baudouin, A. (2013). Indigenous agroforestry knowledge transmission and young people ' s participation in agroforestry prac- tices : The case of Wonago Woreda ,. *Acta Geographica-Trondheim*, (26).

Lelea, M.A., Roba, G.M., Christinck, A. and Kaufmann, B.(2014). Methodologies for stakeholder analysis – for application in transdisciplinary research projects focusing on actors in food supply chains. German Institute for Tropical and Subtropical Agriculture (DITSL). Witzenhausen, Germany.

Meskela, T. and Teshome, Y. (2014). From economic vulnerability to sustainable livelihoods: The case of the Oromia coffee farmers cooperatives union (OCFCU) in Ethiopia. *International Food and Agribusiness Management Review*, *17*(SPECIALISSUEB), 103–108.

Minten, B., Dereje, M., Engeda, E. and Kuma, T. (2019). *Coffee value chains on the move : Evidence from smallholder coffee farmers in Ethiopia*. (August 2017).

Mojo, D., Fischer, C. and Degefa, T. (2015). Social and environmental impacts of agricultural cooperatives: Evidence from Ethiopia. *International Journal of Sustainable Development and World Ecology*, *22*(5), 388–400.

Negash, M. (2007). Trees management and livelihoods in gedeo's agroforests, ethiopia. *Forests Trees and Livelihoods*, *17*(2), 157–168.

Neilson, J. and Pritchard, B. (2009). Value Chain Struggles, Institutions and Governance in the plantation districts of South India First., Oxford: Wiley-Blackwell

Nkonya, E. and Kato, E. (2011). *Climate Risk Management through Sustainable Land Management in Sub-Saharan Africa*. IFPRI Discussion Paper 01126.

Ozor, N. and Nnaji , C.(2011).The role of extension in agricultural adaptation to climate change in Enugu State, Nigeria. J*ournal of Agricultural Extension and Rural Development*, 3(3), 42-50

Poole, N. and Donovan, J. (2014). Building cooperative capacity: the Qualitycoffee sector in Nicaragua. *Journal of Agribusiness in Developing and Emerging Economies*, *4*(2), 133–156.

Rahn, E., Vaast, P., Läderach, P., van Asten, P., Jassogne, L. and Ghazoul, J. (2018). Exploring adaptation strategies of coffee production to climate change using a process-based model. *Ecological Modelling*, *371*(January), 76–89.

Reed, M. S., Graves, A., Dandy, N., Posthumus, H., Hubacek, K., Morris, J., … Stringer, L. C. (2009). *Who ' s in and why ? A typology of stakeholder analysis methods for natural resource management*. *90*, 1933–1949. https://doi.org/10.1016/j.jenvman.2009.01.001

Riisgaard, L., Bolwig, S., Ponte, S., du Toit, A., Halberg, N. and Matose, F. (2010). Integrating poverty and environmental concerns into value-chain analysis: A strategic framework and practical guide. *Development Policy Review*, *28*(2), 195–216.

Shiferaw, B., Hellin, J. and Muricho, G. (2016). *Markets Access and Agricultural Productivity Growth in Developing Countries : Challenges and Opportunities for Producer Organizations* (February). https://doi.org/10.4337/9781784719388.00013

Tesfaye, A., Hansen, J., Radeny, M. and Belay, S. (2020). *Actor roles and networks in agricultural climate services in Ethiopia : a social network analysis*. *Climate and Development* 12(8), 769-780.https://doi.org/10.1080/17565529.2019.1691485

USAID. (2010). Ethiopia coffee industry value chain analysis profiling the actors, their interactions, costs, constraints and opportunities. Chemonics International Inc.

Wang, J. and Aenis, T. (2019). Stakeholder analysis in support of sustainable land management : Experiences from Southwest China . *Journal of Environmental Management*, *243* (May), 1–11. https://doi.org/10.1016/j.jenvman.2019.05.007

Wollni, M., Lee, A.R. and Thies, E.J. (2010). Conservation Agriculture, Organic Marketing, and Collective Action in the Honduran Hillsides. *Agricultural Economics*, (4) 373 – 384.

Wonnacott, T. H. and Wonnacott, J. (1990). Introductory Statistics. New York: John Wily and Son.

Zeleke, G., Kassie, M., Pender, J. and Yesuf, M. (2006). *Stakeholder Analysis for Sustainable Land Management (SLM) in Ethiopia*. Assessment of Opportunities, Strategic Constraints, Information Needs, and Knowledge Gaps. (January).

CHAPTER SEVEN…………………………………………………………………………..

SUMMARY AND CONCLUSIONS

7. Summary and Conclusions

The study commenced with the assumption that coffee production is a land resource-based industry to have impacts on the environment, and it represents the environmental ‘hot spot’ of the coffee value chain. It is also an important component of the rural economy in many developing countries including Ethiopia, and is particularly important for smallholders. Coffee farmers in Yirgacheffe make glaring of heavy dependence on coffee production. Since coffee is a cash crop, multiple factors and actors across the value chain affect its production, and decisions of actors in the downstream of the value chain influence land use and climate change adaptation by coffee farmers. Market saturation in commodity coffee has resulted in increasing trend in the demand for quality coffee in the global and national markets, with its implications on the socio-ecological systems in coffee producing areas.

The increasing demand for quality coffee (with its high market value and differentiation) in the global and national market opens the new chapter for quality-oriented production; which in turn affects land use decisions and farm practices on coffee farms. Quality coffee production also requires appropriate land use practices and climate change adaptation, which coffee producers seldom undertake, and it should have contribution to progressing towards a more sustainable coffee livelihood. Therefore, improvements undertaken in coffee production in response to the increasing demand for quality coffee requires understanding about both the natural and social scenes of coffee production.

Known to be the birthplace and the center of coffee diversity, Ethiopia is a major coffee producer country, and it has a high potential for quality coffee production due to the suitable altitude, climate and soil types. Ethiopian quality coffee got a global demand in the international market, as it is sold at high premiums, as quality coffee of single origin. As a result, its role in the global coffee market hinges on the fine quality of its coffee. Coffee production plays a vital role in both the environment and socio-economy of Ethiopia. About 25 million citizens in Ethiopia depend on coffee for their livelihood in production and processing, yet the production system is characterized by a low input-low output production system. The contribution of coffee production to land use and climate change adaptation in Ethiopia remained contested, which this study endeavoured to go farther.

Theoretically, political ecology underpinned this study in order to interpret and understand how quality coffee production affects land use and climate change adaptation by coffee farmers in the context of value chain, as coffee is a cash crop for the global market. Political ecology suggests that environmental change is part of an integrated socio-ecological process that produces and reproduces the society and its environment simultaneously. Coffee production from political ecology perspective is much more than production of a commodity for the global markets; it is an ecologically embedded production process. It includes the ability of people to navigate the changing climate and working with the land use practices, and involves stakeholders with different power and interest in a politicized environment. Therefore, the study was guided by a political ecology perspective to delve into the land use, climate change adaptation and the role and linkages of multilevel stakeholders in quality coffee production.

The three interacting spheres- the practical, personal and political spheres- and the value chain approach, as a conceptual framework, also informed the study. Each spheres align with the different specific objective of the study. The practical sphere directly aligns with the land use (objective 1) and climate change practices, (objective 3). It backs up the intent to understand how coffee production is influencing land use and practices to adapt to climate change. The issue of perceptions on climate change (objective 2) coincides with the personal sphere. The personal sphere guided the objective of identifying how the values, beliefs and worldviews of actors within the value chain of quality coffee influences land use and adaptation to climate change. The role and linkages of stakeholders in quality coffee production and the implications to climate change adaptation (objective 4) is directly aligned with the political sphere. The political sphere is where actors in the value chain link and interact each other, and then decide and act in quality coffee production. The fundamental tenet of the three spheres framework is that the decisions and actions within the political sphere are influenced by their subjective beliefs, values and worldviews, while simultaneously these decisions and actions influence the practical sphere. This shows that these spheres in the framework are interacting each other and can be appropriate conceptual niche for this study in the context of local coffee value chain.

The aim of this study was to assess how quality-coffee production impacts land use and management activities and climate change adaptation practices by smallholders in Yirgacheffe district, which is a typical quality coffee producing area in Ethiopia. The study specifically endeavored to investigate the extent and processes of land use change and climate change adaptation in quality coffee production, and to evaluate the role and linkages of stakeholders in quality coffee production and the implications for land use management and climate change adaptation by coffee farmers. Such explorations are useful to improve the socio-ecological conditions of quality coffee production, as quality coffee production is socio-ecologically embedded process and requires knowledge-based land management and adaptation practices, which coffee farmers are lacking. The study used satellite remote sensing images, and socioeconomic data generated through household survey, focus group discussions and in-depth interviews. The data analyses involved satellite image analysis, statistical analysis and stakeholders' analysis.The major findings and conclusions are summarized in the following paragraphs.

In Yirgacheffe, coffee production has contributed to land use and cover change over the past three decades (1988-2018). The satellite image analysis revealed a general trend of change from forest coffee to semi-forest coffee and from forest and semi-forest to semi-plantation cover. Specifically, the semi forest coffee cover showed a high increase (0.9% per year) followed by semi plantation coffee (0.07% per year); whereas forest coffee cover depicted a significant decline over the study period (1.02% per year), indicating a gradual decline in the vegetation cover of the area. This has been driven by the need to increase coffee production through conversion of forest coffee into semi-forest coffee and then to semi-plantation system by way of removing canopy trees.

The substantial increase of semi-plantation coffee cover could be due to the increasing global demand of quality coffee, as coffee is a global commodity, and subsequent increasing trend of quality coffee export over the study period. While the findings indicated a commonly held view on marked LULC change, variations appeared between quality and conventional coffee producers in terms of the drivers for the change. Quality coffee producers pinpointed that the LULC changes mainly attributed to the increasing demand for quality coffee in the global market, whereas conventional coffee farmers were more likely to recognize domestic coffee market as a main driver for the LULCC, as Ethiopia consumes about 50% of its annual production. This variation attributes to the closer linkage of quality coffee producers to the global market than the conventional group. This also highlights that quality coffee production links smallholders in the remote south to consumers in the north, whilst smallholders are of limited voice in the global coffee market.

It has also been noticed that the global demand in quality coffee drives LULC changes as quality coffee production in Ethiopia is export oriented, and thereby exacerbate forest degradation with implications on smallholders' livelihoods and ecosystem services of the area. Yet, as quality coffee producers endeavour to increase quality and yield of their coffee, and thereby meet the growing quality standards (e.g. organic), they undertook different quality- maintaining land management practices. Quality coffee producers were more likely to uptake terracing, soil bund and compost than the conventional coffee producers were. This shows that quality coffee production can in some conditions contribute to sustainable land management while it exacerbates forest degradation through the conversion of forest and semi forest coffee to semi-plantation coffee cover at larger spatial scales. These finding suggests the need to further study in order to 'net out' the trade-offs of quality coffee production vi-a-vis sustainable land management practices and deforestation.

In conclusion, quality coffee production driven by the demand for it in the national and global markets reflects the commercialization of the rural economy, which can be a driver of environmental change. As coffee is a global commodity and then it is traded across different market sizes and scales, there is apparent interconnectivity between the coffee production systems and the coffee market; with implications on the socio-ecological conditions of coffee producing areas. This calls to actions to decrease the current heavy dependence of the local economy coffee producing areas - as well as the national economy of Ethiopia - on coffee, so that the environmental costs of coffee production would be minimized.

The study has also found that the local climate had changed. Specifically, the Mann-Kendall test indicated that mean annual maximum, mean annual minimum and annual mean temperatures increased at rates of 0.01, 0.03 and 0.02^{0}C per year, respectively, over the study period (1988-2018). The majority of farmers also recognized that the local climate had changed over the past three decades. Coffee farmers did observe rising air temperatures, declining rainfall, and changes in the onset and duration of the rainy season in the local climate. Farmers' perceptions of increasing temperature was supported by analysis of meteorological data from a local station. However, farmers perceived declining rainfall did not mirror the meteorological rainfall data analysis. Whereas coffee farmers perceived a declining rainfall, the meteorological data indicated no clear trend of change. The possible explanation for the discrepancy between in the measured and perceived trend in rainfall can be because of coffee farmers' greater concern on shortage of rainfall as a major constraint to optimal coffee production than increasing temperature. Farmers' perceptions are greatly influenced by anomalies in rainfall patterns; i.e. onset, duration and cessation, as they consider rainfall as a more critical factor for optimal coffee production than temperature. Coffee farmers also may not have been able to recognize variability in rainfall over a long period, as interior human dimensions like emotions and capability to recall climate system affect their perceptions; perhaps coffee farmers most easily evoke a dry period than a hot one.

Furthermore, there were also some differences in terms of perceptions between quality and conventional coffee farmers. In essence, the findings demonstrated that the perceptions of quality coffee producers on change in air temperature and rainfall were more coincident with the measured meteorological data analysis than that of the conventional coffee producers. This revealed that quality coffee producers have better understanding about the local climate change, highlighting the influence of quality coffee production on farmers' perceptions about local climate change, and its contribution to sustainable coffee livelihoods for coffee farmers. This could be because quality coffee producers had better access to information about weather and other pertinent extension services related to the local climate change.

In conclusion, coffee farmers might have locally bounded perceptions that are the results of their experience with the local environment and their worldviews on coffee livelihoods. A glaring example of findings in terms of the values and belief system of coffee farmers in coffee production is that '*coffee farmers would prefer to die with the dry coffee trees affected by climate change, in steady of shifting to other crop production*'. This clearly shows that the likelihood of coffee farmers to continue coffee production in the face of adversities of climate is very high mainly due to the belief in coffee their coffee livelihood. Therefore, traditional knowledge and experiential knowledge as well as other beliefs would have their place in dealing with quality coffee production in the changing climate. These findings also suggests that the endeavours to make comparative assessment on coffee farmers' perceptions on local climate and the scientific understanding on climate change needs precautions.

With regard to the impact of quality coffee production on farm-level adaptation to climate change, the study divulged that quality coffee production has contribution to progressing towards building climate resilient coffee livelihood. While the vast majority of the surveyed coffee farmers carried out different adaptation practices, the PSM analysis revealed that quality coffee producers were more likely to implement on-farm adaptation practices like use of new cultivars, rainwater harvesting, shade tree management and shifting nursery seasons for coffee seedlings compared to the conventional coffee producers. This shows that quality coffee farmers made more effort for on-farm adaptation practise to comply with the quality standard set in the production processes; they undertook better adaptation practices as well as the application of organic inputs like compost and agronomic managements. This indicates that the global and national demand for quality coffee determines smallholders' decision to perform various quality-maintaining adaptation practices to climate change.

On the other hand, the participation of conventional coffee farmers in off-farm adaptation practices was higher than that of the quality coffee producers. Conventional coffee farmers were highly involved in migration and off-farm activities like local petty trade and daily labours in the study area, suggesting that many of the off-farm adaptation practices are related to the conventional coffee production. While benefits from the in-field adaptation strategies are mainly cumulative and long term such as ecological sustainability, the adaptation practices by the conventional coffee producers point to activities with short-term returns, i.e like migration and petty off-farm activities- even with meagre benefits to the coffee ecosystem. Therefore, the PSM analysis revealed differential on-farm and off-farm adaptation practices between the two groups of coffee farmers, suggesting that quality coffee production is useful to build a more sustainable and climate change resilient coffee production in the study area.

The different stakeholders along the value chain have varied power and interest in quality coffeee production; with its own implications to adaptation to the local climate change. The stakeholder analysis showed that stakeholders like government agencies are more powerful in decisions and actions related to quality coffee production, whereas coffee farmers (though key actors) are less powerful. In particular, the power/interest matrix in the stakeholder analysis demonstrated that coffee farmers were inappropriately positioned in the coffee value chain where their room for maneuver for deep engagement in decisions and actions in quality coffee production is limited. This signifies the asymmetrical power relationship between coffee farmers on one hand and downstream actors of the value chain on the other hand. Therefore, actions of actors of stakeholders with higher influence such as government agencies and input suppliers have the potential to help coffee farmers invest in sustainable land management, and to build the adaptive capacity of the coffee livelihood.

The links and flows between stakeholders in quality coffee production were mirrored by material input supply, knowledge and financial flows, and market access, suggesting that quality coffee production is the result of combined efforts of multilevel stakeholders along the value chain. In this vein, quality coffee producers were closely linked to other stakeholders in the coffee value chain compared to the conventional coffee producers. This also implies that quality coffee production strengthens the linkage of smallholder coffee farmers with other actors in the coffee value chain, and enhances efforts towards effective coffee farming and adaptation practices by coffee farmers. Quality coffee production is useful to reduce that asymmetrical relationship between the upstream and downstream actors in the coffee value chain. It is also notable that stakeholders along the value chain have the potential to help coffee farmers make decisions on quality coffee production, with added benefits to adaptation to climate change in Yirgacheffe and other coffee producing areas of Ethiopia.

The study makes important contributions in practical, policy and research regimes. In terms of practical contribution, the results of this study will assist the conservation and sustainable management of coffee forests and their associated forest dependent biodiversity and ecosystem services. It is suggested that practical measures should be taken to alleviate problems related to the land use and climate change for quality coffee production in Yirgacheffe and other coffee producing areas. These measures might include decreasing the heavy reliance of the local economy coffee producing areas and the national economy of Ethiopia on coffee as the single most important commodity. In line with this, promoting quality coffee production along with halting deforestation processes would be useful to the sustainability of the coffee agroforests. A need also exists to bridge the gap between coffee farmers' perceptions and scientific understanding of the local climate change through capacitating coffee farmers through trainings and extension services. This would also help fine-tune coffee farmers' understanding the local climate change, and create room for manoeuvre to take context-relevant adaptation measures.

The study also indicated that coffee farmers undertake appropriate adaptation practices as well as the application of organic inputs like compost and agronomic managements, while they comply with the quality standard set by the consumers in the production processes. Thus, enhancing quality coffee production through informed decision and actions on land use and climate change adaptation promotes the progress towards a more sustainable and climate change resilient coffee livelihood. Additionally, quality coffee production is a complex social-ecological system that requires not only understanding of biophysical conditions but also the links and interactions between stakeholders. Therefore, it is imperative to capitalize on actions and decisions of stakeholders as well as the links and flows between them to foster quality coffee production through appropriate land use and adaptation practices.

With regard to policy contribution, the study draws policy attention to enhance climate change adaptation and sustainable land management through capacitating stakeholders in the coffee value chain, and then to make the coffee livelihood more sustainable and climate resilient. In addition, since farmers and their associations like cooperatives could not directly influence policy decisions on coffee production, higher level of organization like ECTDMA should represent farmers' voice in policy discussions. Policies and strategies that improve the integration of the vast majority of coffee farmers (primarily the conventional coffee farmers) with other stakeholders would help coffee farmers manage well their land under pressure in the changing climate. This would be possible through providing targeted and clearly defined policies on financial supports and technical advice to cooperatives. Additionally, adaptation to climate change in the context coffee production should also be well informed by the national strategies like the Climate Resilient Green Economy (CRGE) strategy of Ethiopia, as this strategy envisaged to increase commercial agriculture through capacitating smallholder coffee farmers.

In terms of research contribution, the study utilized a recent algorithm for image classification (the Random forest algorithm) using the QGIS software to enhance the accuracy of image classification for the study of the effects of quality coffee production on land use/cover change, while most previous studies did apply non- machine learning algorithms like maximum likelihood classifications. In addition, the study attempted to categorize coffee production into quality coffee production and conventional coffee production to assess the differential effects of coffee production on land use and climate change adaptation by coffee farmers, while land use and climate change adaptation pertinent to quality coffee production are understudied. Hence, coffee farmers were stratified into quality coffee and conventional coffee producers, and co-variates were selected in order to assess the impact of quality coffee production on climate change adaptation using the propensity score matching method.

Moreover, drawn from the political ecology perspective and being informed by the conceptual framework of the three interacting spheres- which are rarely used in climate change and land use studies , the study endeavoured to explore how quality coffee production influences the socio-ecological conditions of coffee production in the context of local value chain. In particular, little work has been carried out to consider multilevel stakeholders and factors for quality coffee production and previous works have not sufficiently surfaced out the roles and linkages of stakeholders in quality coffee production in the context of value chain. Therefore, this study looked into the actors in and factors for quality coffee production beyond the coffee farm level using stakeholder analysis to build a more sustainable coffee livelihood. In terms of knowledge dissemination, two-journal articles have been published, and made available for the scientific community.

As a final point, quality coffee production requires not only understanding of biophysical issues involved but also unfolding the 'more subtle human dimensions' of local climate change. Thus, substantial continuing research is required to yield in-depth understanding about the notion of values and beliefs on local climate change. This will reduce the disparity of coffee farmers' explanation about climate change from the scientific understanding. Moreover, this study disclosed the influence of quality coffee production on adaptation practices by smallholders in Yirgacheffe and other coffee producing areas in the context of local value chain. Yet, much more work is needed to surface-out the clear connections between climate change adaptation practices and the demand for quality coffee at 'a distance' in the context of global coffee value chain. Furthermore, future research focusing beyond the coffee farm level efforts should be conducted for further investigation into the roles and linkages of stakeholders in quality coffee production, and then to build a more sustainable and climate resilient coffee livelihood.

Appendix

The general objective of the study is to assess the impacts of quality coffee production on land use and climate change adaptation in the context of value chain in Yirgacheffe district, Southern Ethiopia.

A. *Survey questionnaire for smallholder coffee producers*

Part I: Survey identification

Sub-district(*Kebele*)	code	Coffee production type	
		Quality coffee	Conventional coffee

Part II: Biophysical and socio-economic characteristics of smallholders

1.1 For each of the following characteristics, please mark the answer that comes closest to the way you feel and apply to you as a household head.

S.N	Characteristics	Response
1	Age (number)	
2	Sex (1=male, 0= otherwise)	
3	Household size(number)	
4	Highest education level achieved	
5	Number of generations of the HH that has produced coffee(number)	
6	Experience in coffee farming(in years)	
7	Off-farm employment(yes/no), 1= yes, 0=otherwise	
9	Land size(ha)	
10	Land size for coffee farming(ha)	
12	Distance from coffee processing facility(km)	
13	Coffee yield (qt/ha) in 2018/19?	
14	Coffee production (Qt) in 2018/19?	
15	Access to information (yes/ no) 1= yes, 0=otherwise	
16	Access to credit service(yes/no) 1= yes, 0=otherwise	
17	Perceived management about cooperatives (positive/ negative)	
19	Years lived in the locality(number)	
20	Number of plot of land(Number)	
21	Number of coffee plot of land(number)	
22	Number of coffee trees	

Part III. **Questions on quality coffee production and land management practices**

1. Do you think that quality coffee production has impact on land management practices?

A. Yes B. No

2. If your response to Q1 is yes, how quality coffee production is useful or impeding factor in improved land management?

____

3. Is there difference between land management strategies on quality coffee farmlands and conventional coffee farmlands? A. Yes B. No
4. If your response to Q3 is yes, could you explain the difference?

____

5. Do you have access to information about the global demand of quality coffee? A. Yes B. No
6. If your response to Q5 is yes, how do you use the information in your land use decision for quality coffee production?

____

7. Do you think that coffee land coverage is changing in the last 20 years? A. Yes B. No
8. If your response to Q7 is 'Yes', indicate your opinion on the direction of changes and their respective driving forces using the following table(Please mark as many driving forces on the list below as apply)

No	Perceived driving forces for change in coffee coverage	Direction of change		Has no effect
		Increasing	Decreasing	
8.1	Change in the global demand of quality coffee			
8.2	Change in the national demand of quality coffee			
8.3	Climate change			
8.4	Change in food crop coverage			
8.5	Change in coverage in other cash crop			
8.6	Afforestation			
8.7	Overgrazing			
8.8	Other(write in)__________________________			

9. If your response for Q8.1 is other than has no effect, could you mention the ways in which the global demand is influencing your land management practices in quality coffee production?

____ __

10. Which of the following precondition (enabling environment) exist(s) and influences your land use decision for coffee production?

a. development of new variety of coffee

b. incentives from other stakeholders

c. growing demand of quality coffee

d. increase in the international coffee prices

e. suitable climate f. any other (specify)_______________________________

Part IV. Questions on quality coffee production and perceptions about climate change adaptation

1. Do you perceive that climate change exists? A. Yes B. No

2 If your response to Q1 is yes,

(2a) do you think that climate change brings increased temperature? A. Yes B. No

(2b) do you think that climate change affects coffee Quality production? A. Yes B. No

3. Do you think that climate change induces change in patterns of seasonal rainfall over the past 20 years in your area? A. Yes B. No

4. If your response to Q3 is yes, indicate the indicators of change in pattern and their extent of impact on quality coffee production in your area? (3 = highly problematic; 2 = moderately problematic; 1 = Less problematic ; 0 = not problematic)

S.N	Perceived constraints for quality coffee production	0	1	2	3
1	More frequent storms				
2	More intense storms				
4	More frequent droughts				
5	More severe droughts				
6	Early onset of rainfall				
7	Late onset of rainfall				
8	Early offset of rainfall				
9	Late offset of rainfall				

5. Based on your response to Q4, which of the following are the effects of change in pattern of rainfall over the past 20nyears?(Multiple response is possible)

A. Erratic flowering	B. Incomplete fruit drop	E. Shift in suitable area
C. Incomplete maturation	D. Decrease in suitable area	F. Increase in suitable area

6. Do you think that quality coffee production increases the adaptive capacity of your coffee production? A. Yes B. No

7. If your response to Q6 is yes, in what ways quality coffee production improves the adaptive capacity of your quality coffee production?

____

8. Is there difference between adaptation practices on quality coffee farms and conventional coffee farms? A. Yes B. No
9. If your response to Q8 is yes, could you explain the differences you observe?

____

10. To what extent you feel confident in the ability of quality coffee production to reduce the potential impacts of climate change?

    A. Not confident B. less confident C. Moderately confident D. Highly confident
11. How often do you hear or read about climate in your area (temperature or rain)?

    A. Always B. Often C. Sometimes D. A few Times E. Never
12. What are the sources of information about climate (temperature and rain) do you read or see most? A. Television B. Radio C. Friends D. other (Specify)_____________
13. Does information about the state of climate make your feel more prepared to face climate change? A. Yes B. No
14. If your response to Q13 is yes, in what way?___________________________________
15. The following set of questions asks about farm level adaptation measures toward precipitation and temperature changes. Please indicate the adaptation practices that you have carried out in your coffee production activities.

No	Adaptation practices in quality coffee production	Response
1	Income diversification(yes/no)	
2	Shift to other crop(yes/no)	
3	Cultivar selection(yes/no)	
4	Intercropping(yes/no)	
5	Integrated pest management(IPM)(yes/no)	
6	Irrigation (yes/no)	
7	Mulching (yes/no)	
8	Agroforestry (yes/no)	
9	Pruning(number of coffee trees)	
10	Stumping (number of coffee trees)	
11	Soil bund (yes/no)	
12	Stone bund (yes/no)	
13	Terracing (yes/no)	
14	Daily labour (yes/no)	
15	Petty market(yes/no)	

Part V. Questions on main Actors and their role on quality coffee production

1. Do buyers of your coffee set requirements to buy you r coffee product? A. Yes B. No
2. If you response to Q1 is yes,

   (2a) Are requirements the same across the value chain? A. Yes B. No

   (2b) what requirements are to be met (tick off):

Requirements	Cooperatives	Private traders
a. Membership		
b. Quality requirements of coffee product		
c. Quantity requirements (minimum)		
d. Other (specify):		

3. Do you think that land management in quality coffee production is only your responsibility, other than other actors in the coffee value chain? A. Yes B. No
4. If your response to Q3 is no, could you mention the roles of the different actors in the value chain, using the following table?

No	Actors	Main role in adaptation practices
1	Input suppliers	1. 2. 3.
2	Coffee farmers	1. 2. 3.
3	Research institutes	1. 2. 3.
4	Cooperatives	1. 2. 3.
5	Processors	1. 2. 3.
6	Government institutions	1.Woreda agriculture office_______________ 2. Cooperatives___________________________ 3. ECTDA[3]________________________________

[3] Ethiopian coffee and Tea Development Authority

5. Do you think that climate adaptation through quality coffee production is only your responsibility other that other actors in the coffee value chain? A. Yes B. No
6. If your response to Q6 no, could you mention the role(s) of the following actors in building the adaptive capacity of quality coffee production system in your area?

No	Actors	Main role in land management practices
1	Input suppliers	1. 2. 3.
2	Coffee farmers	1. 2. 3.
3	Research institutes	1. 2. 3.
4	Cooperatives	1. 2. 3.
5	Processors	1. 2. 3.
6	Government institutions	1.Local_______________________________________ 2.Regional_____________________________________ 3.Federal____________________________________

7. What are /is Your outlet channels for your coffee products(Multiple response is possible)

A. Cooperatives B. Private traders C. Other (specify) _____________

8. Is there benefit you get from other stakeholders (if applicable)? A. Yes B. No
9. If your response to Q8 is yes, based on your experience with the stakeholders, can you please indicate whether you have 1. *Very low satisfaction*; 2 low satisfaction; 3.moderate satisfaction*;* 4. *High satisfaction* or 5. *Very high satisfied*?

How satisfied are you/would you be with**…**	**1**	**2**	**3**	**4**	**5**
a. **Government agencies (district agricultural office)**					
Providing Extensions services					
Develop standards that guide quality coffee production					
Create market access and support to farmers					
Coordinating quality coffee production					

b. **Financial sectors**					
Bank Credit availability					
Microfinance services (rural savings)					
c. Research institutes					
Provide technologies on quality coffee production					
Preparing manuals for quality coffee production					
d. **NGOs**					
Financial support					
Trainings on quality coffee production					

10. Please put the following challenges of adaptation to climate change in quality coffee production in order in which you feel most formidable to the least one ('1' is the most formidable and '6' is the least one)

Actors in the coffee value chain	Rank(1-6)
1. Input suppliers	
2. Government agents	
3. Coffee processors	
4. Research institutes	
5. NGOs	
6. Coffee farmers	
7. Other (write in and rank it)	

Part VI: Questions on values and beliefs of smallholder producers about quality coffee production and climate change adaptation

1. Do you consider yourself as producer of quality coffee? A. Yes B. No
2. What is your view on the trend of the demand of quality coffee?

A. Increasing B. Decreasing C. stayed the same D. Unknown

3. Do you think that coffee yield is increased/ decreased/ stayed the same in the past 20 years? A. Yes B. No
4. Do you think that coffee production is increased/ decreased/ no change in the last 20 years? A. Yes B. No
5. Do you think that actors in the upstream and downstream of the value chain are linked each other in terms of values, beliefs and coffee prices? A. Yes B. No
6. If your response to question 5 is "yes"", how they are linked? ______________________
7. Do you know the international destiny of your coffee products? A. Yes B. No

8. If your response to Q7 is yes, do you have awareness about the behaviour of consumers in terms of coffee consumption? A. Yes B. No

9. If your response to Q8 is yes, what are the quality attributes of your coffee production given priority by the consumer?____

10. Regarding the following statements about quality coffee production, could you indicate whether you: 1.strongly *disagree*; 2. *Disagree*; 3. Undecided; 4. *Agree*; 5. *strongly agree*.

	Statement	**1**	**2**	**3**	**4**	**5**
1.	Quality coffee production improves land management					
2.	Local markets for quality coffee are available					
3.	Obtaining information regarding quality coffee is difficult					
4.	Quality coffee production is too labour intensive					
5.	Governmental support to quality coffee production is important					
6.	Quality coffee yield is lower than conventional production					
7.	Local consumers would be willing to pay higher prices for quality coffee					
8	Shifting into quality coffee production requires high costs					
9	There is a lack of subsidies for quality coffee production					
10	Obtaining information about export markets of quality coffee is difficult					

11. Concerning the quality, indicate whether you: 1. strongly disagree; 2. Disagree; 3. *Undecided;* 4. *Agree*; 5.Strongly *agree.*

	Statement	**1**	**2**	**3**	**4**	**5**
1.	The cooperatives rejects berries					
2.	I find it difficult to determine the quality of the coffee by observing it					
3.	I have difficulties to pulp the ripe cherries in time.					
4.	I have difficulties to wash the cherries properly					
5.	I have difficulties to dry the cherries properly					
6.	I have difficulties meeting the required quality					
7.	Rejection rates of the cooperative are higher than other channels					
8.	I do not give much attention to the quality of the coffee					

12. Regarding the following statements about the location of your sale, could you indicate whether you: 1. *Strongly disagree*; 2. *Disagree*; 3. *Neutral;* 4. *Agree*; 5. *Strongly agree*.

	Statement	1	2	3	4	5
1.	Cooperatives make efforts to come and buy from our farm					
2	Private traders make effort to come and buy from our farm					
2.	Transporting the harvest to the collection point of the cooperative within the required time after harvest is difficult and limits my income					
3.	The nature of the roads and bridges complicate the delivery of the product					

13. Regarding the following statements about uncertainty you feel in producing and selling coffee, could you indicate: 1. *strongly disagree*; 2. *Disagree*; 3. Undecided 4. *Agree*; 5. *Strongly agree*.

	Statement	1	2	3	4	5
1.	I have problems obtaining enough fertilizer in time					
2.	I have problems obtaining enough pesticides in time					
3.	I have difficulties accessing enough laborers/workers					
5.	There is a lot of fluctuation in the coffee prices					
6.	I feel uncertain about the price I can get from traders or buyers					
7.	I have difficulties selling my product to the cooperative					
8.	Being in the cooperative reduces uncertainty with regard to the returns from coffee					
9	I feel certain about the climate of the area suitable to coffee production					
10	The mode and speed of payment in the sales of the cooperative are slower compared to other channels					

B. <u>Interview Guide for different actors in the coffee sector</u>

<u>Part I</u> : Interview guide for smallholders on the subjective human dimensions of climate change and coffee production

<u>Section I:</u> Questions on land use and quality coffee production

1. Has quality coffee production/ trade been viewed as more of a business for you, or a lifestyle choice? Some combination of the both?
2. What do you think of quality coffee production?
3. How important is quality coffee production for your land use in comparisons to other crops?

4. What do you value about quality coffee production and its roles in land management and climate change adaptation?
5. What aspects of the environment are believed to be changed by quality coffee production?
6. Have you ever considered getting out of quality coffee production for other type of crop production? If so, what type of crop did you think you might want produce.
7. What land use change you made on your lands and reasons for these decisions?
8. Your views on the local, regional and global changes on the coffee sector and their impacts on your land –use decisions.
9. How do you evaluate the value of producing quality coffee production in improvement land management?

Section II: Questions on Quality coffee production and climate change

1. What visible changes have you observed as related to rainfall, temperature, flow of streams, occurrence of big floods, incidence of drought, forest vegetation cover, river/stream flow etc. during your lifetime in your area?
2. What are your traditional or local indicators to realize that there is climate change during the past 20 years?
3. Is the coffee variety you cultivate now is the same as the coffee your father or ancestors were growing? If no, how is different?
4. Do you believe that it is possibility to reduce or totally stop the negative impacts of climate change on producing quality coffee? If yes how?
5. What adaptation are carried out in the village to avert the impact of climate change on quality coffee production? (Afforestation, water harvesting, irrigation, soil and water conservation, off-farm employment, etc.
6. Do you agree that adaptation interventions in your area are well planned, well discussed and undertaken after consensus or lack these attributes? If yes, how do you evaluate the sustainability of adaptation practices?
7. How important is quality coffee production for climate change adaptation in comparisons to other crops?
8. Do you know success stories in relation to coping and adaptation strategies adopted by farmers to withstand climatic shocks? If so, what are they?

Section III. Questions on stakeholders in quality coffee production

1. Do you have strong organizational arrangement that could enhance the role of quality coffee production in land use and climate change adaptation? If so could you mention them?
2. How do you get access to extension services and supports from other actors and stakeholders of the coffee sector?
3. What trainings are given to you to adaptation to climate change?
4. What agricultural technology and meteorological information/early warning are provided to farmers to avert climate shocks? If yes by whom?
5. What recent social and cultural trends relevant to quality coffee production are occurring in your area?
6. Have you been receiving a premium price for your quality coffee? Why (not)?
7. What do you consider the main strengths of the cooperative (funding, capacity etc.) with regard to land management and climate change adaptation?
8. Do you feel that decisions regarding your land use are largely left to you? Are there any forces or circumstances that influences your decisions?
9. What is your overall opinion on the role of stakeholders to support smallholder producers to improve their land management and adapt to the changing climate?

Part II: Interview guide for district coffee officers and experts in the local coffee value chain

Section I: **Questions about market, power relation and interest in coffee production**

1. Is there clear coffee product differentiation in your marketing system? If so, what are the mechanisms of differentiating coffee products into different levels of quality?
2. What do you think was the most useful advance in quality coffee production in your area? How do you see your role in quality coffee production?
3. What is the nature of relationships between smallholder coffee producers and other actors in the coffee sector?
4. How do you share your beliefs about quality coffee production to other actors?
5. Do you feel that quality coffee production is the most consistent crop in terms of making a good profit?
6. Do you believe that you have contribution in adaptation to climate change by smallholders? If yes, how do you have contribution to adapt to climate change?

7. Do you believe that you have contribution in land management by smallholders? If yes, how do you have contribution to land management?

Section II: Questions on their role in supporting smallholders in adaptation to climate change and land use

1. Have you ever discussed with smallholders on climate change adaptation? If yes, what were the central points of discussion? In what ways the smallholders were beneficiaries from the discussion.
3. How do you feel about quality coffee production and it role in climate change adaptation?
4. How do you relate quality coffee production and climate change adaptation in your locality?
5. How do you relate quality coffee production and land use strategies in your area?
6. Can you think of any innovation that quality coffee producers must employ in order to stay competitive? How do they differ from those who produce conventional coffee?
7. What advice could you give to coffee producers in getting into quality coffee production?
8. Have you seen a change in government involvement with quality coffee production in the last 10 years in your area?
9. What do you think the government should do to improve the relationship between quality coffee production, land use and climate change adaptation?
10. What is your overall opinion on the role of the cooperative to support smallholder producers to improve their land management and adapt to the changing climate?

Part III : Interview Guide for Cooperatives and Cooperative union representatives

Section I: Questions on Cooperatives' role in land use and quality coffee production

1. Do you offer services to your farmer members? If so, what kind of services do you offer to your members in quality coffee production in the changing climate? (e.g. technical training, education, transport, marketing of goods, credit)
2. What do you consider the main strengths of the cooperative (funding, capacity etc.) with regard to supporting smallholders to carry out improved land use?
3. What are the means of standardizing quality in coffee production?
4. To what extent are farmers aware of quality standards?
5. To what extent have the farming practices of farmers changed to maintain quality standards in the past 15 years? (E.g. cultivar selection and use, irrigation, washing coffee, reforestation and shade trees, post-harvest)? How?

6. How does the cooperative keep track of the quality coffee production practices of its farmers?
7. What are the ways of differentiating farmers into quality coffee producers and non- quality coffee producers?
8. Have there been changes in the total annual coffee production in the past few years? What role has quality coffee production played in these changes? (when applicable)
9. Have there been changes in the total number of quality coffee trees owned by members of the cooperative in the past 10 years? If yes, what explains these changes?
10. What is your overall opinion on the role of the cooperative to support smallholder producers to improve their land management and adapt to the changing climate?

Section II: Questions on cooperatives' role in quality coffee production and adaptation to climate change

1. Do you think that quality coffee production positively affected farmers' climate change adaptation strategies? How?
2. What do you think of the idea of developing adaptation strategies by your cooperative?
3. What would be some of the benefits of developing adaptation strategies by your cooperative?
4. What resources does the cooperative or its members already have that could be used to implement adaptation strategies in your cooperative?
5. What other resources would be necessary in order to implement adaptation strategies and can you think of some sources where the cooperative or their members could secure those resources?
6. What kind of training would the cooperative leadership and/or members require in order to implement adaptation strategies
7. What further information would it be helpful to have in order to make a decision about whether or how it would make sense to implement adaptation strategies in your cooperative?
8. Do you think that quality coffee production positively affected farmers' land use and management? How?

Part IV: **Checklist for FDG in Process net mapping (for Zonal and district officers)**

1. What do you think of the idea of developing land use strategies in quality coffee production system?

2. Do you think it would be better/easier to develop land use strategies at the level of the community/sub-coffee association level or with individual households? Why?
3. What would be some of the benefits of developing land use strategies in quality coffee production?
4. What would be some of the barriers that would need to be overcome if adaptation strategies were to be implemented in your community?
5. What resources does smallholders or the individual households already have that could be used to implement land use strategies in quality coffee production?
6. What other resources would be necessary in order to implement land use strategies and can you think of some sources where the community or individual households could secure those resources
7. In your view, what is climate change and what influence is it likely to have on quality coffee production system?
8. To the best of your knowledge, what evidence is there of current and possible future climate change in your area?
9. Who are the current actors in climate change adaptation in your organization, region and/or country?
10. Have there been any changes in temperature or rainfall patterns over the last 15 to 20 years? What is the evidence for this?
11. Have there been any changes in quality coffee production practices, potentially due to changing climatic conditions?
12. How do the coffee producers farmers strategically cope with the changes in climate in coffee production?

Part V: Checklist for FDG in Participant Matrix Analysis

1. Do you think that the adaptation strategies being used by quality coffee producers are viable? Why or why not?
2. What other adaptation strategies do you think might be effective for smallholder coffee producers in Yirgacheffe? Why?
3. What are some of the barriers that exist (i.e. political, policy, financial, environmental technical, etc.) for implementing these types of adaptation strategies in Yirgacheffe?
4. What might some means that actors in the coffee sectors could employ to overcome these barriers?

5. Which actors in Yirgacheffee are already working on these types of adaptation strategies? in what ways?
6. What other sources of support are available (i.e. policy, financial, technical, capacity building, knowledge transfer or training, etc.) in Yirgacheffe?
7. Could you rate the power and interest of the following stakeholders in quality coffee production?

Stakeholder in quality coffee production	Rank(1-10)	
	Power	Interest
1. Agro-input suppliers		
2. Research institutes		
3. CDTMA		
4. Zonal coffee office		
5. District coffee office		
6. Sub-district DA		
7. Primary coffee cooperatives		
8. Coffee farmers' unions		
9. Coffee farmers		
10. Financial sectors		
11. Donors and NGOs		
12. Traders		
13. Exporters		

Curriculum vitae

Asnake Adane Ejigu was born on the 13th of June 1982 in north-eastern Ethiopia (the former Wollo province). He received his B.Ed. degree in Geography from Alemaya University in 2004. After graduating, he was employed as assistant lecturer in the Department of Geography and Environmental Studies at Dessie college of Teachers Education in which he held this position for three consecutive years. He continued his studies in Addis Ababa University and received his M.A. degree in Physical Geography (specialization in land Resources Management) in 2009. The topic of his master thesis was focused on '**Local Adaptive Mechanisms to Moisture Stress by Farmers in North-Eastern Ethiopia**'. After graduating his MA, he was employed as lecturer in the department of Geography and Environmental Studies at Wollo University in which he holds this position. In October 2016, he obtained a scholarship from the joint project between the Department of Geography and Environmental Studies of Addis Ababa University, the Research council Norway and University of Oslo in Norway for a PhD study. He has been invited as a guest researcher and joined the AdaptationConnect Group led by Professor Karen O'Brien of the Department of Sociology and Human Geography at University of Oslo, Norway. He conducted an interdisciplinary research in the field of land use change and climate change adaptation by coffee farmers. He followed several courses and participated in local and international trainings and conferences. This dissertation presents the results of his PhD study, which also contains peer-reviewed articles published in reputable scientific journals.

Contact address:

Department of Geography and Environmental Studies, Wollo University, Ethiopia

E-mail: asnake.adane@wu.edu.et /a.a.ejigu@sosgeo.uio.no

Tel: +251910456712/ +4793950185