# FARMERS' PERCEPTION AND ADAPTATION TO CLIMATE CHANGE PRESSURE IN HIGHLAND COFFEE PRODUCTION, DAK LAK PROVINCE, VIETNAM

**PHAM THI THUYEN**

**MASTER OF SCIENCE**

**IN AGRICULTURAL SYSTEMS MANAGEMENT**



**GRADUATE SCHOOL**

**CHIANG MAI UNIVERSITY**

**DECEMBER 2014**

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**A THESIS SUBMITTED TO CHIANG MAI UNIVERSITY IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR DEGREE OF MASTER OF SCIENCE IN AGRICULTURAL SYSTEMS MANAGEMENT**



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# บทคัดย่อ

สภาพความกดอากาศถูกตระหนักว่าเป็นสิ่งสำคัญอย่างมากต่อการพัฒนาการเกษตร อีกทั้งอาจเป็นภัยคุกคามต่อการผลิตกาแฟได้ ปัจจัยด้านอุณหภูมิและปริมาณน้ำฝน ที่รบกวนต่อ crop phenology และส่งผลต่อประสิทธิภาพและคุณภาพของ ผลผลิต กระบวนการในการปรับตัวของเกษตรกรขึ้นอยู่กับความเข้าใจธรรมชาติของการเปลี่ยนแปลงสภาพภูมิอากาศของเกษตรกร การประเมินผลข้อมูล และความสามารถในการปรับตัวหรือความสามารถเฉพาะตัว การปรับตัวต่อการเปลี่ยนแปลงของอุณหภูมิและปริมาณน้ำฝนของเกษตรกร เป็นกระบวนการสองขั้นตอน เริ่มด้วยการรับรู้เรื่องความแปรปรวนของสภาพภูมิอากาศของเกษตรกร แล้วจึงเป็นการตอบสนองต่อการเปลี่ยนแปลงโดยใช้กลยุทธ์ในการปรับตัวการ ประเมินผลการปรับตัว เป็นส่วนหนึ่งของนโยบายที่ถูกกำหนด เพื่อจัดการกับการวางแผนที่คิดไว้ การปรับตัวที่ถูกคาดหวังไว้ตั้งแต่แรก ของผู้ตัดสินใจ โดยเฉพาะอย่างยิ่งเกษตรกร การประเมินผลนั้นมากกว่าการระบุคุณลักษณะของวิธีการปรับตัว และข้อดีโดยเปรียบเทียบของทางเลือกในการปรับตัว หรือความสามารถในการทำให้บรรลุผล เกณฑ์การประเมินไม่เพียงแต่เกี่ยวพันกับขอบเขตด้านเศรษฐศาสตร์ แต่ยังเกี่ยวพันกับการคิดพิจารณาที่แตกต่างอย่างอื่นอีก

การศึกษานี้มีวัตถุประสงค์ คือ (1) เพื่อเข้าใจการรับรู้ของเกษตรกรเกี่ยวกับสภาพความกดอากาศ (2) พื่อประเมินทางเลือกในการปรับตัวและระบุปัจจัยที่ส่งผลต่อการเลือกทางเลือกในการปรับตัวของเกษตรกร เพื่อจัดการกับความกดอากาศ และ (3) ประมาณค่าผลผลิตเฉลี่ยกาแฟและการทำกำไรของกลุ่มเกษตรกรที่มีระดับความสามารถในการปรับตัวที่แตกต่างกัน การศึกษานี้ใช้ข้อมูลจากการสัมภาษณ์เกษตรกรผู้ปลูกกาแฟจำนวน 176 ราย ในตำบลอีอาฮาลีโอ จังหวัดดักลัก ประเทศเวียดนาม

การศึกษาทำการเปรียบเทียบระหว่างข้อมูลสภาพภูมิอากาศที่บันทึกโดยสถานีอุตุนิยมวิทยา และการรับรู้ของเกษตรกรต่อการเปลี่ยนแปลงเหล่านี้ เพื่อทดสอบการรับรู้เกี่ยวกับสภาพภูมิอากาศของเกษตรกร ผลจากการใช้ Likert Rating Scale และการวิเคราะห์ Chi-Square แสดงให้เห็นว่ามีการเพิ่มขึ้นของอุณหภูมิ และการลดลงของปริมาณน้ำฝนในช่วงสิบปีที่ผ่านมา ซึ่งการรับรู้ของเกษตรกรเกี่ยวกับรูปแบบที่เปลี่ยนแปลง สอดคล้องกับข้อมูลทางสถิติที่มีการจดบันทึกในพื้นที่ เกษตรกรร้อยละ 77.27 รับรู้ถึงอุณหภูมิที่เพิ่มขึ้นในตำบลอีอาฮาลีโอ และร้อยละ 66.48 ของกลุ่มตัวอย่างที่สังเกตเห็นถึงการเปลี่ยนแปลงรูปแบบของปริมาณน้ำฝนที่ลด

การประเมินโดยใช้กฎเกณฑ์หลายอย่าง ถูกรวมเป็นหนึ่งเดียวโดยวิธี normalization และวิธีผลรวมถ่วงน้ำหนัก ที่ถูกใช้เพื่อประเมินทางเลือกในการปรับตัวของเกษตรกร แบบจำลองโลจิกแบบเรียงลำดับ (Ordered Logit Model) ถูกใช้ในการประมาณค่าความสัมพันธ์ระหว่างระดับการปรับตัวของเกษตรกร และคุณลักษณะด้านประชากรศาสตร์ เศรษฐกิจและสังคม ผลลัพธ์จากการประเมินโดยวิธีหลายหลักเกณฑ์ชี้ให้เห็นว่าระหว่าง **5** เกณฑ์ประเมิน ได้แก่ ประสิทธิภาพด้านเศรษฐกิจ ประสิทธิผล ความยืดหยุ่น ความสามารถในการนำไปใช้ประโยชน์ของเกษตรกร และประโยชน์ทางอ้อม ประสิทธิภาพด้านเศรษฐกิจและประสิทธิผลถูกประเมินด้วยค่าน้ำหนักระดับความสำคัญสูงสุด ให้น้ำหนักสูงสุด

ผลการศึกษาแสดงว่ามีเกษตรกร 101 ราย ที่ปรับตัวเข้ากับ 1 ทางเลือก 54 ราย ที่ปรับตัวเข้ากับ 2 ทางเลือก และอีก 21 รายที่เหลือปรับตัวเข้ากับ **3** ทางเลือก ซึ่งทางเลือกหลักในการปรับตัวที่ถูกเลือกโดยฟาร์มกาแฟประกอบด้วย การปลูกพืชแบบหลากหลาย เทคนิคด้านชลประทาน และการอนุรักษ์ดิน อย่างไรก็ตาม ผลรวมถ่วงน้ำหนักของทางเลือกในการปรับตัวชี้ชัดว่าระดับของการปรับตัวไม่ได้มีความสัมพันธ์เชิงบวกกับจำนวนของทางเลือกในการปรับตัวที่เกษตรกรผู้ปลูกกาแฟปรับตัวต่อสภาพความกดอากาศ ซึ่งขึ้นอยู่กับการพิจารณาการปรับตัว ในหลายๆด้าน ผลการศึกษาพบว่ากลุ่มที่ปรับตัวเข้ากับเทคนิคด้านชลประทาน การปลูกพืชที่หลากหลาย และเทคนิคด้านชลประทานมีผลรวมถ่วงน้ำหนักสูงสุด และกฎเกณฑ์ **2** กฎเกณฑ์ได้แก่ ประสิทธิภาพทางเศรษฐศาสตร์และประสิทธิผลมีค่าสูงมากในกลุ่มนี้ ในจำนวนเกษตรกรผู้ปลูกกาแฟทั้งหมด 176 ราย กลุ่มที่มีระดับของการปรับตัวต่ำมีผลรวมถ่วงน้ำหนักระหว่าง 2.15 ถึง 2.49 คิดเป็นร้อยละ 26.14 ส่วนผลรวมถ่วงน้ำหนักระหว่าง 2.50 ถึง 2.84 เป็นของกลุ่มที่ความสามารถในการปรับตัวในระดับปานกลาง ซึ่งคิดเป็นร้อยละ 42.61

ในขณะที่กลุ่มที่มีความสามารถในการปรับตัวในระดับสูง ให้ผลรวมถ่วงน้ำหนักตั้งแต่ 2.85 ขึ้นไป คิดเป็นร้อยละ 31.25 ยิ่งกว่านี้ผลลัพธ์ของแบบจำลองการถดถอย อธิบายว่าตัวแปรด้านการศึกษา ประสบการณ์ของการทำสวนกาแฟ ขนาดของสวนกาแฟ รายได้จากการปลูกกาแฟ รายได้อื่นที่ไม่ใช่กาแฟ การเข้าถึงสินเชื่อ การเข้าถึงข้อมูลด้านภูมิอากาศ การเข้าถึงบริการด้านการส่งเสริม และทางเลือกด้านชลประทาน มีอิทธิพลอย่างมีนัยสำคัญทางสถิติต่อทางเลือกในการปรับตัว ที่ระดับนัยสำคัญ 1% และ 5% ส่วนอายุและเพศของหัวหน้าครัวเรือนไม่มีความสัมพันธ์ต่อระดับของการปรับตัว

ผลการวิเคราะห์กำไรขั้นต้น พบว่า กลุ่มที่มีระดับการปรับตัวสูงได้รับกำไรสูงที่สุดด้วยกำไรขั้นต้นเฉลี่ย 74.51 ล้านเวียดนามดองต่อเฮกแตร์ต่อปีต่อครัวเรือน จากการขายกาแฟในราคาที่สูงกว่า การปรับเทคนิคระบบชลประทานอย่างมีประสิทธิภาพ และความรู้ในระดับสูงในการประยุกต์ใช้กลยุทธ์การปรับตัวอย่างเหมาะสมในสวนกาแฟ ส่วนกลุ่มที่ปรับตัวได้ต่ำถึงปานกลาง ได้รับอัตรากำไรขั้นต้นโดยเฉลี่ยค่อนข้างต่ำที่ 24.63 และ 68.65 ล้านเวียดนามดองต่อเฮกแตร์ต่อปีต่อครัวเรือน ตามลำดับ

ข้อค้นพบจากการศึกษานี้ เป็นเพียงการวิเคราะห์ในเบื้องต้น เป็นจุดเริ่มซึ่งจะเป็นพื้นฐานสำหรับการวิจัยที่เกี่ยวข้องในอนาคต ในการปรับปรุงและพัฒนาแผนหรือการปรับกลยุทธ์ในเชิงรุก สำหรับจัดการกับสภาพความกดอากาศที่มีต่อการเกษตร

| | |
|---|---|
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## ABSTRACT

Climate pressure is considered as a major concern for agricultural development and a potential threat to coffee production in particularly. Temperature and rainfall factors interfere in the crop phenology, and consequently in productivity and quality. The process of adaptation depends on understanding farmers' perception of the nature of climate change, evaluation of information, and also by perception of one's own capacity to adapt, or self-efficacy. Adaptation to changes of temperature and rainfall is a two-stage process, which initially hinges on the farmers' perception of climate variability and then responding to changes through adaptation strategies. Adaptation evaluation is considered as part of a planned policy coping with consciously planned, primarily anticipatory adaptation initiatives undertaken by decision makers, specifically individual farmers. An evaluation goes beyond the identification, characterization of adaptation approaches and with regards to an adaptation option's relative merit, superiority or implement-ability. Evaluative criteria do not only mention on principally economic dimension, but also relate to the different considerations.

The study aims to: (1) understand farmers' perception about climate pressure, (2) evaluate the adaptation options and determine the factors influencing farmers' choices for adaptation options for dealing with climate pressure and (3) estimate coffee yield and the profitability of farmer groups with different adaptation capacity levels. The study used data from structured interviews with 176 coffee farmers in Ea H’leo District, Daklak Province, Vietnam.

The study conducted a comparison between the climate data recorded at the meteorological station and farmers’ perception of these changes in order to examine farmers’ perception of climate pressure. The Likert Rating Scale and Chi-Square analysis results revealed that the temperature had increased and the contrary, a decrease rainfall during over the last ten years; farmers’ perception about the change pattern also appeared to be in accordance with the statistical data record in the region. There were 77.27 percent of the farmers perceived the temperature in the Ea H’leo District to be increasing and around 66.48 percent respondents observed changing in rainfall pattern with a decrease in the amount of rainfall.

The multiple criteria evaluation, unity based normalization and weighted sum methods are employed to assess the farmers’ adaptation options. The Ordered logit model is also used to estimate the relationship between the farmers’ adaptation level and their demographic and socio-economic characteristics. The result of the multiple criteria evaluation indicated that amongst five evaluative criteria such as economic efficiency, effectiveness, flexibility, farmer implement-ability and independent benefits; the economic efficiency and effectiveness were assessed with the highest weights about importance level. The results showed that there were 101 farmers adjusted to one adaptation option; 54 respondents adapted to two options and 21 remaining farmers acclimatized to three options. The major adaptation options were selected for their coffee farms included the crop diversification, irrigation techniques and soil conservation. However, the outcome of the weighted sum of adaptation options highlighted that the level of adaptation was not a positive relationship with the number of adaptation options which the farmers adapted to climate pressure for their coffee farm. It depended on the adaptation’s multiple considerations. The results revealed that the groups who adapted to irrigation techniques, crop diversification and irrigation techniques parallel had the highest sum of weight and two criteria involving in economic efficiency and effectiveness were strongly evaluated for these adaptation groups. In the total of 176 coffee farmers, the low adaptation level, which had the weighted sum from 2.15 to 2.49, constituted 26.14%. The weighted sum which ranged between 2.50 and 2.84 was considered as the medium adaptation group comprised 42.61% while the high adaptation was evaluated with equal or over 2.85 of weighted sum and took up 31.25%. In addition, the findings of regression model also explained that factors likely education, coffees growing experience, coffee farming size, coffee income, non-coffee income, access to credit, access to climate information, access to extension services and irrigation option had statistically significant impacted to choosing adaptation options at significant level 1%, 5%. Age and gender of the household head were negatively insignificant correlated with adaptation levels.

Gross margin analysis results presented that the group of high adaptation level obtained the highest profitability with average of gross margin 74.51 million VND per hectare per year per household through selling coffee at a higher price, adapting efficient irrigation techniques and high knowledge for applying appropriate adaptation strategies for their coffee gardens. The low and moderate adaptation groups gained the average of gross margin lower with 24.63 and 68.65 million VND per hectare per year per household respectively.

The findings of this study will be considered as a preliminary analysis and set up a foundation for possible future research related to improving and developing the planned or proactive adaptation strategies for dealing with climate pressure in agriculture.

**Keywords**: Climate Change, Perception, Adaptation Evaluation, Robusta Coffee.

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| | |
|---|---|
| BCA | Benefits-Cost Analysis |
| CEA | Cost-Effectiveness Analysis |
| GCM | General Circulation Models |
| GDP | Gross Domestic Products |
| IPCC | Intergovernmental Panel on Climate Change |
| LRS | Likert Rating Scale |
| MARD | Ministry of Agriculture and Rural Development |
| MCE | Multiple Criteria Evaluation |
| RDDL | Rural Development Daklak |
| UNDP | United Nations Development Program |
| UNFCC | United Nations Framework Convention on Climate Change |
| USD | United State Dollar |
| VND | Vietnam Dong |
| WASI | The Western Highlands Agro-Forestry Science and Technical Institute |

# CHAPTER 1

# Introduction

## 1.1 Background

Agriculture is the source of livelihood for more than a half of the world's population. Agricultural products contributed 22 percent of the total GDP Vietnam (Vi, 2012). It plays a dominant role in supporting rural livelihoods and economic growth of the Central highland of Vietnam. Specifically, agricultural system in upland areas where only cultivate tropical crops such coffee, cocoa, tea, is considered as the sustainable foundation for the elimination of poverty and food security in Vietnam.

Coffee is produced as an export commodity with an annual value of US$ 15,000 million is the second following oil in the ranking of world products (Kushalappa et al., 1989). It is the major export and the principle source of foreign exchange for many developing countries (Oerke et al., 1994). Coffee was introduced into Vietnam by French missionaries in 1857. Coffee plantation was established in the North Midlands in the late 1800's and in the North Central Coast in the early 20$^{th}$ century. In the 1920s, the suitable coffee growing areas were discovered in the Central Highland regions. By 1945, Vietnam had about 10,000 ha of coffee, most of which was in the central region.

However, climate change is currently highlighted in the international community as a potential threat to coffee production in the Central highland environment of Vietnam. It has already impacted on innumerable communities, exposing them to increasing hazards and making them more vulnerable (UNFCCC, 2007). Vietnam is considered as one of the most affected countries in the world.

According to General Circulation Models (GCM) (UNDP, 2009) the temperature in Vietnam is not expected to increase by 1.4°C to 4.2°C by 2090s, compared to 2009. The number of hot days (above 25°C) is not expected to increase by 23 to 55% by 2090s, mainly in the wet season, compared to 2009. For the Central Highlands, where coffee is grown, the number of hot days per year is even expected to rise to 94 in 2020, 134 in 2050 and 230 in 2100. Groundwater is expected to drop up to 11m compared to the current level.

Despite impressive success in increasing the food production in Vietnam to meet the demands of the rapidly increasing population, the ability to sustain this success is a major concern. In recent years, agricultural systems are vulnerable to variations in climate variables and it can be viewed as a function of the sensitivity of agriculture to changes in climate, the adaptive capacity of the system and the degree of exposure to climate hazards (IPCC, 2001). The productivity of food crops from year to year is sensitive to variations in climate and this affects the agricultural development in particular and economic growth in general. Climate change includes rapid changes in climatic variables such as temperature, radiation and precipitation as well as changes in the atmospheric concentration of greenhouse gases, soil water and nutrient cycling.

## 1.2 Rationale

Dak Lak is the largest province of Vietnam, located in the Central Highland with the total area of 1,312,537 ha, including 480,000 hectares of agricultural land (Tuan, 2012). The most dorminant kind of soil is Basaltic. Under the weather condition of the Central Highland, Daklak is very suitable for high value industrial crops cultivating such as coffee, peper and rubber. Being a hilly area that does not hold impounded surface water and also is the area with moderate tropical climate, Dak Lak is seriously affected by high evaporability from the climatic variable; the demand for irrigation in agriculture is calculated to be two- to threefold compare to current demand (Haggar, 2011). Temperature and rainfall conditions are considered to be important factors in defining potential coffee yield. Both factors interfere in the crop phenology, and consequently in productivity and quality. The coffee plant responds sensitively to increasing temperatures, specifically during blossoming and fructification (Haggar, 2012). Since rainfall distributed unbalance which causes an obstacle for coffee pollination and to extend time drying, coffee price decreases dramatically. This adversely affects to farmer's income. Moreover, the high temperature results in increasing water demand for crops while water resource is becoming scarce. Coffee is a water-intensive perennial crop. About 40% of the current coffee plantation area is irrigated by groundwater, using up about 66 million $m^3$ during the dry season, or 438,400 $m^3$ per day. In the dry season, in the blossom and fruit period, around 1,500-3,000 $m^3$ of water per hectares need to be provided for coffee (Luu, 2002). Each watering was used between 600 and 900 litres per tree. This enormous amount of water is far too much and recommends reducing it to only 320 litres per tree and watering (D'Haeze, 2005). Efficient irrigation will probably be one of the most critical factors in the near future, given the climate change impact scenarios on water resources that predict a decline in rainfall, river flows and the drop of groundwater level, specifically in the Central Highland coffee cultivation area (Haggar, 2012). Provincial authorities find that it is difficult to manage water resources, and the high rate of exploitation has already exhausted a number of sources. Besides the direct impacts of high temperatures on the coffee crop the increase of pests and diseases is supposed to be a consequence of increasing temperatures. According to latest press releases the coffee sector is already suffering from climate variability as the 2010–2011 harvest output was lower by 20% the previous harvest in 2007-2008 due to extreme drought period and delayed rainfalls. The coffee productivity reduced from 3.5 t/ha to 2.0 t/ha/year (Haggar, 2012). And owing to extreme drought the area for growing coffee in Ea H'leo District, Daklak province, the site study is damaged about 2,925.71 ha whereas, the level of damaging less than 30% with 1,318.09ha and more than 30% with 1,607,62 ha between 2012-2013 (Ea H'leo Agricultural Department, 2013).

Climate change pressure is defined by changes of temperature, high frequency of drought and rainfall pattern changes. It is considered as a major concern for agricultural development and food security. Promoting sustainable development in the uplands of the Central Highland in Vietnam poses major challenges. Thus it is essential to include specific adaptation strategies to climate pressure. In addition, adaptation practices require extensive high quality data and clear information on climate, agricultural, environmental and social systems which support considerably for assessing impacts of climate variables.

# CHAPTER 2

## Literature Review

This chapter presents the general information about coffee production, characteristics of robusta coffee which is a major crop in Daklak province and impacted by climate pressure and very vulnerable to drought and high temperature. The fundamentally academic researches which relate to farmers' perception and adaptation in agriculture in general and coffee dimension in particular, are also cited to support for the literature review of this study.

### 2.1 Coffee Production and Characteristics of Robusta Coffee

Robusta coffee is a dominant crop and plays an essential role in the economic development, especially in the Central highland area of Vietnam. Robusta coffee planted in the majority of total crop area in central highland provinces.

2.1.1 Coffee Production

Globally, coffee has a significant impact to the economy of over forty producing countries. In value, it is the second only to oil in terms of international trade and surpasses sugar, rice and wheat as the major agricultural commodity. Coffee production in the Central Highlands is an essential role when the policy of Vietnam's $10^{th}$ Central committee conference decided to transfer land and forests to farmers, and expansion of trade relations with foreign countries. Maximum productivity per tree is expected between the age of 5 and 15 years. In Dak Lak, an optimal planting density of 1,100 trees per hectare is recommended by D'haeze, et al. (2005).

Robusta is the dominant crop in West Africa Brazil and Vietnam. Vietnam is the second largest producer after Brazil, accounting for 14.3 percent of world market, 97 percent of Vietnam's total output by 1.17 million tons exported in 2009, a value of USD 1.7 billion (Nhan, et al. 1999). In Vietnam, Robusta coffee was grown on 480,000 ha, representing 95 percent of the total coffee planted representing 95 percent of total coffee planted and 26 500 ha of Arabica coffee, representing 5 percent of total coffee planted.

Only 26,500 ha were planted with Arabica coffee, representing 5 percent of the total coffee production. The export value in 2010 for coffee amounted to 1.67 billion USD. Since the 1980s coffee production grew rapidly from 8,400 tons with a growth rate of more than 26 percent per year. Around 85 percent of the production is held by small scale farmers. Two-thirds of the farms are smaller than one hectare, and only 3 percent larger than three hectares (Marsch, 2007). The crop year for coffee in Vietnam starts to harvest in October and ends up in September the following year.

In 2006, Viet Nam exported approximately 900,000 tons of mainly Robusta coffee, contributing USD1.1 billion to national earnings (Investment and Trade Promotion Centre of Ho Chi Minh City, 2007 and The World Bank, 2007). Around 60 percent of Viet Nam's coffee output originates in Dak Lak Province, with the majority produced on smallholdings of less than 1.5 hectares. Robusta requires irrigation during Dak Lak's dry season from November to April the next year and competition for scarce water has been increasing in recent years between coffee smallholders and among the urban and agricultural sectors, especially when the preceding wet season rainfall has fallen below the historical average (Ahmad, 2000; Dak Lak Peoples' Committee, 2001; D'haeze, et al., 2003 and Riddell, 1999). Over 70 percent of the Dak Lak Plateau's coffee smallholders draw groundwater from the region's unconfined aquifer for dry season irrigation. Most smallholders own their own mobile pump and have access to at least one private well (Ahmad, 2000 and Chi et al., 2005). Groundwater withdrawals for coffee irrigation have a pervasive influence on Dak Lak's hydrodynamics, and contribute to the increasing incidence of well exhaustion and base flow disruption, especially during low and very low rainfall years (Basberg, et al., 2006; D'haeze, et al., 2005 and Moller, 1997). Poor irrigation timing leads to uneven and reduced flower onset, uneven berry ripening and lower bean quality (D'haeze, et al., 2003 and Titus, et al., 2007).

Table 2.1 Contribution of coffee to provincial GDP in 5 main coffee producing areas

| Province | Acreage (ha) | National production (%) | GDP (Mil. USD) | GDP (%) |
|---|---|---|---|---|
| Dak Lak | 165,126 | 41 | 346.6 | 78 |
| Lam Dong | 116,740 | 24 | 263.1 | 58 |
| Gia Lai | 76,065 | 13 | 250.6 | 33 |
| Dak Nong | 64,912 | 12 | 88.4 | 92 |
| Kon Tum | 11,513 | 2.2 | 75.6 | 19 |

Source: Social-Economic Statistical of Department of Agriculture, 2006

Table 2.2 Area and yield in coffee cultivation

| Province | Acreage (ha) | Yield (Tonnes/ha) | Production (Ton) |
|---|---|---|---|
| Dak Lak | 200,161 | 2.512 | 487,748 |
| Lam Dong | 145,734 | 2.490 | 343,375 |
| Gia Lai | 77,627 | 2.020 | 151,771 |
| Dak Nong | 116,350 | 2.220 | 179,658 |
| Kon Tum | 12,158 | 2.526 | 179,658 |

Source: Department of Agriculture, 2012



1) Characteristics of Robusta coffee

1.1) Vegetative characteristics

The Robusta coffee plant originally grew in African tropical forests from West Coast to Uganda, chiefly between $10^0$ N and S of the equator. Coffee is a shrub type plant with several trunks, although the coffee plant may have one trunk.

1.2) Branch

Coffee has a distinct dimorphic branching system. The vegetative part of the tree grows vertically to form the stem and the central axis. The lateral or primary branches are produced from the stem. These branches develop in succession from the base upward on the stem and grow out horizontally on the opposite of each node. The primary branches cannot be replaced by other branches, if they die or are cut back to the main stem. Add the secondary branches are developed from the primaries; likewise the secondary can produce the tertiary branches (Nghiep, 1985).

1.3) Leaf

Leaf is a bipolar leaf structure, where two leaves grow from the stem opposite each other. The distance between leaf pairs in the stem is about 1 to 3 inches. The leaf pairs generally are at 90-degree rotation of each pair on the stem (Op de Laak, 1992).

1.4) Flowers

The coffee flowers are white, produced in dense cluster, and formed at the axis of the leaves. The coffee flowers have five-toothed calyx (outer wall of the flower), a tubular five-parted corolla (inner wall of the flower). Five stamens (pollen bearing organ) and a single bifid style (one piece pointed and divided into two equal parts). The flowers last only a few days. The coffee plant blooms shortly after irrigation or rainfall. The coffee flowers have a strong pleasant smell. Sexually, the coffee is not automatous, in that it cannot pollinate itself (Nghiep, 1985).

1.5) Root system

Taproot is a sturdy central root, often multiple, tapering more or less abruptly and rarely extending as a recognizable unit more than 80 cm from the soil surface. The lateral roots spread less or more parallel to the soil surface for a distance of 1.6 to 1.8 m from the trunk. Often they originate from the taproot. The feeder bearers are the small root. Extensions of lateral roots are evenly distributed about 25 mm part. They are short and numerous. Finally, feeders developed from feeder bearers, they are white and turgid. They can be found at all depths, but more numerous at the surface soil (Thai, 1997; Tu, 1998).

1.6) Climate and soil requirements

Robusta can be planted at an elevation up to 1,000 m above sea level, with an annual rainfall ranged 1,700 – 3,000 mm, spread over nine to ten months. It requires an optimum temperature of 20 – 30$^0$C and relative humidity of 80 – 90 percent, light wind and needs uniform thin shade. Soil should be deep, friable well drained, slightly acidic in reaction (pH: 5.0-6.5), porous and rich in organic matter content. Soil should be moisture retentive (Nghi et al., 1996; Nhan et al., 1999 and Cambrony, 1992).

## 2.2 Climate Change Vulnerability of Coffee Sector

### 2.2.1 Temperature and coffee

Increasing mean and maximum temperatures and changing distribution of rainfall are expected, and undoubtedly will affect coffee production (Haggar, 2012). Coffee plantations are frequently affected by more severe and more frequently occurring extreme weather events. Specifically for tropical regions an increase in extreme weather events is predicted. Scientific research and participatory assessments show that many of the current coffee growing regions are already suffering from these changing conditions and are very likely to be affected in the near and long-term future. This might have severe consequences, not only for the farmers, but for all actors of the coffee value chain as for the production costs, the coffee price and world market conditions. Temperatures of -3.5°C provoke damage to leaf tissue and trunks. These levels can be practically lethal to the plant, depending on the topographic conditions of the plantation. The crop is more vulnerable to frost when located in valleys, where the air builds up on cold nights (Camargo, 2009).



### 2.2.2 Soil and coffee

The Central Highlands in Vietnam are a basaltic area with moderate tropical climate. Coffee production ranges from 300m upwards, including some small areas up to 1,500m. Climate in the Central Highlands is ideal for Robusta production. The dry season is typically four months and extends from mid-December until mid-April, coinciding nicely with flowering. During this period there is less than 25 mm rain per month. During the eight months wet season from May to November, a monthly average of 200 mm is expected giving an average yearly rainfall of 1,600 to 1,800 mm. The average daily air temperature in the Robusta areas fluctuates between 18°C in December and 25°C in April. The maximum day temperature is 30°C in April. Coffee cultivation in Vietnam goes hand in hand with deforestation, land degradation and depletion of water resources. The resilience of coffee monoculture production systems to e.g. soil erosion, increasing evapotranspiration, drought periods or devastating extreme weather events is very low. The above described projections of temperature increase and changing precipitation patterns should be considered well against the background of irrigated Robusta production in Vietnam and the high dependence on the availability of groundwater or river flows. Water resources are essential for the high yields obtained in Vietnam. The basaltic soils of the Central Highland regions have provided sufficient water with their large stores of underground water, replenished annually by the monsoon rains. Overall rainfall volume has been sufficient for Robusta coffee, but the uneven yearly distribution requires irrigation to achieve the high yields. Water for coffee irrigation is acquired from 3 main sources: manmade ponds and reservoirs (20.8%), natural rivers, lakes and streams (28.5%) and from ground water (56.6%). According to local estimates water resources in Dak Lak are exploited up to 71% of their total capacity. More than 95% of the extracted water is used for irrigation of perennial crops, mainly coffee (March, 2007). The predicted impacts on the availability of water resources might have serious consequences for irrigated coffee production, specifically for irrigation based on rivers and groundwater. Future availability and demand should thus be analyzed profoundly. According to D'Heaze, irrigation is required during the dry season from December to April to receive a 270 day growth period for optimal production conditions in order to break flower bud dormancy and induce fruit setting (D'Heaze, et al., 2003). During the dry season water is applied every 20–25 days with a field application depth of 100 mm. Preliminary investigations on farmers' fields suggest that the amount of water presently used, exceeds the crop water requirement and therefore endangers water resources in the region (D'haeze, 2005). D'haeze (2003) provides the following account of the importance of irrigation in the Robusta fruit set. "The variability in water requirements for coffee is strictly related to flower bud development and fruit growth. After initiation of the flower buds, they grow for several months, reaching an average length of 4–6mm, before becoming dormant by the end of the rainy season. Continuous water stress for 1–4 months in the next stage slowly breaks this dormancy. Subsequent relief of water stress by rainfall or irrigation stimulates the flower buds to grow again. During the first 7–8 days after this stimulus, the water content in the flower buds increases rapidly and they grow in length three-to-fourfold, developing to blossom. A period of water stress therefore seems to be mandatory for normal flower bud development. Pollination and fertilization have completed 24–48 hours after flower opening. From then the fruits undergo a rest period, remaining as so called 'pinheads', and crop water requirements decline. Sixty days after blossoming the fruits start swelling to reach their final size, hence increasing the crop water requirements again (Haggar, 2012). The latter period often coincides with the beginning of the rainy season in the Central Highlands, so that no further irrigation is required."

Although coffee is the second largest trading product in Vietnam and the MARD developed the Action Plan Framework for Adaptation to Climate Change in Agriculture 2008–2020 (MARD, 2009), no specific activities are planned to address climate change risks for Vietnamese coffee production. In the framework of the present work, Mr. Manh Nguyen Quoc was contacted and stated "The Ministry of Agriculture and Rural Development has an Action Plan Framework for Adaptation to Climate Change in Agriculture 2010–2020 with many sectors as: water resource, forestry, aquaculture, dyke management, livestock production, crop production, rural development, etc. In crop production, we have some projects in the action plan for example: assessment of the impact of climate change to crop production in general; changing the crop structure to adapt to climate change; breeding new varieties to adapt to climate change, among others. These projects focus on some crop in low land as rice, maize, soybean, mainly in the Red river and the Mekong River, the area impacted by sea level rise. In the action plan we have not any projects focusing only on coffee, though coffee is second product after rice on export value." In addition, he confirmed those specific impact assessments of climate change on coffee production or any impact scenarios are not available in Vietnam. "We have not any research on impacts of climate change to coffee production yet, but the coffee area of Vietnam is affected by climate change, specifically by droughts and we can provide the data on drought in the Central Highlands."

Vietnam has been affected by an unusual drought period in 2009–2010. Also coffee growing regions in the Central Highlands were affected. In August 2010 responsible government institutions, international development cooperation and some NGOs met to analyze the situation and define activities to manage the existing damages and the risk of future droughts. Also Mr. Truong Hong, Vice Director of WASI confirmed, that no detailed data have been collected referring the impacts of climate change on coffee production. He stated: "WASI has many investigations on coffee production only. We have realized clearly that climate change has impacted the coffee production in Vietnam, particularly in the Western highlands. Farmers have faced many difficulties in cultivation, rainy rules and dry season changed, decreasing yield and coffee quality. And I think this problem is more serious from now on, but no detailed data were collected according to the information now. There are no public or private initiatives, projects or programs dealing with climate change issues related to the coffee growing areas in Vietnam." (MARD, 2009).

### 2.2.3 Climate change pressure

Climate change pressure, such as shifts in the rainy season and variations in temperature, high frequency of drought and precipitation can negatively affect coffee plant physiology, resulting in reduced yields. Some analyses of climate pressure impacts in the region anticipate that certain coffee-growing regions will face on rising temperatures or changed climate patterns that may render production unprofitable or infeasible (Gay et al., 2006). For smallholder farmers, the move to quality production, including quality related certifications, requires access to information and technical assistance, which can be difficult and require substantial investments of time and labor. The mode of disseminating agricultural policies and programs, which govern access to technical support and services as well as credit and knowledge, poses part of the challenge.



## 2.3 Theory of Framework Motivation in Adaptation, Perception to Climate Pressure

Any conscious decision to the adaptation requires motivation. Mitchell (1982) defines motivation as ''the degree to which an individual wants and chooses to engage in certain specified behaviors''. Motivation theory aims to explain the underlying cognitive and psychological processes that drive actions in order to predict. Motivation cannot be observed or measured directly, but can manifest itself through attitudinal and behavioral measures (Ambrose et al., 1999). In assessing adaptive motivation, attitudinal manifestations may include satisfaction or dissatisfaction with certain information and its sources and with certain adaptation options. Behavioral manifestations may include active pursuit and/or use of information and the implementation of adaptations. Generally, individuals tap into a mix of their personal experience, local knowledge, and techno scientific information when assessing their climate risk. The process of adaptation is affected by perception of risk and evaluation of information, and also by perception of one's own capacity to adapt, or self-efficacy (Hu et al., 2006).

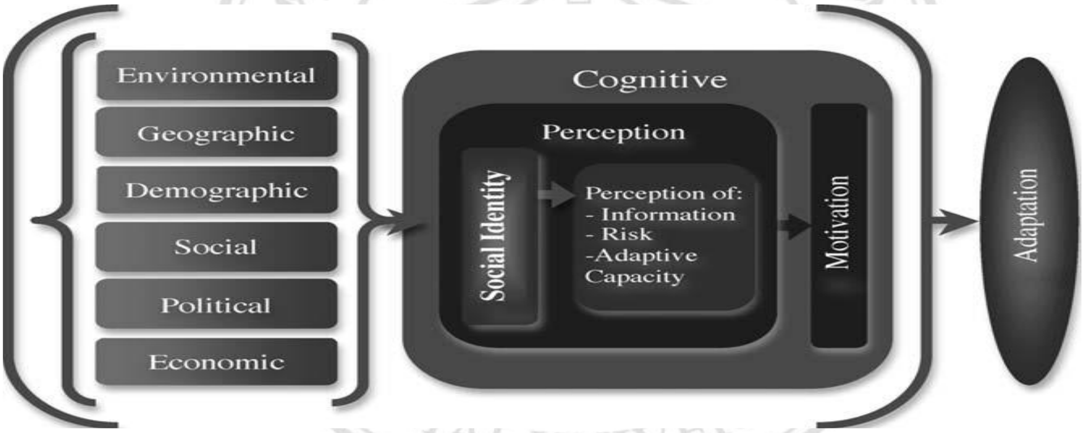



Figure 2.1 Conceptual model of the relationship between social identity and the perception of information. Source: Elisa et al., 2011.



Motivation is the final essential element leading to adaptation; therefore, gaining an understanding of the cognitive processes that affect motivation remains instrumental in developing climate change adaptation initiatives and policy. At the individual level, the socio-cognitive domain of the adaptation process, in which social identity interacts with perception and motivation, is affected by social, economic and demographic characteristics of individuals and their environments. Adaptations thus emerge in a decision process that takes into account not only who an individual is in terms of age, economic status, education, etc., but also how the individual perceives his or herself in relation to others and in relation to risk. When confronting environmental change, however, local knowledge is not always sufficient in building adaptive capacity. In order to adapt to change, new information is often needed – in this case, information about the changing climate and feasible adaptations of farming practices. Focusing on a need for new information does not delegitimize local knowledge, rather, through the social identity framework, one may be able to better explore how identity delegitimizes or enhances understanding, acceptance and use of new or exogenous knowledge (Mitchell, 1982).

## 2.4 Farmers' Perception and Adaptation to Impacts of Climate Change

Since 1974, there has been rapid development of crop models to assess the variations in yields for different crops or management options under given climatic change. Also, there have been a large number of studies analyze farmer's perception to adapt to climate change.

With the objectives to analyse the driving forces behind farm households' decision to adapt to climate change and to investigate the productive implications of this decision, Falco et al. (2011) estimated a simultaneous equation model with endogenous switching to account for the heterogeneity in the decision to adapt or not, and for unobservable characteristics of farmers and their farm. The authors selected 1,000 farm households within Nile Basin of Ethiopia with 20 woredas (districts) and 50 households from each woredas. But the final sample included 20 woredas, 941 farm households and 2,807 plots per farm household with a total of 48 annual crops were grown in the basin, the first five major annual crops (teff, maize, wheat, barley and beans) cover 65% of the plots. The results showed that increased temperature and declining of rainfall were the predominant perceptions in the study sites. Both information on the adaptation strategies and financial resources to implement were necessary for farmers. The lack of access to extension services might be the most crucial obstacle to the adaptation. The paper also presented that the farm households with highly fertile soils were less likely to implement some adaptation strategies. The mainly labor and fertilizers seem to significantly affect the food productivity of the farm households that did not adapt. And the difference between the farm households that did and those that did not adapt concerned the effect of temperature and rainfall on the quantity produced per hectare.

To response of agriculture under impacts of climate change with some questions such as what factors explain the vulnerability of the agricultural system? What is the farm level agricultural risk associated with climate change? What is the impact of climate variability on agricultural profitability? Will agriculture in Cameroon be profitable under future climate change scenarios? Which policies and conditions are necessary to minimize the negative impact of climate change on agriculture? What long-term approaches should be recommended to maintain the adaptive mechanism? A study, which related to the economic impact of climate change on agriculture in Cameroon, was conducted by (Molua and Lambi, 2006). The specific objectives of the research were to assess the impact of climate change on agriculture in Cameroon; estimate how climate affects the current agricultural systems; and project how climate change might affect these systems in the future. In order to obtain these objectives, the authors used two approaches, including the structural and the spatial-analogue. The structural approach was interdisciplinary, linking models from atmosphere embed parameters drawn from crop experiments. After measuring crop yield changes under different climates, by using forecast from General Circulation Models (GCM), the yields estimates were then incorporated into the economic model of the agricultural sector to estimate changes in acreage and supply and consequent changes in market clearing price. The economic models seek to either minimize costs or maximize consumer and producer welfare subject to climate constraints while the spatial-analogue approach involved models that estimate the effects of climate change on agriculture based on observed differences in agricultural production and climate between regions. These models included the Ricardian analysis and Restricted Profit Function to measure the economic impact of climate on farm values. The restricted profit function measured both the loss to individual producers and consumer surplus if supply change due to price variation. The paper used 15 scenarios derived from five different well tested models (CSIRO2, HadCM3, CGCM2, ECHAM and PCM) in conjunction with two different emission scenarios (A2, B2) with a farm-level survey of over 800 farms, using cross-sectional approach to measure the relationship between climate and the net revenue from crops. Net revenue was regressed on climate, water flow, soil and economic variables. The research results showed that Cameroon’s farmers adapted the agricultural systems and practices to changing economic and physical conditions, by adopting new technologies and changing crop mixes and cultivated acreage. Crop and soil management techniques included pruning, staking, plant spacing, multiple cropping per year, mono-cropping, growing solely perennial crops, and zero tillage. The study also depicted that Cameroon was faced with difficult socio-economic conditions, insufficient institutional framework and inadequate infrastructure. Inadequate research, training and credit limit farmers' capacity to adapt to climate variation and change. The necessary adjustments such as changing crops, introducing irrigation or modifying farm management methods were too costly for many farmers to implement. On the other hand, the study also depicted that Cameroon was faced with difficult socio-economic conditions, insufficient institutional framework and inadequate infrastructure. Inadequate research, training and credit limit farmers' capacity to adapt to climate variation and change.

Climate change adaptation is possible through farmers' perception of changes and their autonomous response to the changes, aside from planned the implementation of adaptation policy. Such autonomous adaptation usually happens on ad-hoc basis, triggered by climate variability and extreme events. Economic wealth, technology, information and skills, infrastructure, institutions, and equity all affect the adaptive capacity of a community (Smit and Pilfosova, 2001). Yamauchi et al. (2012) conducted a research involved climate change, perceptions and the heterogeneity of adaptation and rice productivity: evidence from Indonesian villages. The study surveys covered agricultural production activities in 48 villages chosen from different agro-climatic zones in seven provinces (Lampung, Central Java, East Java, NTB, South Sulawesi, North Sulawesi, and South Kalimantan) and added new villages in each province. In total 98 villages were covered. And collected the information directly from farmers in Indonesia in 1999 and 2007, to understand how farmers perceive the change in rainfall patterns?, How the perception affects their adaptation strategy? And how the perceived change in climate affects rice productivity and roles of irrigation?. Data for rice production and the production growth were obtained from the panel constructed from the 1997 and 2007 data. Data for four different types of rice products were collected: wet paddy; unhusked rice; unhusked rice for storage and rice ready for sales. Productivity of rice was measured as the value of production per land. Data directly elicit farmers' perceptions of changes in rainfall patterns during the recent decades, including the change in the onset of rainy season, and their response to adapt perceived changes. In order to achieve these above objectives, the authors used ordered probit to analyze the effect of the perceived changes in onset on the above mentioned other changes in rainfall patterns, and probit models to identify factors that determine whether farmers prioritize the change in planting timing and crop variety. With the dependent variable took the value of one if the farmer adopt the above strategy as the planting timing or crop variety choice and zero otherwise. Change in onset was the difference between the reported onset month for crop year 2006 and the reported month 20 years ago. The research results showed that returns to irrigations could be eroded when the onset of the rainy season is delayed. For rice farming in Indonesia, climate change decreases rather than increases returns on irrigation infrastructure. The delays in the onset of the rainy season substantially decrease the rice production growth. One-month delay in the onset of the rainy season cancelled the average growth of rice production. Furthermore, the results revealed some important insights on returns to irrigation when rainfall patterns are under the change. Irrigation had a potential to mitigate negative effects of the delayed onset in areas where relatively stable water supply is available and accessible to the users of the system.

On the other hand, there are more some of studies looking particularly at the factors which affect farmers' decision to adapt to climate change at the farm level (Roncoli et al., 2002) and (Hansen et al., 2004). The studies examine farmers' perception, use of information and other factors influencing the decision making process. Bryan et al. (2009) conducted a research about adaptation to climate change in Ethiopia and South Africa: options and constraints with objectives particularly (1) understanding about the adaptation strategies used by farmers and (2) analyze the factors influencing the decision to adapt. In order to obtain these objectives, the study used factor analysis and probit model with the dependent variable for adaptation was created. It was as a dummy variable equal to 1 if the farmer adopted with any the adaptation options and 0 otherwise. The sample of the study included 800 observations from 19 districts of 4 provinces of South Africa and 1,000 observations from 20 districts in 5 regions in Ethiopia. The results showed that farm-level adaptation involved more than adopting new agricultural technologies, accessing to extension services and accessing to information and credit. And another paper related to farmers' perception and adaptation practices to cope with drought: perspectives from Northwestern Bangladesh which conducted by (Habiba et al., 2012). The research objectives included examining the level of farmers' perception and awareness about climate change and drought; and understanding about various adaptation practices of farmers in a comprehensive manner. Farmers who involved in the study, devised into groups as owner, owner-cum-tenant and tenant for irrigated and non-irrigated villages in 14 sub-districts with a total 718 farmer questionnaires were collected from the study area. The study used a semi-structured questionnaire in order to collect information from the farmers' point of view these selected villages. The results highlighted that determining farmers' perception and awareness on climate change and drought, age was important factor which helped to understand the real scenarios happening in climatic issues. The higher education possibly facilitated better access to information, adopt new technologies and increase farmers' income.

In conclusion, available literature provides only a partial intuition of the problem. Considering the vulnerability of global warming on agricultural development, some questions about climate variability in the study area and the response of agriculture can be interested: How do farmers perceive about changing of climate attributes? What are the factors impacting farmer's choices for adapting to climate pressure? How is the level of practicing adaptation options for coffee farming? What long-term adaptation strategies should be recommended to maintain the adaptation? How is the profitability of coffee farmers who practice adaptation options?



## 2.5 Research Objectives

There is a need of careful and detailed analyzing the factors that affect to farm households' decision to adapt to climate pressure. It is crucial to understand how the social, economic, institutional and ecological context mediates the climate impacts and influences the adaptation response. Farming coffee will be the major object for the study because of a dominant crop and a scale limitation. Thus, the research objectives of this proposed study are the followings:

1. To understand farmers' perception about climate pressure

2. To evaluate the adaptation options and determine the factors influencing farmers' choices for adaptation options for dealing with climate pressure
3. To estimate coffee yield and the profitability of farmer groups with different adaptation capacity levels.

# CHAPTER 3

## Research Methods

This chapter presents the issues relating to site selection, the way to calculate the sample size, kinds of data and data analysis in the study. Moreover, the research methodologies are provided and explained clearly in order to obtain the objectives of the research.

### 3.1 Site selection

The domain of study was carried out in Ea H'leo district, where a certain group of farmers was impacted by climate variability and based on coffee production. The main criteria for selecting of this district were that it had a heavy concentration of coffee area. Coffee was a dominant crop and considered as a backbone of household's income and livelihood. Almost all the households were both directly and indirectly engaged in coffee production. Moreover, the frequency and severity of extreme drought in the region have been increasing and declined rainfall in recent years. Owing to extreme drought the area for growing coffee in Ea H'leo District, Daklak province, the site study is damaged about 2,925.71 ha whereas, the level of damaging less than 30% with 1,318.09 ha and more than 30% with 1,607,62 ha between 2012-2013 (Ea H'leo Agricultural Department, 2013). This causes challenges for coffee sustainability in this area.

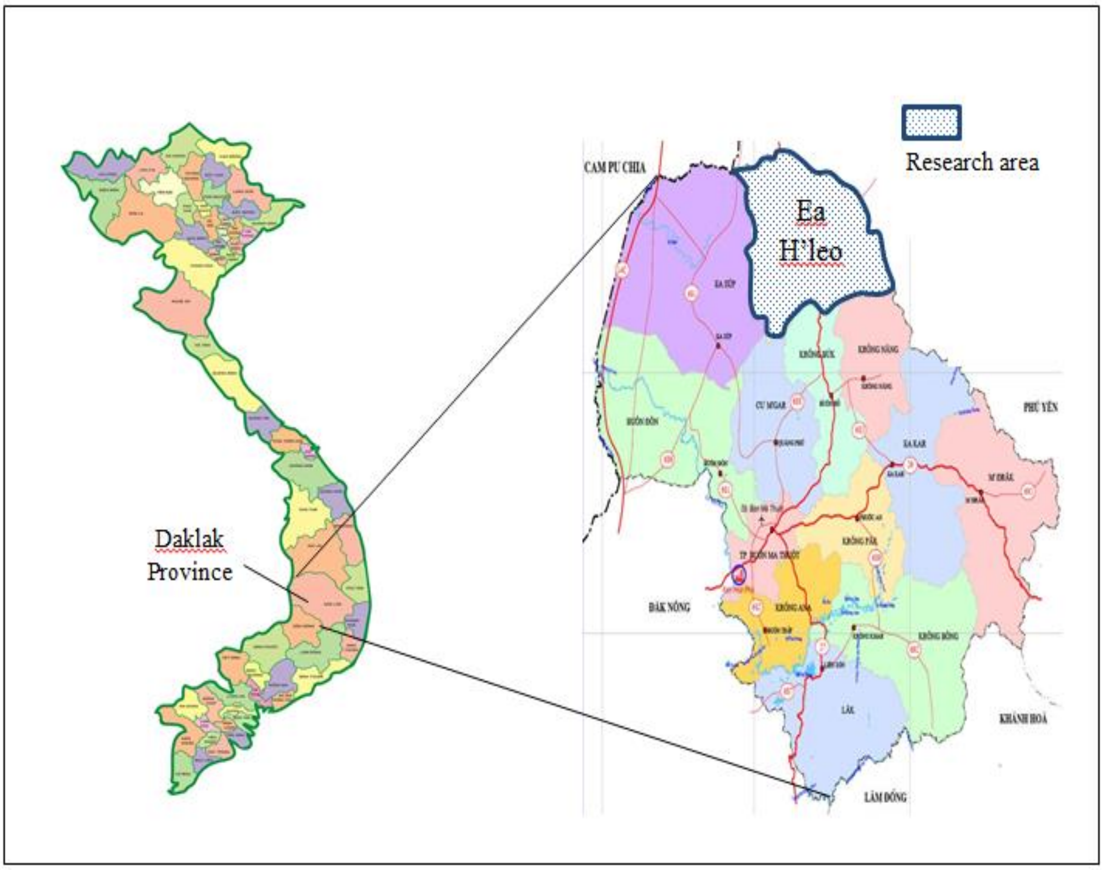



Figure 3.1 Location of research area. Source: Department of Agriculture, 2013.

### 3.2 Sampling technique

A simple random sampling method was adopted to select households for questionnaire survey. The sample size for farmers is calculated based on Yamane's formula (Yamane, 1967)

$$n = \frac{N}{1 + N * e^2}$$

Whereas, n is the sample size

N is the size of coffee farming population

e is allowable error 7.5%

By using this formula, with total coffee farming in the study area is 23,613 households (RDDL, 2013), and due to the time and cost limitation, the study accepted the allowable error 7.5% instead of error 5%. With the result that, interview consists 176 farmers in the selected villages belong to Ea H'leo district, in Dak Lak province. Data was collected through face to face interview using a semi-structured survey questionnaire technique. Descriptive statistics were applied to describe the socio-economic profile of farmers such as farmers' personal characters, economic and biophysical characteristics, present farming technology and existing farming practices for adopting on climate change.

## 3.3 Data collection

### 3.3.1 Primary data

Data on farmers' perception about climate pressure and factors impacted on choosing adaptation strategies will be collected through an intensive household survey using a questionnaire survey instrument. The instrument will then be pre-tested via pilot survey for the relevancy and correctness of the questions. The main survey will be done in targeted areas in Daklak, specifically in Ea H'leo district with sample size is about 176, using face to face interview technique. The questionnaire contains information on socio-economic characteristics of the households (eg. age, gender, education, climate change knowledge, income, credit, land ownership, etc); coffee production (eg. age, inputs, yield, irrigation, price, etc); respondent's perception of climate pressure, adaptation options. It is not easy to measure the level of the respondent's perception of climate change in general; therefore, the study will focus on the change of temperature and rainfall in the region.



### 3.3.2 Secondary data

The secondary data will be collected from relevant reports, statistical data and published information related to study issues, web-research, local departments such as Department of Agriculture and Rural Development, Department of Statistic; Meteorological Station. Based on this analysis, a general view to changing of climate attributes such as temperature, rainfall as well as adaptation strategies in the study area will be sketched.

### 3.4 Data analysis

The general profile, coffee production systems and climate variability of the study area were described from information generated through the biophysical and so-economic survey and other relevant documents. These informations were useful to understand all aspects of coffee production systems, farmers' perception about climate pressures and adaptation strategies practicing for their farming. The path to the impacts of climatic variability, farmers' perception and adaptation approaches could find by following analysis methods.

3.4.1 Methodology

1) Likert rating scale and chi-square analysis

To examine the farmers' perception of climate pressure, the study undertakes a comparison between climate data recorded at the meteorological station and farmers' perception of these changes. The questions about climate pressure, types of changes, causes and effects of climate variability are asked from respondents' base on their level of agreement or decision making. A 5-point Likert Rating Scale (LRS) is employed. This is graded as strongly agree (SA) = 5, agree (A) = 4, undecided (U) = 3, disagree (D) = 2, strongly disagree (SD) = 1. Chi- square analysis will be also conducted to find out the relationship between farmers' perception to the impacted factors as well.

2) Multiple criteria evaluation and ordered logit model



The process of adaptation depends on understanding farmers' perception of the nature of climate pressure, evaluation of information, and also the perception of one's own capacity to adapt, or self-efficacy. Adaptation refers to responses of individuals to climatic effects in order to reduce vulnerability or unfavorable impacts or damage potential. Evaluation of the adaptation options is intended to assess the overall merit, suitability, utility or appropriateness of potential adaptation strategies or measures (Titus, 1992; Carter et al., 1994; Smith, 1996b; Fankhauser, 1996).

The evaluation framework was designed by the Intergovernmental Panel on Climate Change (Carter et al., 1994), along with others developed under its framework (Benioff et al., 1996; Carter, 1996; Smith, 1996b) suggested various methodologies for the evaluation of adaptation options in decision-making coping with climate change. These included benefit-cost analysis, cost effectiveness analysis, risk benefit analysis, multiple objective analyses, and multiple criteria evaluation. Benefit-cost analysis (BCA) focused on the economic benefits and costs of alternatives (Manning, 1987; Mitchell, 1997). Cost-effectiveness analysis (CEA) was considered to be an implicit benefit-cost analysis (BCA), as the primary goal was to determine a strategy to meet a pre-determined objective as inexpensively as possible (Toth, 2000), or to determine the least-cost measure for reaching a specified goal. CEAs focused on economic criteria (Smith et al. 1996). Meanwhile, multiple criteria evaluation (MCE) was designed to assess alternatives using more than one criterion (Hobbs et al., 1992; Munda et al., 1994; Smith, 1996b). In this study, multiple criteria evaluation (MCE) was selected for evaluation because assessment alternatives used more than one criterion, not only on principal economic factors.  MCE allowed consideration of both quantitative and qualitative data in the ranking of alternative options. Its approaches included identifying alternative options, select criteria, scores (weighted scales) options against criteria, assign weights to each criterion, calculate weighted sum and rank options (De Bruin et al., 2009).

There are various researches, providing the evaluative criteria for assessing adaptation options under different scales. In the level of the farm, *effectiveness* was often considered as a first step in the adaptation evaluation. Smith (1996b) illustrated the utility of identifying the effectiveness of various adaptation options in meeting specific objectives under alternative climate change scenarios. It refers to the ability of the adaptation option to reduce the income loss as a result of increases in frequency and magnitude of the temperature and rainfall changes. A very effective adaptation option will eliminate the risk of income loss, while an ineffective adaptation option will not greatly change this risk. Therefore, those options that eliminate the risk of income loss are more desirable and will receive a higher score than those that do not reduce risk. The evaluations can be converted to five categories of effectiveness (1 = very ineffective, 2 = ineffective, 3 = neutral, 4 = moderately effective, 5 = very effective). In order to illustrate the conversion from a monetary scale, ‘moderately effective’ could be defined where a measure averts between 20% and 50% of expected income loss, whereas 'very effective' averts greater than 50% of loss (Smith, 1996b).

*Economic efficiency* is also as an important criterion in the adaptation evaluation literature. It refers to the economic benefits of the adaptation relative to the economic costs of implementing the adaptation option. Economic efficiency is commonly measured as the ratio of benefits to costs. The value of this ratio can be used to establish levels of efficiency and represented in the Likert scale. For example, an adaptation option, which has a benefit-cost ratio greater than 1.5 may be designed as very economically efficient, ratios between 1.1 and 1.5 are moderately efficient, ratios between 1 and 0.9 are of neutral efficiency, ratios between 0.9 and 0.8 inefficient, and ratios less than 0.8 are very inefficient (1 = very inefficient, 2 = moderately inefficient, 3 = neutral, 4 = moderately efficient, 5 = very efficient) (Smith and Lenhart, 1996; Mizina et al., 1999).

Smith and Lenhart (1996) identified evaluative criteria, including *flexibility* in their evaluation of adaptation options for climate-sensitive sectors in Africa. Similarly, in their evaluation of agricultural adaptation options in Kazakhstan, Mizina et al., (1999) identified *flexibility* (options meet policy objectives under a wide range of climate change conditions) as one essential criterion in identifying anticipatory adaptation options. Flexibility refers to the ability of the adaptation option to function under a variety of climate change conditions. For example, a very flexible adaptation option will avert income loss, whether the frequency of drought increases by 0%, 5%, 20%, 50% or 100%, and whether there are changes in the magnitude, timing or duration of climate pressure, and perhaps associated heat stress or other related problems. An adaptation option that will only reduce income loss under a very particular set of climate conditions, and is ineffectual for other climate change conditions, is considered to be inflexible. Measurement of flexibility could be based on formal probability assessment, such as the ability to deal with specified drought frequency regimes, a decreasing trend in the annual amount of rainfall, a delay in the onset of rainy season and their associated risks. In this analysis, flexibility is measured directly on the five point Likert scale (1 = very inflexible, 2 = moderately inflexible, 3 = neutral, 4 = moderately flexible, 5 = very flexible).

Fankhauser and Tol (1997) and Smith and Lenhart (1996) agreed that prevailing uncertainties constrain the identification, assessment and implementation of adaptation options. The decision-making environment in agriculture was complex and the implementation of an adaptation option in an often highly specialized production system was not always straightforward and simple (Brklacich et al., 1997b; Smithers and Smit, 1997). An adaptation option can be implemented by a farmer given existing management, established practices, farmer values and resources. In this study, an adaptation option that has a high degree of understandability, observability and compatibility with operations is considered to have a high degree of *farmer implement-ability* which is considered as an indispensable criterion for adaptation evaluation (1 = very low implement-ability, 2 = moderately low implement-ability, 3 = neutral, 4 = moderate implement-ability, 5 = very high implement-ability). Those that have a high degree of complexity, and are not socially and culturally acceptable, and/or do not fit readily with established management practices, investment strategies or technology are considered to have very low farmer implement ability.

*Independent benefits* that refer to the ability of an adaptation option to generate benefits independent of climate change, is also an important evaluative criterion. The adaptation options that reduce the risk of income loss regardless of climate change are more desirable to farmers than the options that are helpful only in addressing climate change risks, or that require some kind of trade-off (1 = high tradeoffs, 2 = moderate tradeoffs, 3 = neutral, 4 = moderate independent benefits, 5 = high independent benefits) (Smith and Lenhart, 1996). An adaptation strategy is viewed more favorably, the greater the benefits it brings, quite apart from its contribution to reducing or avoiding risk associated with climate change. For example, soil conservation measures encourage soil moisture retention, therefore reducing vulnerability to drought conditions. However, soil conservation measures also reduce potential for wind and water erosion, promote in soil fertility, and may enhance carbon sequestration. These benefits, independent of reducing vulnerability to climate change, are considered positive features of adaptations (Smith and Lenhart, 1996).

After using five alternatives in order to evaluate the adaptation options, the study used the unity based normalization method (features scale) to make the categories of criteria to scale the range in [0, 1] for each adaptation option. The general formula (Arthanari and Dodge, 1993) was given as:

$$x' = \frac{x - \min(x)}{\max(x) - \min(x)}$$

Whereas, $x$ was an original value (the value which farmers responded the scale for each adaptation appropriately each criterion), $x'$ was the normalized value. Then, the study used the weight method (Rosemberg, 1992) to obtain the weighted scale for adaptation option in proportion to each criterion. The weighted scale for each adaptation was computed as:

$$W_j = \frac{\sum S_i}{\sum n_j}$$

Whereas, W is the weighted scale corresponding each adaptation; S is the value of five points which farmer i (1, n) responds for each adaptation in proportion to each criterion; n is the number of farmers who adjust to adaptation j.

The results of the evaluation are shown using the MCE aggregation method. A subsequent evaluative step can be undertaken where each selected criterion is explicitly assigned a weight according to its significance or importance relative to the other criteria. The assigning of weights to each criterion is a subjective exercise and can be completed in a variety of ways. It may be assigned by expert panels, public participation process, researchers or government decision makers (Maclaren, 1985). In this study, the weighted was assigned by individual farmers; they assigned their own weights, reflecting their personal values, goals and expectations. The study used Likert rating scale with 5 points as 1 = very low importance, 2 = low importance, 3 = medium, 4 = importance, 5 = very importance of representing the importance level of each criterion in adaptation evaluation. And the unity based normalization method was also used to assign the weight for each criterion under scale ranging in [0, 1].

The next step, the weighted scale of each adaptation was multiplied by the assigned criterion weight before the values are summed to establish a single evaluative measure for each adaptation option. The weighted sum (Marler and Arora, 2010) was given as:

$$F_j = \sum_{i=1}^{k} W_i \cdot W_j$$

With $F_j$ is the weighted sum of each adaptation, $W_i$ is the assigned weights of the criterion i, $W_j$ is weighted scale of adaptation j, k is the number of evaluative criteria.

Then, using the equal interval scale method (Steven, 1946) ranked the adaptation options in three different adaptation categories as high, medium and low:

$$IS = \frac{HV - LV}{N}$$

Whereas, IS is interval scale, HV is the highest value, LV is the lowest value and N is the number of classes.

After using the multiple criteria evaluation tool for adaptation evaluation, the ordered logit model is employed to analyze factors impacting on the farmers' choice of adaptation categories adopted to mitigate climate pressure effects in the study area. The dependent variable is ordinal adaptation categories as high = 2, moderate = 1 and low = 0 derived through the Multi-Criteria Evaluation tool with five criteria, including effectiveness, economic efficiency, flexible, farmer implement ability and independent benefit above.

An Ordinal logit model is built around a latent regression in the same manner as the binomial choice

$$\text{Let } y^* = \beta' X_i + \varepsilon$$

Where y* is the underlying latent variable that indexes the level of contributions of respondents to perceptual decision making, X is a vector of parameters to be estimated, ε is the error term.

The latent variable exhibits itself in ordinal categories, which could be coded as 0, 1, 2. And its framework can then be used to form a model as follows

$$\begin{aligned} Y &= 0, \text{ low adaptation if } y^* \le 0 \\ &= 1, \text{ moderate adaptation if } 0 < y^* \le \delta_1 \\ &= 2, \text{ high adaptation if } y^* > \delta_1 \end{aligned}$$

with the δ's being threshold parameter to be estimated with β (Green, 2000). $X_i$ represents a set of conditioning variables which are the household attributes like:

$X_1$: Age of head of household (years)

$X_2$ : Gender of head of household (1 for female, 0 for male)

$X_3$: Education level of head of household (years)

$X_4$ : Coffee cultivation experience (years)

$X_5$: Coffee cultivated size (ha)

$X_6$: Coffee growing income (1,000,000VND/year)

$X_7$: Non-coffee income (1,000,000VND/year)

$X_8$: Access to credit (1 for accessing, 0 for otherwise)

$X_9$: Access to climate information (1 for accessing, 0 for otherwise)

$X_{10}$: Access to extension service (1 for accessing, 0 for otherwise)

$X_{11}$: Irrigation option ( 1 for irrigation option, 0 for otherwise)

*Age:* Age can be a factor determining individuals' differences because age relates to past experiences which make them have wider maturity and thought. A person in different age would have different knowledge and capability as well as experience. The age is positive impact with choosing of adaptation options.

*Gender:* Male-headed households are more likely to get information about new technologies and undertake risky businesses than female-headed households (Asfaw and Admassie, 2004). Moreover, Tenge De Graffe and Heller (2004) argue that having a female head of household may have negative effects on the adoption of soil and water conservation measures, because women may have limited access to information, land, and other resources due to traditional social barriers. So the research also aims to explore the choosing of adaptation and gender relationship.



*Education:* Education is a basic factor leading to the individual's different perception and adaptation. Education helps people to increase their perception and understanding about climate variability and impacts as well as practicing adaptation approaches for their coffee farming. Higher level of education is believed to be associated with access to information on improved technologies and higher productivity (Norris and Batie, 1987). Evidence from various sources indicates that there is a positive relationship between the education level of the household head and the adoption of improved technologies (Igoden, Ohoji, and Ekpare, 1990) and adaptation to climate change (Maddison, 2006). Therefore, farmers with higher levels of education are more likely to adapt better to climate change.

*Coffee cultivation experience:* Experience is another factor directly affecting on adaptation. Experienced farmers have high skills in farming management techniques and are able to spread risk when facing climate variability. Majority of the respondents are matured and more experienced in farming, and assumed to have a better knowledge and information on changes in climatic conditions as reported by (Nhemachena and Hassan, 2007). There are a positive relationship between experience and choosing adaptation.

*Coffee farming size:* Farm size is always associated with greater wealth rather than capital and resources, the larger the farmer's farm size, the more likely the probability of adapting to climatic change in the study area.

*Coffee growing income and Non-coffee income:* Coffee and non-coffee income represent wealth. It is regularly hypothesized that the adoption of agricultural technologies requires sufficient financial wellbeing (Knowler and Bradshaw, 2007). Other studies that investigate the impact of income on adoption found a positive correlation (Franzel, 1999). Higher-income farmers may be less risk averse and have more access to information, a lower discount rate, and a longer-term planning horizon (CIMMYT, 1993).



*Access to credit:* Availability of credit eases the cash constraints and allows farmers to buy purchased inputs such as fertilizer, improved crop varieties, and irrigation facilities in order to reduce the negative impact of climate change. Research on adoption of agricultural technologies indicates that there is the positive relationship between the level of adoption and the availability of credit (Yirga, 2007; Pattanayak *et al*., 2003). *Access to climate information:* There is the same impact relationship as accessing to extension services. Accessing to climate information plays a vital role in improving the knowledge and awareness. If the farmers access to the information, they will perceive and have appropriate solutions for their farm under negative impacts of climate pressure.

*Access to extension services:* Having access to extension services increases the likelihood of using adaptation options mentioned above in the study area. This study is in line with various studies in developing countries that report a positive relationship between access to information and the adoption behavior of farmers (Yirga, 2007), and that access to information through extension increases the likelihood of adapting to climate change (Maddison, 2006; Nhemachena and Hassan, 2007).

*Irrigation option:* Under the change of temperature and rainfall, irrigated water is scarce and makes high pressure for the coffee farming. Households access to the irrigation system, they reduce risk and pressure for irrigating. Therefore, they have the capability to adapt negative impacts of climate change.

3) Gross margin analysis

And with the last objective, gross margin analysis will be used in order to determine the profitability of farmers who have the different level of adaptation option for climate pressure.

Gross margin for an item is the sales revenue obtained from the item sold, minus the direct costs of producing and selling the item. Therefore gross margin is a good indication of how profitable an enterprise is initially although, finally, fixed costs should be deducted.

The variable cost includes cost of inputs, cost of hired labor, cost of land preparation, cost of harvesting and transportation. Gross revenue is computed multiplying the price of a unit of output by the total amount of output. Family labor is computed as opportunity cost. Price is considered as the farm gate price.

In order to measure the profitability of coffee production in the study area, gross margin of farm households is calculated as follows:

$$GM = GR - TVC$$

$$GR = \sum_{i}^{n} Q_i P_i$$

$$TVC = \sum_{i}^{n} W_j X_j$$

Where,

GM is gross margin (1,000,000 VND/ha)

GR is gross revenue (1,000,000 VND/ha)

TVC is total variable cost (1,000,000 VND/ha)

Pi is the price of output (1,000,000 VND/ton)

Qi is the quantity of output (ton/ha)

Wj is the price of input variable j (1,000,000 VND)

Xj is the quantity of input variable j (kgs/package/bottle/litter)

i is 1,…, n (n: size of sample)

j is input variables

3.4.2. Data analysis

The data which was gathered from the survey will be processed and analyzed with the quantitative and qualitative analysis techniques. The Excel and Limdep 9.0 will be employed to analyze the data set in both standard descriptive statistic and econometric model.

In response to the first objective regarding the farmers' perception about climate pressure, the primary data and secondary data collected from household interviews using the questionnaire and institutional survey will be analyzed using Likert rating scale, descriptive statistics, frequency distributions, means and standard deviations, as well as Chi-square analysis.

In order to fulfill the second objective, the selected variables (demographic, socio-economic and biophysical data) will be analyzed using ordered logit model.

And to meet the last objective, the information about cost and revenue of coffee cultivation is used for calculating the coffee farmers' profit.

# CHAPTER 4

## Profile and Coffee Production of the Study Area

This chapter presents the issues of the climate conditions, overview processes for coffee farm practices in coffee production of Daklak province. In addition, the characteristics of climate, soil types, socioeconomic of the study site (Ea H'leo) are briefly described in order to figure out the advantage and disadvantage of the farms in coffee production.

### 4.1 Characteristics of Daklak province

4.1.1 Topography

Daklak, with the total area of about 19,830 square kilometers is located in Vietnam's Central highland. It is situated between 11˚30′ – 13˚25′ N Latitude and 107˚30′ – 109˚3′ E Longitude, adjacent to the North of Gia Lai province, the South of Lam Dong and Binh Duong provinces, the east of Khanh Hoa and Phu Yen provinces, and Cambodia to the West (Figure 4.1). Its relative flat terrain averages 600 meters above sea level. There are many mountain ranges and hills, concentrating in Daklak's northeast and southeast regions, of which the highest is Chu-Yang-Sin Mountain. The high mountains in the south and the southeast of the territory occupy about 35 percent of the natural area (Phong, 1998).

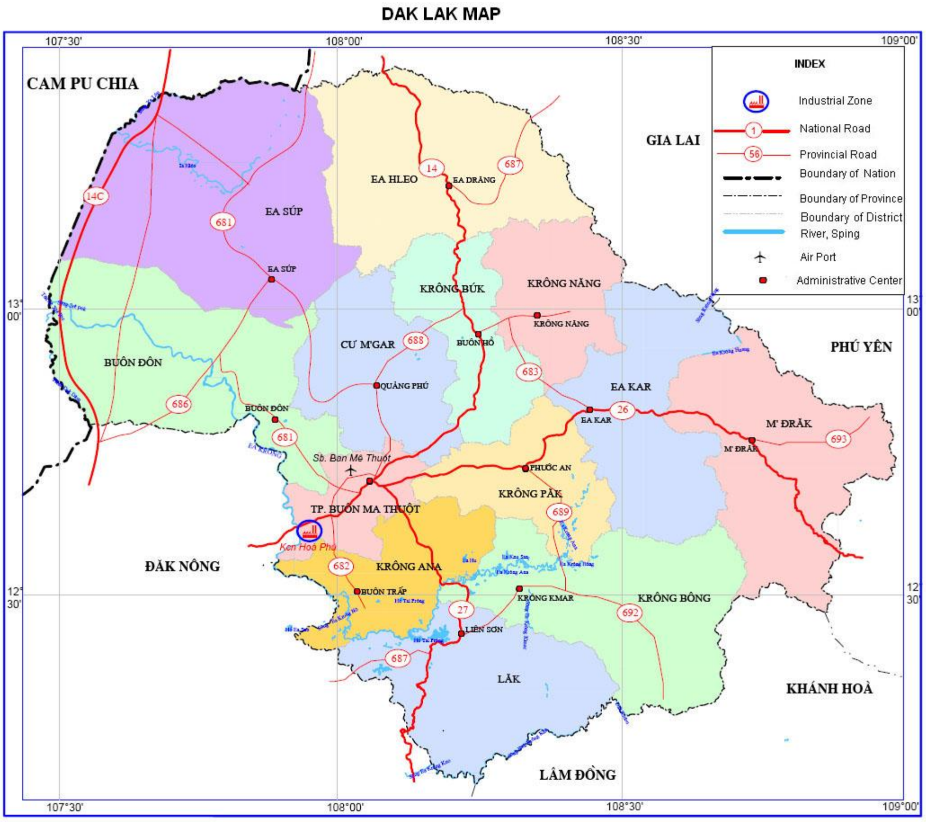



Figure 4.1 Daklak Map. Source: Phong, 1998

4.1.2 Soils

Soil of Daklak was classified into 8 groups: alluvial soils (Fluvisols), gley soils (Gleysols), peat soils (Histosols), black soils (Luvisols), red soils (Ferrasols), grey soils (Acrisols), alit humus soils (Alisols) on the high mountain and eroded soils (Leptosols). Of which basaltic soil (Rhodic Ferralsols) with an area of 713,508 hectares is suitable for planting perennial crops such as coffee, rubber, cashew, black pepper, fruit tree from different varieties (Tri, 1997).

The Plateau, on which Buon Ma Thuot, a capital of Daklak, and its surrounding areas, occupies 53.5 percent of the total area and has a mean evaluation of 450m above sea level. There are three main river systems: the Ba river that runs to the Eastern sea, the Serepoc river running up back to the Mekong River and the Dong Nai river in the southwest of Daklak. These rivers are the main sources to supply water for living and production in the whole province (Phong, 1998).

### 4.1.3 Coffee production in Daklak

1) Overview basis procedures of coffee cultivation in Daklak province

Figure 4.1 indicates the management practices of coffee production in Daklak. Irrigation, fertilization, pruning, weeding and maintaining basin, pest control, and harvesting are the chief works of the farm management practices in one year of production of coffee planting in Daklak.

*Watering:* Watering needs to be consistent with the climate condition. Depending on the specific climate condition of a certain year that irrigation starts early or later. But normally about 40-50 days after finishing harvest, the coffee is irrigated in order to break dormancy of flowers and induce blossom.

*Fertilization*: Coffee responds to nitrogen, phosphorus, potassium and minor elements in tropical settings. Most fertilizers are applied in rainy season, from May to October. However, many farms are fertilized two or three times in dry season simultaneously with irrigation in recent years.

*Pruning*: The main purposes of pruning are to control the tree not to be over bearing, to prevent alternate bearing, and to eliminate all disease infested and unproductive branches. By doing this can be carried out year-round, but mainly concentrated on two periods, after finishing harvest and at the beginning of rainy season.

*Weeding and maintaining soil erosion*: Coffee is very sensitive to competition from any kind of weeds, both in the wet and dry seasons, a huge reduction in yield can be expected free growing uncontrolled in the coffee farms. However, for coffee in productive stage of the province, weed is not a problem in coffee production because coffee coverage prevents weeds from growing. Now weeding activity is always combined with maintaining basin in each coffee hill to protect soil surface from erosion in the wet season.

*Pest and diseases control*: This stage requires the knowledge of the growers in identifying characteristic of each kind of pest or disease and level of damage to make a good decision for controlling. Year-round monitor of insect pest and disease levels on the farm is very important for better decision-making.

*Harvesting*: In the province, coffee harvest is obtained by hand picking the ripen-berries at intervals of several weeks, often this work starts in October and ends in December or early January. After collecting the berries, the berry coffee usually is processed by two common methods of dry or wet processing to become green beans for market.

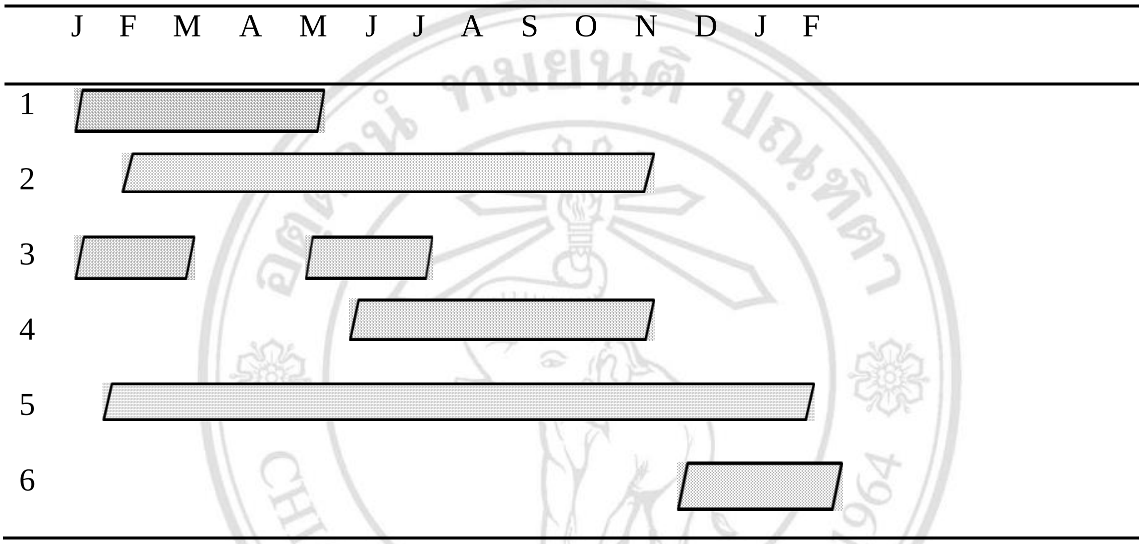



Figure 4.2 The management practices of coffee production in Daklak.
Notes: 1-Irrigating, 2-Fertilizing, 3-Pruning, 4-Weeding and maintaining basin, 5-Pests and diseases control, 6-Harvesting. Source: Survey, 2013

## 4.2 Description of the survey area

Ea H’leo District is one of 13 districts of Daklak Province. The district consists of Ea Drang town and ten communes with total area 1,330.73 square kilometers and population 106,185 (Ea H’leo Agricultural Department, 2013). Topography of the district is characterized by a relatively flat upland that is intersected by deep streams crossing the communes, and at some locations, it is hilly and rolling with relatively steep slopes. The area is covered with perennial crops like coffee, rubber, black pepper and annual crops such as rice, maize, soybean and groundnut. Of which, coffee is the main commercial crop and the main income source for the farmers here.

### 4.2.1 Climate of the survey area

The climate of the study site is characterized by a wet and a dry season. The wet season starts from May and ends in October. The annual average temperature changes from 22.68 to 23.10 degrees centigrade, the maximum temperature about 31.70 degrees centigrade. The annual average precipitation ranged from 989.90 to 3090.60 millimeters. The relative humidity ranged from 79 to 85 percent. More than 80 percent of the rainfall is concentrated between the month of August and September. In the dry season rainfall is usually very low; therefore, crop cultivation is not possible without irrigation. But the irrigation system is poorly developed and managed, which poses a problem both in dry and rainy season. The climatic condition in Ea H'leo is presented in table 4.1.

Table 4.1 The average meteorological data in Ea H'leo between 2001 and 2012

| Year | Mean temp. ($^0$C) | Precipitation (mm) | RH (%) |
|---|---|---|---|
| 2001 | 22.73 | 1690.4 | 81.75 |
| 2002 | 22.80 | 1201.0 | 80.42 |
| 2003 | 23.10 | 989.9 | 81.17 |
| 2004 | 22.98 | 1347.0 | 79.50 |
| 2005 | 22.81 | 1347.0 | 78.83 |
| 2006 | 22.68 | 1867.9 | 80.33 |
| 2007 | 22.79 | 1981.2 | 81.58 |
| 2008 | 22.86 | 1434.3 | 85.42 |
| 2009 | 22.95 | 3090.6 | 85.17 |
| 2010 | 23.05 | 2215.3 | 80.75 |
| 2011 | 23.09 | 2396.4 | 80.75 |
| 2012 | 23.08 | 2129.0 | 84.58 |

Note: Temp: Temperature, RH: Relative Humidity

Source: Ea H'leo Meteorological Station, 2013

4.2.2 Land use

The agricultural land occupied 79 percent of the total land area of Ea H'leo District. Land use for coffee cultivation is 31,147.5 ha. Forest is 1 percent but under afforestation, there is no natural forest in the study site. Special lands such as construction land, road land and burial land occupies about 10% (Figure 4.2). Total are of lakes, ponds, reservoirs and streams is 3%; these are vital source to supply water for irrigation. However, this system developed very poorly and insufficient water by drought in recent years.

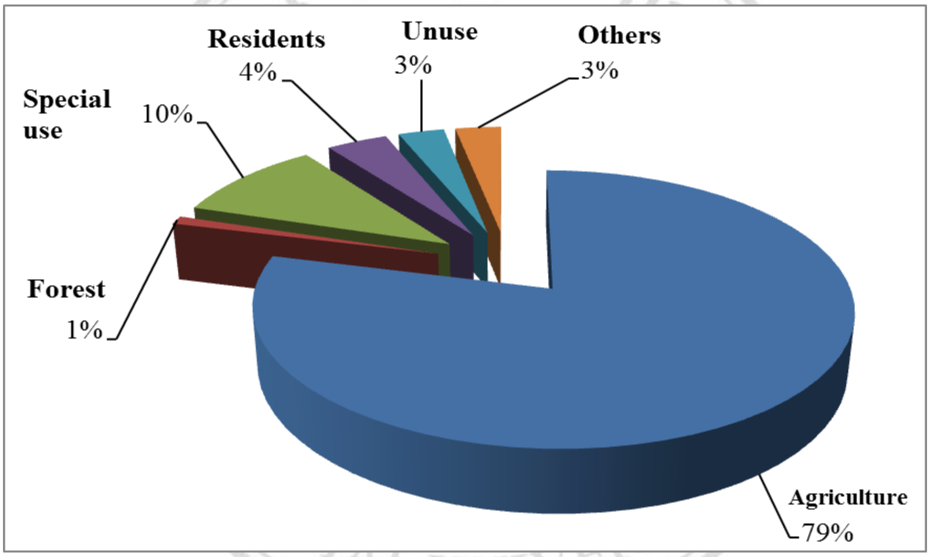



Figure 4.3 The status of land use in Ea H'leo district

Source: Ea H'leo Land Management Department, 2013.

4.2.3 Crop systems

Figure 4.3 shows that coffee is the dominant crop of cropping system of the village, with total area of 31,147.5 ha. In the past, designing coffee farm exposed under sun was a desire of coffee growers who thought that sun coffee farms produced higher yield and easier management than intercropping farms. However, in recent years, under climate pressure, price of other crops such as black pepper, rubber is increasing; some of farmers develop their coffee farms under intercropping coffee with other tree crops in order to reduce external and internal risks in production, to stabilize income.

Besides coffee, there were some other crops such as rubber, black pepper, and fruit tree planted in the study area, with the area of less than 2 percent for each crop. The food crops of lowland and upland rice, which occupied 8.23 percent, and gave average yield of 5.3 tons and 0.95 tons per hectare respectively.

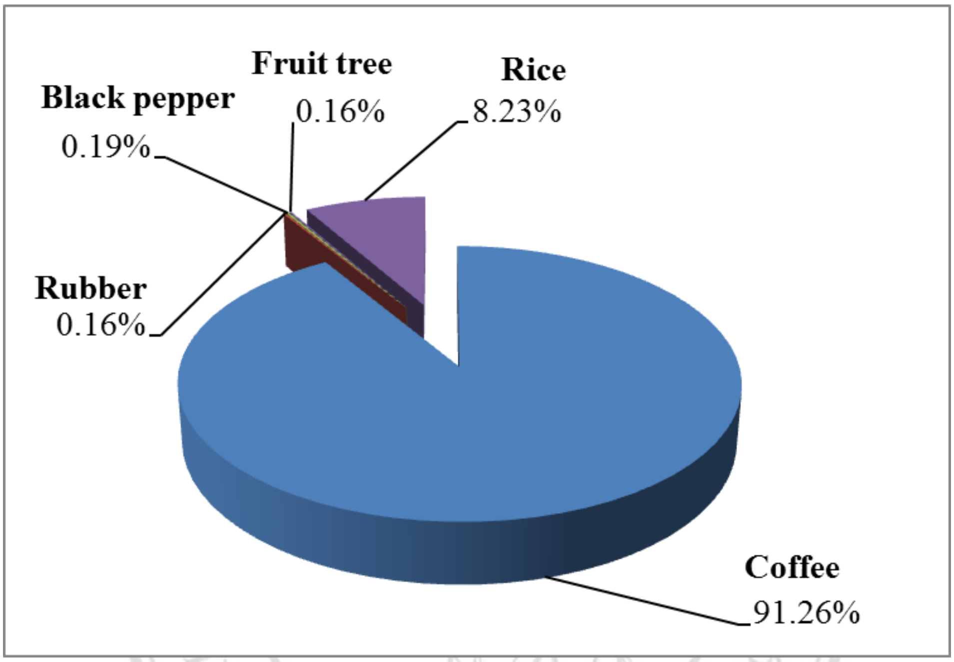



Figure 4.4 Cropping area in Ea H'leo

Source: Ea H'leo Land Management Department, 2013.

4.2.4 Respondents' distribution by socio-economic characteristics

The Table 4.2 showed that the coffee farming size ranged between four levels whereas ranking of 1 to 2.5 ha accounting the highest percentage around 71.02 percent. In this group, 31.82 percent farmers who had age ranged between 41 and 50 years old; farmers with the number of schooling years from 10 to 12 years occupied 28.41 percent; 43.18 percent informants who had experience in growing coffee from 11 to 20 years and 46.59 percent farmers gaining income between 101 and 250 million VND.

Table 4.2 The socio-economic characteristics of 176 households in Ea H'leo district, Daklak province

Unit: percentage

| Household characteristics | Coffee Farming Size (ha) | | | |
|---|---|---|---|---|
| | < 1 (22.73%) | 1 -> 2.5 (71.02%) | 2.51 -> 4 (5.11%) | > 4 (1.14%) |
| Age (years) | | | | |
| 24 -> 40 | 9.66 | 21.02 | 1.70 | 0.57 |
| 41 -> 50 | 6.82 | 31.82 | 2.27 | 0.00 |
| 51 -> 60 | 5.68 | 16.48 | 1.14 | 0.57 |
| > 60 | 0.57 | 1.70 | 0.00 | 0.00 |
| Gender | | | | |
| Female | 6.25 | 24.43 | 1.70 | 1.14 |
| Male | 16.48 | 52.27 | 3.41 | 0.00 |
| Education (years) | | | | |
| 1 -> 5 | 0.57 | 4.55 | 0.57 | 0.00 |
| 6 -> 9 | 18.18 | 5.44 | 1.14 | 0.00 |
| 10 -> 12 | 3.98 | 28.41 | 2.84 | 0.57 |
| > 12 | 0.00 | 1.70 | 0.57 | 0.57 |
| Coffee plantation experience (years) | | | | |
| ≤ 10 | 7.39 | 11.93 | 0.00 | 0.00 |
| 11 -> 20 | 8.52 | 43.18 | 2.84 | 1.14 |
| 21 -> 30 | 0.00 | 15.34 | 2.27 | 0.00 |
| > 30 | 6.82 | 0.57 | 0.00 | 0.00 |
| Income (1,000,000 VND) | | | | |
| 0 -> 100 | 13.07 | 6.82 | 0.00 | 0.00 |
| 101 -> 250 | 8.52 | 46.59 | 0.57 | 0.00 |
| 251 -> 350 | 0.00 | 18.75 | 1.14 | 0.00 |
| > 350 | 1.14 | 1.70 | 3.41 | 1.14 |

Source: Survey, 2013

# CHAPTER 5

## Farmer's Perception and Adaptation to Climate Pressure

The perception of farmers and adaptation options conduction were studied at Ea H'leo district, where coffee is the dominant crop that had remained a backbone of household's income. Chief outputs of this study were furnished with awareness of farmers about changing in temperature and precipitation, adaptation options were undertaken in their coffee farm to cope with climate pressure and assessment these adaptation strategies was conducted to obtain the objectives as well. This chapter also attempted to assess the yield and profitability of different adaptation groups.

### 5.1 Farmers' Perception of Climate Change

Among 176 farmers who were interviewed on the level of agreement about changing in temperature and rainfall at Ea H'leo district, there were 75 percent of respondents with the level of agree, 15.34 percent of strongly agree for changing in temperature and rainfall. Only 2.27 percent responding strongly disagree and undecided answering accounting 1.14 percent while 6.25 percent noted disagreement about these changes (Figure 5.1).

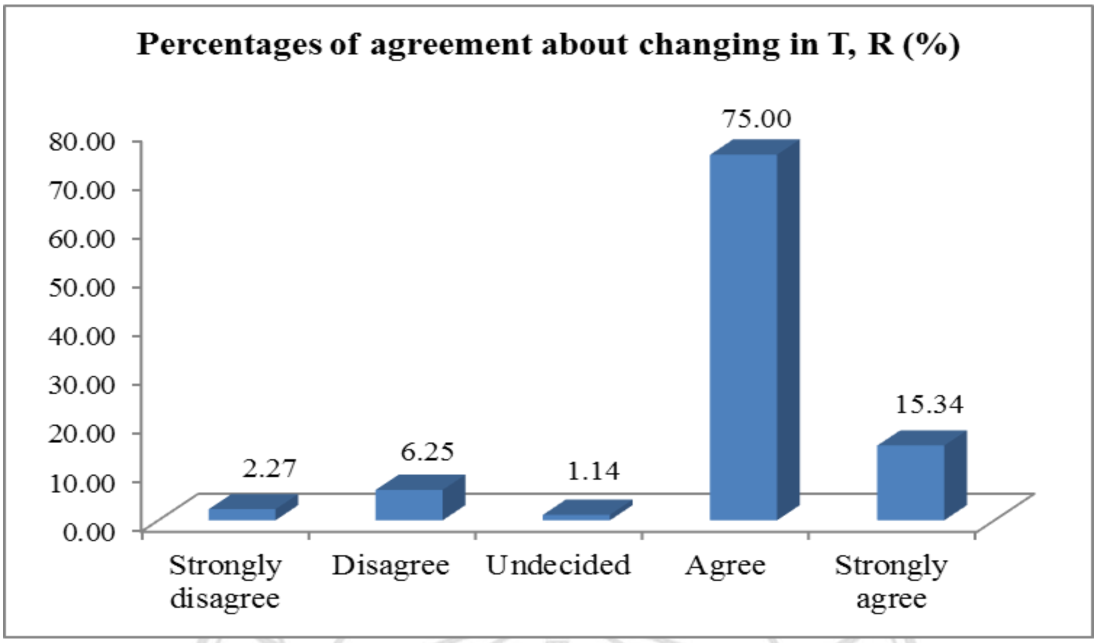



Figure 5.1 Level of agreement about changing in temperature (T) and rainfall (R)

Source: Survey data, 2013

Table 5.1 showed that 77.27% of the farmers perceived the temperature in the Ea H'leo District was on an increasing trend. Only 2.84% noticed the contrary, a decreasing in temperature and 1.7% of the farmers who deny answering the question. Meanwhile, the finding in Table 5.2 revealed that 66.48% of respondents observed a decreasing trend in the annual amount of rainfall; whereas 17.05% of the informants noted a change not in the total of the amount of rainfall but in the timing of the rainy season with a delay in the onset of rainy season.

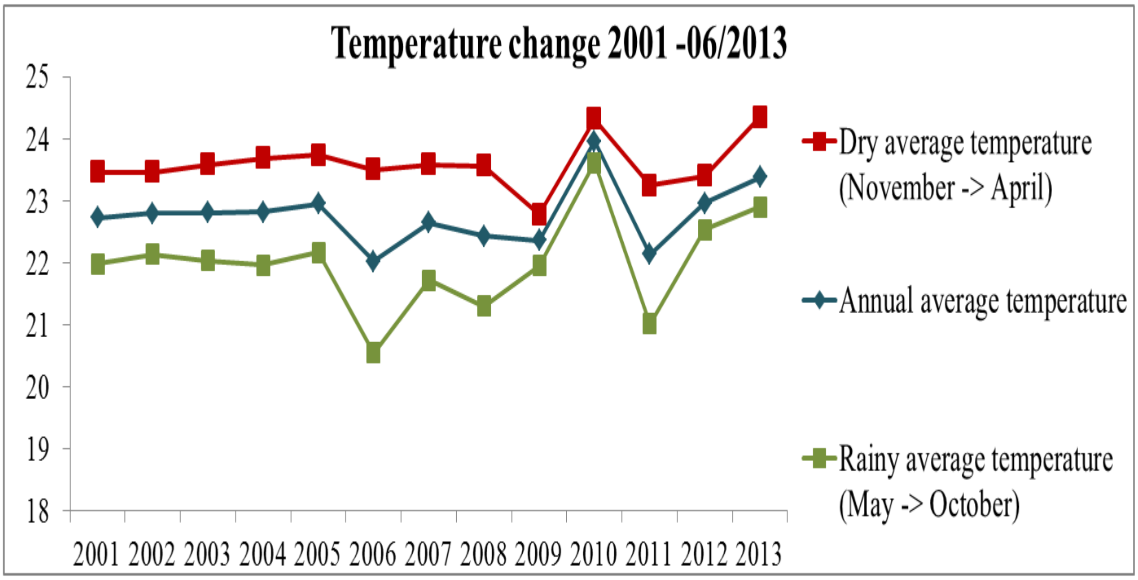
The results of Table 5.1, Table 5.2 also declared that the farmers, who had a high education level, growing coffee for several years, having access to more information about climate information and irrigation options, had a higher level of perception about the changing in temperature and rainfall. The perception of climate pressure was directly proportional to the age of the coffee growers. Among 176 interviewed farmers, there were 40.91% who had the age ranged between 41 and 50 years old. Through observing climate conditions by their experience and information from neighbors, radio and television, they perceived highly about changing of increased temperature and decreased rainfall respectively 32.39 and 27.27%.

Education level of farmers also played an important role in perceiving change of climatic conditions. The results indicated that there was a direct relationship between the number of schooling years and ability to know whether temperature and rainfall had changed or not. This implied that the farmers' perception of climate pressure increased with more education. There were 55.68 percent in total 176 coffee growers had the number of schooling year from 6 to 9 years, followed the 10 to 12 years group with 35.8 percent. They perceived climate situation during last ten years with trend of temperature had expanded and rainfall had decreased. Higher level of education associated with access to information and knowledge about climate variability. Most of coffee growers with over 12 schooling years responded temperature increasingly and declined rainfall.

In addition, the coffee cultivation experience affected the farmers' perception in changing of temperature and rainfall. The survey results distinguished the responses of coffee growers had 10 or less than years, between 11 and 20 years, between 21 and 30 years, and more 30 years of experience. It appeared that the more experience farmers had, the more likely they were to claim that the temperatures had increased and precipitation had declined. They perceived through observing and taking notice the amount and distribution of rainfall during the crop season, changing in the timing of the rains or increasing the number of times for irrigation and fertilizer application due to drought.

Moreover, the different forms of change for climate conditions were enhance when the coffee growers accessed to climate information and had irrigation option. The results exposed that these farmers perceived that temperature had increased and rainfall had dropped down respectively from 53.41 to 70.45 percent. Accessing to climate information and irrigation option implied that they had knowledge and understood clearly about climate variability. They watched television and listened to the radio in the morning and night time and transmitted from their friends and neighbors.

The statistical record data from Ea H'leo's Meteorological Station between 2001 and June 2013 (Figure 5.2) showed an increasing trend in temperature but a decreasing trend in precipitation during last ten years. Thus, farmer's perceptions appeared to be in accordance with the statistical record in the region.



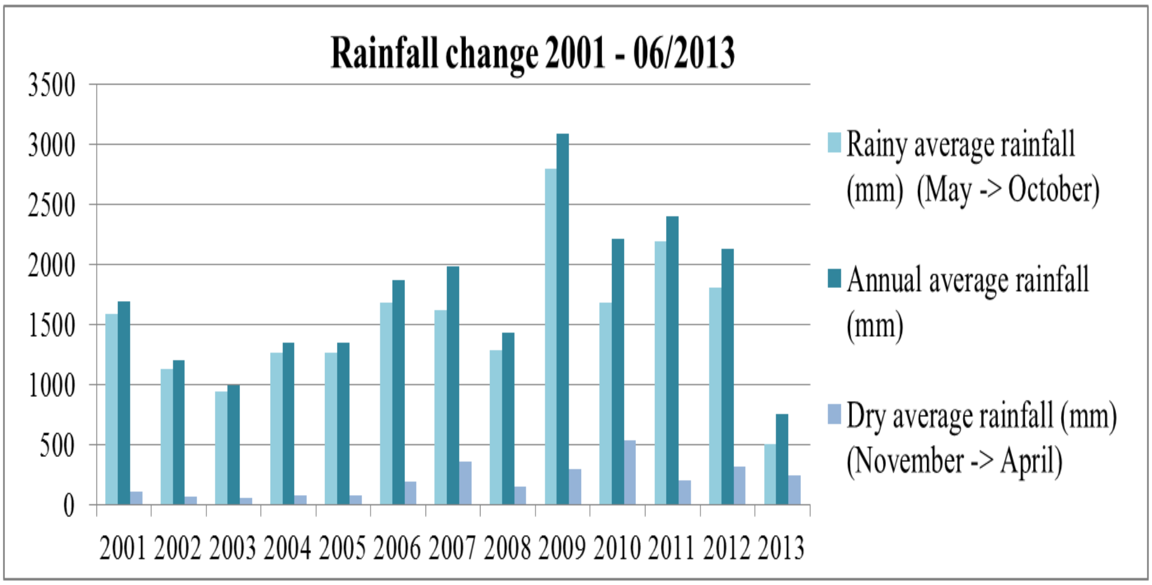




Figure 5.2 Trend of temperature, rainfall data for Ea'Hleo District 2001-6/2013

Source: Ea H'leo Meteorological Station, 2013

Table 5.1 Percentage of respondents' perception in temperature change

Unit: percentage

| Household characteristics | Do not know (1.7%) | Do not change (7.95%) | Altered temperature (10.23%) | Decreased (2.84%) | Increased (77.27%) |
|---|---|---|---|---|---|
| Age (years) | | | | | |
| 24 -> 40 | 1.14 | 2.84 | 3.41 | 0.57 | 24.43 |
| 41 -> 50 | 0.57 | 3.98 | 2.27 | 1.14 | 32.39 |
| 51 -> 60 | 0.00 | 0.57 | 3.98 | 0.00 | 19.32 |
| > 60 | 0.00 | 0.00 | 0.57 | 1.14 | 1.70 |
| Education (years) | | | | | |
| 1 -> 5 | 0.00 | 5.68 | 0.00 | 0.00 | 0.00 |
| 6 -> 9 | 1.70 | 1.70 | 7.95 | 2.27 | 41.48 |
| 10 -> 12 | 0.00 | 0.00 | 1.70 | 0.57 | 34.09 |
| > 12 | 0.00 | 0.00 | 0.57 | 0.00 | 2.27 |
| Coffee plantation experience (years) | | | | | |
| ≤ 10 | 1.70 | 1.70 | 3.98 | 0.00 | 5.68 |
| 11 -> 20 | 0.00 | 3.98 | 5.11 | 2.84 | 43.75 |
| 21 -> 30 | 0.00 | 1.14 | 1.14 | 0.00 | 28.41 |
| > 30 | 0.00 | 0.57 | 0.00 | 0.00 | 0.00 |
| Access to climate information | | | | | |
| Yes | 0.00 | 4.55 | 6.82 | 2.84 | 70.45 |
| No | 1.70 | 2.84 | 3.41 | 0.00 | 6.82 |
| Irrigation option | | | | | |
| Yes | 0.00 | 3.98 | 7.39 | 2.27 | 63.07 |
| No | 1.70 | 3.41 | 2.84 | 0.57 | 14.20 |

Source: Survey data, 2013

Table 5.2 Percentage of respondents' perception in rainfall change

Unit: percentage

| Household characteristics | Do not know (1.7%) | Do not change (7.39%) | Changing in the timing rain (17.05%) | Decreased (66.48%) | Increased (7.39%) |
|---|---|---|---|---|---|
| Age (years) | | | | | |
| 24 -> 40 | 1.14 | 2.84 | 5.68 | 19.89 | 2.84 |
| 41 -> 50 | 0.57 | 3.98 | 7.39 | 27.27 | 1.70 |
| 51 -> 60 | 0.00 | 0.57 | 3.98 | 17.05 | 2.27 |
| > 60 | 0.00 | 0.00 | 0.00 | 2.27 | 0.57 |
| Education (years) | | | | | |
| 1 -> 5 | 0.00 | 5.68 | 0.00 | 0.00 | 0.00 |
| 6 -> 9 | 1.70 | 1.70 | 11.36 | 36.93 | 3.98 |
| 10 -> 12 | 0.00 | 0.00 | 5.68 | 26.70 | 3.41 |
| > 12 | 0.00 | 0.00 | 0.00 | 2.84 | 0.00 |
| Coffee plantation experience (years) | | | | | |
| ≤ 10 | 1.70 | 1.70 | 3.98 | 9.66 | 2.27 |
| 11 -> 20 | 0.00 | 3.98 | 10.80 | 36.93 | 3.98 |
| 21 -> 30 | 0.00 | 1.14 | 2.27 | 19.89 | 1.14 |
| > 30 | 0.00 | 0.57 | 0.00 | 0.00 | 0.00 |
| Access to climate information | | | | | |
| Yes | 0.00 | 4.55 | 13.64 | 60.23 | 5.68 |
| No | 1.70 | 2.84 | 3.41 | 6.25 | 1.70 |
| Irrigation option | | | | | |
| Yes | 0.00 | 3.98 | 13.07 | 53.41 | 6.25 |
| No | 1.70 | 3.41 | 3.98 | 13.07 | 1.14 |

Source: Survey data, 2013

The chi-square analysis estimated the relationship between agreement levels perceiving about changing in temperature and rainfall and explanatory variables including the households' characteristics. The statistical results explored variables, including age, education, coffee growing experience, access to climate information, access to extension services and irrigation option having statistically significant impacts to farmers' perception about changing in temperature and rainfall at 1%, 5% level while gender, total income and access to credit are insignificant with effect relating to perceptions.

Table 5.3 Chi-square analysis with impacting of factors to farmers' perception for changing in temperature and rainfall

| Variables | Pearson Chi-Square | |
|---|---|---|
| | Value | Asymp. Sig. (2-sided) |
| Age of head of household | 98.13 | 0.015** |
| Gender of head of household | 3.47 | 0.176 |
| Education of head of household | 0.0013 | 0.000*** |
| Coffee Growing Experience | 0.0014 | 0.000*** |
| Coffee farming size | 50.61 | 0.801 |
| Total income | 0.0020 | 0.975 |
| Access to credit | 2.37 | 0.306 |
| Access to climate information | 23.042 | 0.000*** |
| Access to extension service | 6.97 | 0.031** |
| Irrigation option | 15.44 | 0.000*** |

Note: *, **, *** Statistically significant at 10%, 5%, 1%

Source: Survey data, 2013



The findings of cross tabulation explained the frequency of the significant variables about agreement levels, which involved in five scales such as A for strongly disagree, B for disagree, C for undecided, D for agree and E for strongly agree for changing in temperature and rainfall. Table 5.4 indicated that the farmer groups who had the age ranged from 24 to 40 and from 41 to 50 years old, had high frequency about agree and strongly agree scales for changing in temperature and rainfall. There were 49 and 14 respondents respectively answered in agree and strongly agree scale in the age group between 41 and 50 years old, took up 27.8 and 7.95 percent respectively. The coffee growers between 51 and 60 years and more than 60 years responded in the agree and strongly agree scale for climate variability. They observed that the temperature in the recent period of time was hotter, the frequency of drought more than the past and delay raining also. The elder people used their own knowledge on rainfall prediction which was evolved through observation and experience over a period of time. Their perception of climate by locally observed variables and experience using combinations of plant, animal, insects. They were more knowledgeable and able to give more information with its reliability rate (Okonya et al., 2013). They associated changes of climate conditions with failure and destruction of crops, property, declining with livestock and frequent famine.

Table 5.4 Agreement level about changing in temperature and rainfall with the age of household

| Age of head of household | Level of agreement | | | | | Total |
|---|---|---|---|---|---|---|
| | A | B | C | D | E | |
| 24 - 40 | 0 | 5 | 2 | 46 | 4 | 57 |
| 41 - 50 | 4 | 5 | 0 | 49 | 14 | 72 |
| 51 -60 | 0 | 1 | 0 | 32 | 9 | 42 |
| Above 60 | 0 | 0 | 0 | 5 | 0 | 5 |
| Total | 4 | 11 | 2 | 132 | 27 | 176 |

Note: A-strongly disagree; B-disagree; C-undecided; D-agree; E-strongly agree
Source: Survey data, 2013

The number of schooling years of coffee growers had the statistically significant effect to perceiving about changing in temperature and rainfall. The farmers who had the number of schooling years between 6 and 9 and from 9 to 12 years, comprised the high frequency about the agreement level of these changes. There were 22 farmers who accounted for 12.5 percent in the education group from 9 to 12 years, responded strongly agreement for changing in temperature and rainfall. The agree scale was with 41 respondents and constituted 23.3 percent while the education group from 6 to 9 years had 91 coffee growers with agree answer about climate change respectively 51.7 percent. The farmers with education more than 12 years perceived the climate change in the strongly agree scale. The higher education they obtained, the more they understood, updated climate information from their knowledge, mass information such as television, newsappers, radio or internet and their ability for awareness and accessing information comparing with lower education groups. They explained that the climate pressure due to the phenomenon of global warming, increasing of industrial regions and deforestation for agriculture production and accommodations.

Table 5.5 Agreement level about changing in temperature and rainfall with education level of head of household

| Education level of head of household | Level of agreement | | | | | Total |
|---|---|---|---|---|---|---|
| | A | B | C | D | E | |
| 1 - 5 | 2 | 8 | 0 | 0 | 0 | 10 |
| 6 - 9 | 2 | 3 | 2 | 91 | 0 | 98 |
| 9 - 12 | 0 | 0 | 0 | 41 | 22 | 63 |
| Above 12 | 0 | 0 | 0 | 0 | 5 | 5 |
| Total | 4 | 11 | 2 | 132 | 27 | 176 |

Note: A-strongly disagree; B-disagree; C-undecided; D-agree; E-strongly agree

Source: Survey data, 2013



Table 5.6 noticed that there were 76 farmers who responded about agree level for changing in temperature and precipitation, belonged to experience group ranged between 11 and 20 years. The experience group ranged from 21 to 30 years had 30 farmers with agree scale and 11 answers for strongly agree level. The coffee growers responded that the quality of the coffee was low owing to increasing temperature and water scarcity due to drought. They also reflected that, the raining was irregular. In the beginning of dry season, the drizzle rain happened, led to coffee’s flowers bloomed intermittently, rate of harvest was low. This affected coffee productivity and the processing of harvest then. The raining in this period impacted negatively to extending of the dry time, coffee beans were black that incorrect for quality standard and low price. Moreover, the average amount of rain changed, specially, from April and July coffee trees needed more water for meeting their growth and development; however, the coffee growers said that the recent years, in these months, the low amount of rain, the low frequency of rain resulted to the lack of water irrigation for coffee, coffee beans were dry, fell and declining the quality.

Table 5.6 Agreement level about changing in temperature and rainfall with coffee plantation experience of head of household

| Experience of head of household | Level of agreement | | | | | Total |
|---|---|---|---|---|---|---|
| | A | B | C | D | E | |
| Below or equal 10 | 2 | 3 | 2 | 26 | 1 | 34 |
| 11 - 20 | 2 | 5 | 0 | 76 | 15 | 98 |
| 21 - 30 | 0 | 2 | 0 | 30 | 11 | 43 |
| Above 30 | 0 | 1 | 0 | 0 | 0 | 1 |
| Total | 4 | 11 | 2 | 132 | 27 | 176 |

Note: A-strongly disagree; B-disagree; C-undecided; D-agree; E-strongly agree

Source: Survey data, 2013

The accessing to climate information had a significant impact to perception about changing in temperature and rainfall. The coffee growers who accessed to climate information, responded about agreement in those changes by agree and strongly agree scale respectively 114 and 26 farmers. They perceived climate variability by listening to the radio, watching television and access information from their relatives, friends and neighbors. Klein (1999) also emphasized that the more detailed, accurate and relevant to the individual the climate change information was, the higher perception and the more effective the adaptation strategies undertaken would be. Accessing appropriate and adequate information was critical in the process of perceiving and enhancing the adaptive capacities of the coffee farmers to the impact of climate pressure. The sources of information such as radio, television, internet, neighbors and family members were major sources in disseminating information to farmers on responding to weather events and seasonal climate conditions in the study region.

Table 5.7 Agreement level about changing in temperature and rainfall with the accessing to climate information

| Access to climate information | Level of agreement | | | | | Total |
|---|---|---|---|---|---|---|
| | A | B | C | D | E | |
| No | 2 | 5 | 2 | 18 | 1 | 28 |
| Yes | 2 | 6 | 0 | 114 | 26 | 148 |
| Total | 4 | 11 | 2 | 132 | 27 | 176 |

Note: A-strongly disagree; B-disagree; C-undecided; D-agree; E-strongly agree

Source: Survey data, 2013

Table 5.8 expressed that the farmers who accessed to extension services occupied the frequency higher than otherwise group for strongly agree level about changing in temperature and rainfall respectively 20 farmers, made up 11.36 percent. However, the coffee growers responded that they were trained and attended the training or extension programs, oftenly focusing on the way to apply fertilizer rather than climate information. And through the number of times of training, during field days and training they updated and discussed also climate information from their friends, neighbors. Agricultural extension influenced the behaviour of farmers through education and information exchange (Okonya et al., 2013). There was no accessing to extension services because extension services were located far from the locations of the farmers. Therefore, extension officers did not usually visit these farmers as well as may lack adequate mobility to reach these farmers.



Table 5.8 Agreement level about changing in temperature and rainfall with the accessing to extension service

| Access to extension service | Level of agreement | | | | | Total |
|---|---|---|---|---|---|---|
| | A | B | C | D | E | |
| No | 4 | 9 | 2 | 81 | 7 | 103 |
| Yes | 0 | 2 | 0 | 51 | 20 | 73 |
| Total | 4 | 11 | 2 | 132 | 27 | 176 |

Note: A-strongly disagree; B-disagree; C-undecided; D-agree; E-strongly agree

Source: Survey data, 2013

The result of Table 5.9 denoted that the farmers who had irrigation option, responded highly about agree scale for climate change. There were 101 in the total of 176 respondents answered with agree level and strongly agree level with 27 farmers perceived about changing in temperature and rainfall. They responded about those variations hinged on the number of times for irrigation increased, digging more wells for meeting the irrigation demand owing to drought. They noticed that the water supply from the dam in the region became decreasingly and water shortage. In order to meet the demand for irrigation, they focused on the groundwater, however the level of groundwater reduced through observing it took them more time for pumping. The coffee growers expressed that with the normal climate conditions, it took 2–3 times for irrigation in each season. However, the consecutive dry recent years they spent 4-5 times for irrigation and the level of water in the streams and ponds also decreased about 1 meter comparing with the past. Glwadys (2009) concluded that having access to water for irrigation increases the resilience of farmers to climate variability. The Agricultural Department in Ea H'leo District also mentioned that there were about 39 irrigation works with water availability about 6 million $m^3$ in the region. But they only met water demand for around 3,400 hectare of whole of crop system in the study area. It was synonymous with 32,000 hectare coffee in the total of the area were facing on the high pressure for water irrigation.

Table 5.9 Agreement level about changing in temperature and rainfall with irrigation option

| Irrigation option | Level of agreement | | | | | Total |
|---|---|---|---|---|---|---|
| | A | B | C | D | E | |
| No | 4 | 4 | 2 | 31 | 0 | 41 |
| Yes | 0 | 7 | 0 | 101 | 27 | 135 |
| Total | 4 | 11 | 2 | 132 | 27 | 176 |

Note: A-strongly disagree; B-disagree; C-undecided; D-agree; E-strongly agree

Source: Survey data, 2013



The coffee farmers' ability to perceive climate pressure was a key precondition for their choice to acclimatization. The accuracy of their perceptions of climate pressure was assessed by comparing their perception of the long term variations in the temperature and rainfall with trends recorded at nearby meteorological stations. And the results revealed that the coffee growers' perception was in line with the climate recorded data.

## 5.2 Farmers' Adaptation of Change in Climate

Adaptation to changes of temperature and rainfall was a two-stage process, which initially required the perception that climate was changing and then responding to changes through adaptation strategies. Therefore, after understanding and assessing the coffee growers' perception and awareness of climate pressure, this section attempted to vividly depict the farmers' adaptation measures in order to cope with the adverse impact of climate pressure. The adaptation strategies were measured and evaluated by a three-point scale through the multiple criteria evaluation tool. The dependent variable was ordered and categorical. The study estimated the effect of the determining factors on the different adaptation levels by an ordered-logit model, with various possible explanatory variables related to socio-economic characteristics of coffee households.

### 5.2.1 Multiple Criteria Evaluation of Adaptation Options

1) Assigning Weights to Evaluative Criteria

With a five-point scales of evaluative criteria (1 = very low importance, 2 = low importance, 3 = medium, 4 = importance, 5 = very importance), the finding of interviewing 176 farmers about their response for the importance level of each criterion in adaptation evaluation indicated that most of farmers answered the importance level of evaluative criteria from medium to very high. There were around 73.9% and 97.1% farmers who responded the effectiveness, economic efficiency was very importance level (5) respectively (Table 5.10). The remaining percentage responded in the importance level (4). Meanwhile, the flexible and independent benefits were evaluated at medium importance level (3) with 68% proportionally; 32% responded were important (4) for two of these criteria. In terms of implement-ability, there were 56.3% farmers presented that it was considered as an important indicator (4) and the medium level (3) took up about 43.7%.

Table 5.10 The percentage of evaluation about the important level of criteria

| Criteria | The percent of 176 households about important levels | | | | |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 |
| Economic efficiency | - | - | - | 2.9 | 97.1 |
| Effectiveness | - | - | - | 16.1 | 73.9 |
| Implement-ability | - | - | 43.7 | 56.3 | - |
| Flexibility | - | - | 68.0 | 32.0 | - |
| Independent benefits | - | - | 68.0 | 32.0 | - |

Note: 1 – very low important; 2 – low important; 3 – medium; 4 – important; 5 – very important. Source: survey, 2013.

Hinging on the farmers' responses under five scales in proportion to each criterion, the study used the unity based normalization method to rescale into the range in [0, 1]. After calculating the weight of the scales, the result was represented in Table 5.10. The result exposed that amongst five criteria, the economic efficiency was assessed very importance with the highest weight 0.98, following the effectiveness criterion with 0.95. This was also synonymous with the importance level of these two criteria were nearly equal, played an essential role for adaptation evaluation and the farmers also mentioned more to capacity of reducing income loss of adaptation options. The weight of the farmer implement-ability alternative was the third ranking with 0.64 while the flexibility and independent benefits criteria were assigned the equal weight 0.58 respectively.



Table 5.11 Criterion Weighting

| Criterion | Weight |
|---|---|
| Economic efficiency | 0.98 |
| Effectiveness | 0.95 |
| Farmer Implement-ability | 0.64 |
| Flexibility | 0.58 |
| Independent benefits | 0.58 |

Source: survey, 2013

2) Assigning Weights to Evaluation of Adaptation Options

Facing on changes in temperature and rainfall, the coffee growers selected the adaptation options (Table 5.12) for their farm in order to cope with climate pressure. In the total 176 farmers, there were 101 farmers adjusted to one adaptation option; 54 respondents adapted to two options and 21 remaining farmers acclimatized to three options. The major adaptation options were selected for their coffee farms included the crop diversification, irrigation techniques and soil conservation.

Table 5.12 The Adaptation Options in Proportion to Number of Farmers

| Adaptation | A | B | C | AB | AC | BC | ABC | Total |
|---|---|---|---|---|---|---|---|---|
| Number of farmers | 30 | 40 | 31 | 15 | 15 | 24 | 21 | 176 |

Note: A – Crop diversification, B - Irrigation techniques, C – Soil conservation, AB – Crop diversification and irrigation techniques, AC – Crop diversification and soil conservation, BC – Irrigation techniques and soil conservation, ABC – Crop diversification, irrigation techniques and soil conservation. Source: survey data, 2013

❖ *Crop diversification*

Since 2006, most of the coffee growers have been faced with the simultaneous risks of drought, abnormal rainfall and pest and disease outbreak coupled with the falling coffee price in the world market. They developed their coffee farms under the intercropping coffee with other crops such as fruit trees with durian, banana, mango, avocado, soursop, rambutan; black pepper or shading trees to reduce the external and internal risks in production and stabilizing income. However, the size of intercropping currently was not large enough to make significant contributions to farmers' income compared with the dominant coffee tree. These crops planted as the boundary in the coffee garden for windbreak purpose, planted at uproot coffee areas with low yield, pests and diseases destroyed and home consumption.

There were 59.3% and 34.6% farmers who adapted to crop diversification, asserted that crop diversification adaptation had the moderately effectiveness (4) and neutral (3) scales respectively (Table 5.13). By contrast, 6.1% farmers responded that it was a moderately ineffective (2) option because of the capital and knowledge requirements in investing and controlling diseases for other crops, especially black pepper. The neutral and moderately effectiveness evaluation were explained that crop diversification reduced the risk of income loss as a result of climate conditions, but was not considered highly effective because changes in temperature and aberrant rainfall still impacted on some crop varieties, likely leading to some income loss. In addition, some farmers claimed that plantation shading trees with inappropriate density and techniques in the coffee gardens could obstruct the coffee's photosynthesis resulting in the adverse quality of coffee.

In terms of economic efficiency, crop diversification was moderately effective (4) by 59.3% and neutral (3) with 29.6% of respondents as the benefits of reduced income loss were expected to exceed the costs of implementation when the pressure of climate conditions took in place in recent years. They claimed that there were some additional costs expected with growing a wider variety of crops, including the possible additional farm equipment for planting, harvesting, storing, labor costs or disease control which, were dependent on the nature of the change in cropping practices. There were 11.1% responded that it was a moderately ineffective (2) adaptation.

However, it was considered as a very flexible (5) adaptation option with 8.6% and 80.2% with moderately flexible (4) by giving its potential for yield production under a variety of climate conditions. 11.1% respondents answered with neutral (3). There were 59.3% of farmers answered that this adaptation had moderate implement-ability (4). About 40.7% responded that it had neither high nor low farmer implement-ability (3) given current social and cultural norms. They were discouraged by the potential complexity of the practice, the need to change established practices, attitudes and behaviour and additional equipment or contracting, the potential demands on time, knowledge, resources for production and marketing. Moreover, crop diversification as an adaptation was difficult to implement for some farmers who lacked training, skills or investment.

In independent benefits dimension, 86.4% of farmers responded that crop diversification had moderately independent benefits (4) and 13.6% with neutral (3) because in addition to reducing the risks associated with changing temperature and rainfall, it reduced risks associated with improvement in soil fertility and reductions in pesticide use through improvements in natural pest resistance.

Table 5.13 The percentage of evaluation level for crop diversification adaptation

| Crop diversification | The percentages of evaluation level | | | | |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 |
| Economic efficiency | - | 11.1 | 29.6 | 59.3 | - |
| Effectiveness | - | 6.1 | 34.6 | 59.3 | - |
| Implement-ability | - | - | 40.7 | 59.3 | - |
| Flexibility | - | - | 11.1 | 80.2 | 8.6 |
| Independent benefits | - | - | 13.6 | 86.4 | - |

Note: 1 – Very ineffective; 2 – Ineffective; 3 – Neutral; 4 – Moderately effective; 5 – Very effective. Source: survey data, 2013

❖ *Irrigation techniques*

The irrigation technique which farmers applied included the basal technique, sprinklers system from up to down and water saving irrigation. The coffee farmers claimed that, the implementation of irrigation was a predominant adaptation option for the purpose of improving productivity and reducing risk of income loss, due to recurring drought and rainfall delay. There were 44% farmers asserted that implementation of irrigation was a very effective (5) adaptation option and moderately effective (4) comprised 54% (Table 5.14). It allowed for the artificial application of moisture during times of stress, maintained and enhanced crop yields relative to climate conditions. The irrigation application helped to meet water demand, improve quality and enhance the coffee yield. Only 2% of farmers responded with moderately ineffective (2) because of unavailability water.

Under economic efficiency aspect, irrigation technique needed more investment cost such as the purchase of irrigation equipment and on-farm distribution infrastructure, while other costs associated with pumping and water allocation volumes would be incurred, they also contributed in proportion of the total costs of irrigation implementation. Thus, irrigation implementation was considered to be very effective (5) with 25%, moderately economically efficient (4) with 73% and 2% responding moderately ineffective (2).

Implementation of irrigated agriculture for coffee was considered moderately flexible (4) accounted for 79%. When water was available for irrigation, the adaptation was considered under flexible a variety of moisture constraints over a five-year period. However, given the uncertainties in predicting local and regional changes in precipitation, evaporation and the amount of available soil moisture, implementation of an irrigation system was moderately inflexible (2) adaptation strategy with 21% due to repercussions of water availability and access to irrigation practices.

In terms of farmer implement-ability of irrigation technique adaptation, there were 17% of farmers implied very implement-ability (5), moderately implement-ability (4) with 50% and neutral (3) took up 33%. Application irrigation technique for their farm required substantial investment in time to learn new skills related to irrigation management given the specific soil and land characteristics of the farm property, the nature of the crop types intended to be irrigated, fertilizer application techniques and credit capacity as well. On the other hand, irrigation as an adaptation need little additional learning and effort, especially if farmers had irrigated in the past such as other farm properties and adjacent fields.

Implementation of irrigation had high independent benefits (5) with responses comprising 77%. The remained 23% presented with moderately independent benefits (4). Irrigation enhanced the productivity of many crops irrespective of climate pressure and increases the moisture of soils.

Table 5.14 The percentage of evaluation level for irrigation technique adaptation

| Irrigation technique | The percentages of evaluation level | | | | |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 |
| Economic efficiency | - | 2 | - | 73 | 25 |
| Effectiveness | - | 2 | - | 54 | 44 |
| Implement-ability | - | 33 | - | 50 | 17 |
| Flexibility | - | 21 | - | 79 | - |
| Independent benefits | - | - | - | 23 | 77 |

Note: 1 – Very ineffective; 2 – Ineffective; 3 – Neutral; 4 – Moderately effective; 5 – Very effective. Source: survey data, 2013

❖ *Soil conservation*

Overuse of chemicals, groundwater level decrease and increase in evapotranspiration would magnify the vulnerability of coffee plantations to climate pressure. Thus, approaches to enhance the resilience of soils such as organic fertilization, planting trees and bushes or legumes that helped to prevent from soil erosion, enhancement of water storage capacity of the soils should be identified and implemented early enough to avoid serious damages and yield loss. The survey result indicated that there were 91 farmers adopted soil conservation for dealing with climate pressure.

Under effectiveness dimension, 49.5% of farmers considered soil conservation as a moderately effective adaptation (4) and neutral (3) with 50.5% (Table 5.15). They explained that it promoted in soil fertility, enhanced carbon sequestration, reduced potential for wind and water erosion. This also helped to improve the yield of coffee. However, lack of knowledge and appropriate technique in fertilizer application caused the adverse effects on soil fertility and quality of coffee.

Soil conservation provided and maintained an optimum condition of the root-zone to maximum possible depth for coffee roots to function more effectively and without hindrance by capturing high amounts of desired plant nutrients and water passes down to the groundwater and stream flow, not over the surface as runoff. There were 49.5% respondents claimed moderately effective (4) for term of economic efficiency and

43.9% answered in neutral scale (3). Soil conservation enhanced soil fertility leading to improve and increase coffee yield. But this also spent more cost for kind of fertilizer, which had high quality and more labor cost as well. Only 6.6% noted in moderate ineffective (2) scale. They mentioned enhancement coffee productivity and soil moistures thank to irrigation techniques rather than soil conservation.

Dimension of flexibility and implement-ability was evaluated moderate level (4) comprised 49% respectively. The remaining percent responded with neutral (3). Meanwhile, 58% farmers considered this adaptation had moderately independent benefits (4) and neutral (3) constituted 42%.

Table 5.15 The percentage of evaluation level for soil conservation adaptation

| Soil conservation | The percentages of evaluation level | | | | |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 |
| Economic efficiency | - | 6.6 | 43.9 | 49.5 | - |
| Effectiveness | - | - | 50.5 | 49.5 | - |
| Implement-ability | - | - | 51.0 | 49.0 | - |
| Flexibility | - | - | 51.0 | 49.0 | - |
| Independent benefits | - | - | 42.0 | 58.0 | - |

Note: 1 – Very ineffective; 2 – Ineffective; 3 – Neutral; 4 – Moderately effective; 5 – Very effective. Source: survey data, 2013

From the survey results about farmers' different scales for each adaptation under various criteria, the study used the unity based normalization tool in order to normalize the original values into the range in [0, 1]. The scales for the groups who adapted to two and three adaptation options were defined by calculating the average values of scales that they answered for each adaptation. The weight method was also employed to compute the weighted scale for each adaptation option. The result of Table 5.16 presented how each adaptation performed for each criterion. The finding deposed that the crop diversification adaptation had high weight on flexibility. Facing on the high frequency of drought and changes in rainfall pattern, to reduce the risk of climate pressure and enhance the resilience of their agriculture production system, the farmers adapted crop diversification by planting more other crops included durian, banana, avocado, cashew, rubber and black pepper in their coffee farm with purposes of reducing income loss. Implementation of irrigation techniques adaptation was evaluated high weight scale on effectiveness, economic efficiency and independent benefits. Meanwhile, the weight of scales of economic efficiency, flexibility and implement-ability for soil conservation adaptation were the same. The weighted scale of effectiveness and economic efficiency of the groups who adjusted to crop diversification and irrigation techniques, irrigation techniques and soil conservation and three of the options were higher than the group of both crop diversification and soil conservation. In addition, the adaptation groups which involved in the irrigation technique were evaluated strongly in all of the criteria. This expressed that the irrigation technique adaptation played an essential role in coffee production and appropriately responded to pressure of temperature and rainfall changes.

Table 5.16 Criteria Weighted Scale and Selected Farmer Adaptations

| Criterion | Reduce risk of losses due to climate pressure | | | | | | |
|---|---|---|---|---|---|---|---|
| | A | B | C | AB | AC | BC | ABC |
| Effectiveness | 0.65 | 0.95 | 0.6.0 | 0.86 | 0.59 | 0.8.0 | 0.83 |
| Economic efficiency | 0.71 | 0.94 | 0.56 | 0.86 | 0.62 | 0.75 | 0.74 |
| Flexibility | 0.96 | 0.71 | 0.56 | 0.84 | 0.65 | 0.64 | 0.74 |
| Implement-ability | 0.73 | 0.62 | 0.56 | 0.75 | 0.63 | 0.59 | 0.64 |
| Independent benefits | 0.73 | 0.92 | 0.6.0 | 0.83 | 0.68 | 0.76 | 0.75 |

Note: A - Crop diversification, B - Irrigation techniques, C - Soil conservation, AB – Crop diversification and irrigation techniques, AC – Crop diversification and soil conservation, BC – Irrigation techniques and soil conservation, ABC – Crop diversification, irrigation techniques and soil conservation. Source: survey data, 2013.

Using the weighted sums method, the rank of the adaptation options was presented in Table 5.17. Two criteria related to effectiveness and economic efficiency had high weight in adaptation evaluation. The different weights evaluated the relative overall merit of adaptation options. The finding indicated that the groups who adapted to irrigation techniques, crop diversification and irrigation techniques had the highest sum of weight while the adaptation groups of soil conservation, crop diversification and soil conservation had the lowest weight.

Table 5.17 Sum of Weighted Scale of Adaptation Evaluation

| Criterion | Reduce risk of losses due to climate pressure | | | | | | |
|---|---|---|---|---|---|---|---|
| | A | B | C | AB | AC | BC | ABC |
| Effectiveness | 0.62 | 0.90 | 0.57 | 0.82 | 0.56 | 0.76 | 0.79 |
| Economic efficiency | 0.70 | 0.92 | 0.55 | 0.84 | 0.61 | 0.74 | 0.73 |
| Flexibility | 0.56 | 0.41 | 0.32 | 0.49 | 0.38 | 0.37 | 0.43 |
| Implement-ability | 0.47 | 0.40 | 0.36 | 0.48 | 0.40 | 0.38 | 0.41 |
| Independent benefits | 0.42 | 0.53 | 0.35 | 0.48 | 0.39 | 0.44 | 0.44 |
| Sum | 2.76 | 3.17 | 2.15 | 3.11 | 2.34 | 2.68 | 2.79 |

Note: A - Crop diversification, B - Irrigation techniques, C - Soil conservation, AB – Crop diversification and irrigation techniques, AC – Crop diversification and soil conservation, BC – Irrigation techniques and soil conservation, ABC – Crop diversification, irrigation techniques and soil conservation. Source: survey data, 2013

3) Ordering the adaptation level

From the result of Table 5.17, using the equal interval scale method defined the ordinal three categories of adaptation options (Table 5.18).

$$\text{Interval scale} = \frac{3.17 - 2.15}{3} = 0.34$$



Table 5.14 result revealed that in the total of 176 coffee farmers, the low adaptation level, which had the weighted sum from 2.15 to 2.49, constituted 26.14%. The weighted sum which ranged between 2.50 and 2.84 was considered as the medium adaptation group comprised 42.61% while the high adaptation was evaluated with equal or over 2.85 of weighted sum and took up 31.25%.

Table 5.18 Level of Adaptation Options

| Level of adaptation | The weighted sum |
|---|---|
| Low (26.14%) | 2.15 – 2.49 |
| Medium (42.61%) | 2.50 – 2.84 |
| High (31.25%) | ≥ 2.85 |

Source: survey data, 2013

Even though a large number of farmers interviewed noticed changes in temperature and rainfall and selected the adaptation options for their farm, the coffee growers have still faced to difficulties in practicing the adaptations. More than 80 percent of farmers cited lack of access to credit for undertaking the remedial actions. Around 35.80 percentage of farmers designed lack of knowledge of appropriate adaptation measures as barriers to adaptations. There were 28.41 percent of respondents also cited a shortage of labor in adaptation undertake (Figure 5.3)

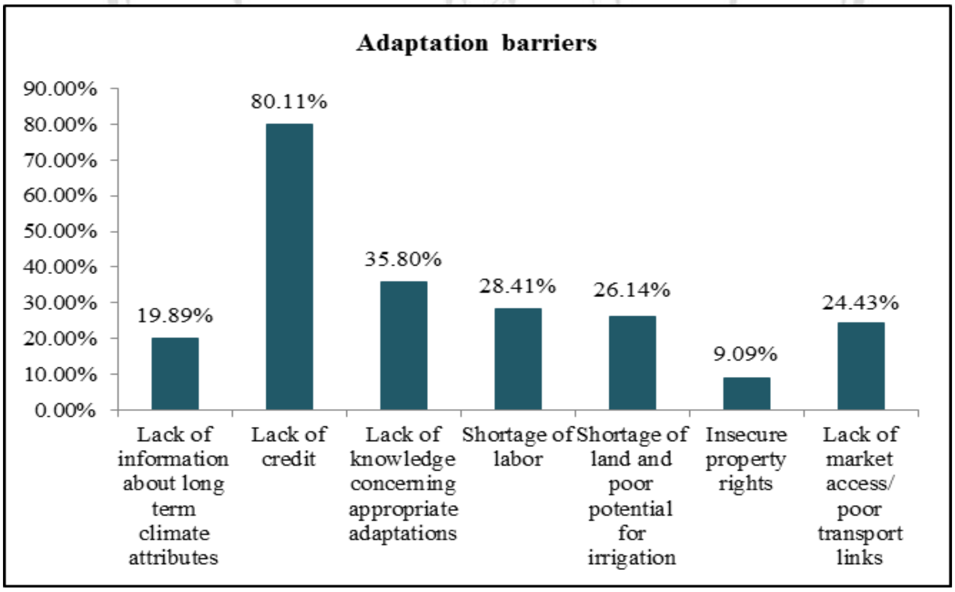



Figure 5.3 Adaptation barriers (% of the respondents)

Source: Survey data, 2013

5.2.2 The ordered logit model

After ranking the order of the adaptation options under three categories as low, medium and high; the ordered logit model was estimated to examine the impact of explanatory variables on the adaptation level. The estimated coefficients of the ordered logit model, along with significance levels, were presented in Table 5.19.

In term of the appropriate model, the McFadden Pseudo R-squared of model represented the statistically explanatory variables could explain about 44.5 percent of the variation level of farmers' adaptation. The chi-squared of model is 168.81 which statistics were highly significant ($P < 0.00000$), suggesting the model had a strong explanatory power or high goodness of fit.

The estimated coefficients presented the direction of the effect of the significant independent variables on the dependent variable, the discrete changes in the probabilities was used to explore the effects of the independent variables on the farmers' adapting for a particular adaptation strategy. The regression finding noticed that the estimated coefficients for education, coffee growing experience, coffee farming size, coffee income, non-coffee income, access to credit, access to climate information, access to extension services and irrigation option had statistically significant influence to level of adaptation dealing with climate pressure. One unit increase of this each significant independent variable would lead to an increase in the probability in choosing the adaptation categories. Only age and gender were insignificant.

*Education of head of household*, one unit increase in education of head of household would result in an increase in the probability of choosing adaptation categories while the other variables in the model were held constant at 1% level.



*The coffee growing experience*, one unit increase in coffee growing experience would lead to the probability in choosing adaptation categories increase while the other variables in the model were held constant at 5% level.

*The coffee farming size*, one unit increase in coffee farming size resulted in an increase in the probability of choosing adaptation categories while the other variables in the model were held constant at 10% level.

*The coffee income*, one unit increase in coffee income would lead to the probability of choosing adaptation categories went up while the other variables in the model were held constant at 5% level.

*Non-coffee income*, one unit increase in non-coffee income would lead to the probability of choosing adaptation categories increased while the other variables in the model were held constant at 10% level.

*Access to credit*, the probability of choosing adaptation categories of the farmers who had an access to credit was higher than no access when the other variables in the model were held constant at 5% level.

*Access to climate information*, the farmers who could access to climate information had higher probability in choosing adaptation option than otherwise when the other variables in the model were held constant at 1% level.

*Access to extension services:* the result was in line with various studies in developing countries that report a positive relationship between access to information and the adoption behavior of farmers (Yirga, 2007). The farmers, who had more information, training by extension service programs, had higher the probability in choosing adaptation option compared with the otherwise when the other variables in the model were held constant at 5% level.

*Irrigation option*, the farming households who had irrigation option, the probability of choosing adaptation category was higher than no irrigation option when the other variables in the model were held constant at 1% level.

By contrast, the insignificant of age was explained that the coffee tree was a perennial crop that required more experience and knowledge for taking care and improving new techniques in processing of coffee cultivation. It hinged on the coffee growers' experience, education or income for investment and development of coffee rather than you were elders.

The negative relationship and insignificance between gender and adaptation levels explained that female' probability for selecting the adaptation options to cope with the climate pressure was lower than the male. Through the survey, the women appeared more likely than men to rely on neighbors for information, whereas men appeared more likely than women to hinge on traditional knowledge. Male and female farmers had identical perceptions of temperature and precipitation trends and over time these perceptions matched well with the climate records which shown an increase in climate condition over the past ten years. However, the gender differences in access to institutions, information and acclimatize to climate variability reflected differences in male and female's education levels and literacy as well as culturally defined roles in decision making and division of labor. The role of women in making decision was still weak and did not interact with extension agents or training programs. As a result would be less likely to report having the choice of adaptation strategies.

The marginal effect result revealed that there was the different impact of the significantly independent variables on the probability of adapting for a particular adaptation strategy. The effects of all significant independent variables on the probability of selecting high adaptation level were high and positive contrast with the probability of selecting low adaptation was negative. The probability of adapting moderate adaptation group was negative but higher than the low adaptation group and had the positive effects in some significant variables.

*Education of head of household*: The effect of education was largest on the probability of high adaptation level comparing with the low and moderate groups. A unit increase in the number of years of schooling would result in a 3.8 percent increase in the probability of high adaptation contrast with a 2.6 and 1.2 percent decrease in the probability of low and moderate adaptation respectively at significance level 1%. It was expected that the coffee farmers with higher level of education were more likely to adapt better to climate pressure. They were more likely to adopt improved methods and expected to be more efficient to understand and obtain high and new technologies than less-educated people. From the result of multi criteria evaluation, the high adaptation group was ranked by the adaptation options that involved in irrigation techniques and irrigation techniques combining crop diversification. Education had positive with this adaptation level. This was possibly owing to educated farmers who had better knowledge and information about new techniques, new crops variety than the less-educated farmers. They understood and had good skills for applying the water saving techniques and mixed fertilizer into water for irrigation instead of using too much chemical fertilizers and basal irrigation method that spent more cost of input and labor likely the less-educated farmers.

*The coffee plantation experience*: An increase in the farmers' coffee growing experience by one year increased the probability of selecting high adaptation level by 1.1 percent while the probability of low and moderate decreased by 0.7 and 0.3 percent respectively at 5% level. Increase in farming experience had the high positive effect on the probability of preferring irrigation techniques and irrigation techniques combining crop diversification. The more coffee growing experienced farmers were more likely to use irrigation techniques to deal with climate pressure because coffee was a crop responded sensitively with changing in temperature and rainfall, especially in the period time of blossoming and fructification. The implementation of irrigation techniques for the purpose of meeting the water demand and improving coffee productivity was more effective than the application of more fertilizers for enhancing soil fertility.

*The coffee farming size* was also a significant factor that affected the farmers' choice for the adaptation strategies to climate pressure. In a similar way, an increase in the coffee farming size by 1 hectare increased the probability of moderate and high adaptation level by 1.8 and 2.6 percent respectively, while the probability of low adaptation level decreased by 0.8 percent at 10% level. This result implied that the households, who had larger farms, tend to work more intensively on their farms likely applying organic fertilizer, water saving techniques for reducing income loss and helping spread the negative impacts of changes in climate conditions instead of going another alternative to adapt to climate variability.

*The coffee income:* An increase in the coffee income increased the likelihood of adapting to climate pressure selecting the high adaptation. For instance, a unit increased in the coffee income resulted in a 0.2 percent increase in the probability of choosing the high adaptation, while the probability of low and moderate adaptation decreased by 0.1 respectively at 5% level. It was believed that comparing with the other adaptation strategies, irrigation techniques and crop diversification combining irrigation techniques required more financial resources than others. If farmers had more coffee income, they could afford to develop irrigation and multiple cropping with the latest technologies. The result was reflection of the actual behavior of households that was when their income went up; they tended to shift to activities which need more income.

*Non-coffee income* was also found to be significant independent variable that impacted on the farmers' choice for adaptation options. One unit increased in non-coffee income led to an increase in the probability of choosing high adaptation by 0.1 percent, while the probability of low and moderate adaptation declined by 0.1 and 0.02 percent respectively at 10% level. This result could clear that the farmers who had non-coffee income were expected to have nonfarm job or change other crops which could possibly be an approach they took to climate variability. Its effect will be negative the probability of selecting some other adaptation measures, while it could influence positively the probability of adaptation options that could be undertaken in combination with non-coffee income.

*Access to credit*: The farmers, who accessed to credit, had the probability of adapting low and moderate adaptation strategies lower 7.7 and 9.7 percent respectively than otherwise, while the probability of selecting high adaptation higher 17.4 percent than otherwise at 5% level. This asserted that the farmers who had an access to credit, had more the chance to choose the high adaptation with the high techniques that required more investment and high ability for reducing income loss for their coffee farms rather than the farmers who were limited by accessing to credit.

*Access to climate information*: The probability of moderate and high adaptation options for the farmers who accessed to climate information higher about 0.9 and 14.3 percent while the probability of low adaptation was lower than otherwise about 15.2 percent at 1% level. This result expressed that the farmers who received climate information were more likely to apply irrigation techniques and grow other crops in order to deal with the climate pressure.



*Access to extension services*: The probability of selecting high adaptation for the farmers who received extension services was higher about 14.1 percent than those who did not. However, the probability of low and moderate adaptation options for farmers who access to extension services were lower than otherwise about 1.6 and 3.5 percent respectively at 5% level. This result revealed that the important of increasing institutional support to encourage the adapting of irrigation techniques and irrigation techniques combining crop diversification in order to acclimatize to the impacts of climate pressure.

*Irrigation option*: The farming households who had irrigation option, the probability in choosing high adaptation was higher than those no option with 22.1 percent, while the probability of selecting low and moderate adaptation for the farmers who did not have irrigation option were higher than otherwise about 15.9 and 6.3 percent at 1% level. This result implied that the probability for the farmers accessing to irrigation in adapting irrigation techniques were higher. Under the tremendous impacts of prolongation of drought and change in the rainfall pattern, the irrigation technique adaptation played an essential role for maintaining the coffee' blossoming and fructification and reducing the coffee yield loss. The farmers, who had no irrigation option, had the higher probability in selecting soil conservation adaptation or growing another crops for purpose of reducing income loss.

The value of threshold parameter explained that, subjects that had a value between 0 and 2.43 on the underlying latent variable would be classified as moderate adaptation. And the subjects that had a value more than 2.43 on the underlying latent variable would be classified as high adaptation option. The underlying latent variable had value less or equal 0 would be classified as low adaptation group.

Table 5.19 The estimation of coffee farmers' adaptation on climate pressure

| Variables | Ordered logit model | | Marginal effects | | |
|---|---|---|---|---|---|
| | Coefficient | S.E | Low | Moderate | High |
| Constant | -2.062 | 0.733 | 0.000 | 0.000 | 0.000 |
| Age (years) | -0.016 | 0.013 | 0.003 | 0.001 | -0.004 |
| Gender (1 for female, 0 for male) | -0.291 | 0.237 | 0.042 | 0.029 | -0.071 |
| Education (years) | 0.164*** | 0.057 | -0.026 | -0.012 | 0.038 |
| Coffee Growing Experience (years) | 0.047** | 0.02 | -0.007 | -0.003 | 0.011 |
| Coffee farming size (hectare) | 0.116* | 0.274 | -0.008 | 0.018 | 0.026 |
| Coffee income (1,000,000 VND) | 0.012** | 0.255 | -0.001 | -0.001 | 0.002 |
| Non-coffee income (1,000,000 VND) | 0.004* | 0.002 | -0.001 | -0.0002 | 0.001 |
| Access to credit (1 for accessing, 0 for otherwise) | 0.637** | 0.305 | -0.077 | -0.097 | 0.174 |
| Access to climate information (1 for accessing, 0 for otherwise) | 0.765*** | 0.282 | -0.152 | 0.009 | 0.143 |
| Access to extension service (1 for accessing, 0 for otherwise) | 0.638** | 0.254 | -0.106 | -0.035 | 0.141 |
| Irrigation option (1 for irrigation option, 0 for otherwise) | 0.977*** | 0.294 | -0.159 | -0.063 | 0.221 |
| Threshold parameter | 2.43 | 0.272 | | | |

Number of observations =176 , McFadden Pseudo R-squared = 44.5

Log likelihood function = -105.27, Restricted log likelihood = -189.67

Chi squared =168.81, Prob [ChiSqd > value] = .000000

Note: *, **, *** Statistically significant at 10%, 5%, 1%

Source: Survey data, 2013

The result of Table 5.20 showed that there were more actual farmers with low adaptation level than predicted, 46 of actual versus 38 of predicted. Similarly, there were more actual farmers with moderate adaptation level than predicted, 75 of actual versus 54 of predicted and 55 of actual versus 41 of predicted for high adaptation level. The high predicted percent concluded that the model was more appropriate in explaining the variation of dependent variables when the explanatory elements changed.

Table 5.20 The accuracy of ordered logit model

| Level of adaptation | Predicted outcome | | | Actual Outcome |
|---|---|---|---|---|
| | Low | Moderate | High | |
| Low | 38 | 8 | 0 | 46 |
| Moderate | 8 | 54 | 13 | 75 |
| High | 0 | 14 | 41 | 55 |
| Percent (Actual over predicted) | 82.61 | 72.00 | 74.55 | |

Source: Survey data, 2013

## 5.3 Gross Margin Analysis

In order to assess the coffee yield and profitability of farmer groups with different adaptation capacity levels, gross margin analysis of 176 sampled coffee farmers were carried out with three ordinal adaptation categories. Cost of coffee production was computed covering three types of variables such as cost of inputs, cost of hired and family labors, and cost of harvesting and transportation.

### 5.3.1 Cost of coffee production in three adaptation levels

The maintenance activities on coffee production as reported by respondents consisted of annual pruning, weeding, enlargement of irrigation basal, fertilizer and pesticide application, irrigation application, harvesting and, finally, post-harvest. Labor included family and hired labors or (implicit and explicit cost) which were computed to one hectare of mature coffees in three groups were presented in Table 5.22, 5.23, 5.24 respectively.

Most of the activities such as fertilizer and pesticide applications and weeding were carried out from May to November. During the harvesting period, a high number labor was required between October and December.

All farmers applied chemical fertilizers including compound fertilizer, urea, super phosphorus, potassium chloride and ammonium sulphate to their coffee plantation. The chemical fertilizers were applied to coffee plantations during the raining season or after irrigating when the soil moisture content was sufficiently high for coffee trees to uptake major and minor elemental nutrients. Initially, fertilizer application often took place after harvesting at the end of January or the beginning of February. The second time was conducted in May, after the first day of the rainy season, and the last two applications were carried out in July and during the end of October. On the other hand, there were 136 famers who also used additional organic fertilizers such as mixing composted grasses, crop residues, leaves, firewood, husk and animal manure in order to keep soil moisture for coffee roots, increase the physical properties of the soil and nutrient-holding capacity of the soils.

The water sources for irrigation in the study area were from farm well, stream, pool, and dam whereas ground water from farm well was the main source of irrigation. The result in Table 5.21 shown that about 34.78 percent of farmers in the group of low adaptation obtained ground water for their coffee by digging wells, around 30.91 and 28.00 percent were respectively for groups of high and moderate adaptation.

Table 5.21 Source of irrigation in three adaptation levels

Unit: percentage

| Source of water irrigation | Low | Moderate | High |
|---|---|---|---|
| Well | 34.78 | 28.00 | 30.91 |
| Ponds | 21.74 | 28.00 | 20.00 |
| Stream | 21.74 | 26.67 | 29.09 |
| Dam | 6.52 | 2.67 | 0.00 |
| Stream, Ponds | 10.87 | 8.00 | 10.91 |
| Stream, Ponds, Well | 4.35 | 6.67 | 9.09 |

Source: survey, 2013

Irrigation plays an essential role in management practices, which can either increase yields when precipitation is marginal for coffee, or decrease yield by applying excessive amount of water. Although the water from stream, ponds also had an important contribution for irrigating, it could only be used during the beginning of the dry season owing to drying out soon in January or February. For the remaining months, about 80 percent of farmers relied on ground water from their own wells for irrigating their coffee farm. Moreover, the irrigation system in the study area in recent years faced a shortage of water in the storage and created the water scarcity situation and was not enough to allocate for irrigation, due to climate pressure. Facing problems of droughts, the delay of the rainy season and irrigation demand for their coffee crop, the farmers invested more on irrigation practices, i.e. purchased irrigation pipes, combined digging and drilling wells. Under this situation, the financial problem of the investment in irrigation of coffee production is a burden for poor and small households in the region.

Table 5.22 revealed that the farmers in low adaptation level group had the highest cost of labor at 42.62 million VND per hectare per year per household whereas the implicit cost occupied 28.85 million VND per hectare per year per household. Coffee was a crop that needs much time for taking care. The labor cost accounted the highest percent of the total cost of coffee production around 52 percent, following fertilizer with 34.9 percent. Labors were used for soil conservation and crop diversification adaptation options, spent more time for taking care their coffee farm, such as weeding, grafting pruning and irrigation were mostly undertaken by traditional methods. This group had the highest fertilizer cost of their coffee farm about 28.6 million VND per ha per year per household. They also spent about 5.25 million VND per ha per year per household on fuel for irrigation, which was higher than the fuel cost spent by the two remain groups. By using the basal irrigation method (Figure 5.4), the farmers explained that they applied a total of 600 liters per tree per week however evaporation rate may also be very high and wasted. In addition, the basal irrigation method required high labor and cost of irrigation. Most of coffee growers in this group spent more time in moving the irrigation pipes to each coffee tree and maintain the bund around the coffee tree. The findings indicated that they spent about 4.42 million VND per hectare per year per household for fundamental investment such as water pump, irrigation pipes, drilling wells, crop sprayers and maintain costs.

The effects of insecticides and pesticides on the productivity of coffee were also a special concern of almost all the farmers in the study area. The result shown the low adaptation group spent cost pest and disease control 1.07 million VND per ha per year per household.

Table 5.22 Cost of coffee production of low adaptation group

| Items | Explicit cost | Implicit cost | Total 1,000,000VND | Total % |
|---|---|---|---|---|
| Variable cost | | | 77.54 | |
| 1. Labor | 13.77 | 28.85 | 42.62 | 52.00 |
| 2. Fuel cost irrigation | 5.25 | | 5.25 | 6.40 |
| 3. Fertilizer | 28.60 | | 28.60 | 34.90 |
| 4. Pest and disease controls | 1.07 | | 1.07 | 1.30 |
| Fixed cost | | | 4.42 | |
| 1. Machines: crop sprayer, | 0.10 | | 0.10 | 0.12 |
| 2. Irrigation equipment: pipes, water pump, drilling wells | 3.32 | | 3.32 | 4.05 |
| 3. Maintenance | 1.00 | | 1.00 | 1.22 |
| Total | 53.11 | 28.85 | 81.96 | 100.00 |

Note: *Explicit costs were the direct payments made to others in the course of running a business or agricultural production. In this case, it included all of money payments from coffee growers' own pocket which they used to invest for their coffee cultivation. Implicit costs were the opportunity cost equal to what a firm must give up in order to use factors which it neither purchases nor hires. In this study, it included the cost of family labor which farmers gave up alternative activities to spent time for taking care of their coffee farming. *1 USD = 21,276.6 VND (June, 2014)

Source: Survey, 2013

Most of coffee growers in the study area are using pipes to irrigate their coffee trees as basal irrigation method (Figure 5.5).

Figure 5.4 The basal irrigation method in study area

Source: Survey, 2013

There was no much difference between fertilizer costs of the moderate adaptation and the high adaptation groups. These groups concerned for the fertilizer application techniques and improved the irrigation system. The medium adaptation group spent 25.42 million VND per hectare per year per household for fertilizer application while 24.99 million VND per hectare per year per household was invested with the same activity for high adaptation group (Table 5.18, Table 5.19). However, the group under high adaptation invested in farm machines or learning new technical methods, mixing fertilizer into tanks of irrigation due to declining of labors and time. They saved the cost of labor which was lower than the medium adaptation group. They spent 30.62 million VND per hectare per year per household for labor whereas the implicit cost 17.97 million VND per hectare per year per household compare with 37.61 million VND per hectare per year per household for the medium adaptation group.

Table 5.23 Cost of coffee production of moderate adaptation group

| Items | Explicit cost | Implicit cost | Total | |
|---|---|---|---|---|
| | | | 1,000,000VND | % |
| Variable cost | | | 69.20 | |
| 1. Labor | 10.67 | 26.94 | 37.61 | 51.00 |
| 2. Fuel cost irrigation | 4.99 | | 4.99 | 6.77 |
| 3. Fertilizer | 25.42 | | 25.42 | 34.47 |
| 4. Pest and disease controls | 1.18 | | 1.18 | 1.60 |
| Fixed cost | | | 4.55 | |
| 1. Machines: crop sprayer, mowing machine | 0.25 | | 0.25 | 0.33 |
| 2. Irrigation equipment: pipe, motor, sprinkler, drilling wells | 3.37 | | 3.37 | 4.57 |
| 3. Maintenance | 0.93 | | 0.93 | 1.26 |
| Total | 46.81 | 26.94 | 73.75 | 100.00 |

Note: *Explicit costs were the direct payments made to others in the course of running a business or agricultural production. In this case, it included all of money payments from coffee growers' own pocket which they used to invest for their coffee cultivation. Implicit costs were the opportunity cost equal to what a firm must give up in order to use factors which it neither purchases nor hires. In this study, it included the cost of family labor which farmers gave up alternative activities to spent time for taking care of their coffee farming. *1 USD = 21,276.6 VND (June, 2014)

Source: Survey, 2013

Table 5.24 Cost of coffee production of high adaptation group

| Items | Explicit cost | Implicit cost | Total | |
|---|---|---|---|---|
| | | | 1,000,000VND | % |
| Variable cost | | | 61.20 | |
| 1. Labor | 12.65 | 17.97 | 30.62 | 46.69 |
| 2. Fuel cost irrigation | 4.94 | | 4.94 | 7.53 |
| 3. Fertilizer | 24.99 | | 24.99 | 38.11 |
| 4. Pest and disease controls | 0.65 | | 0.65 | 1.00 |
| Fixed cost | | | 4.56 | |
| 1. Machines: crop sprayer, mowing machine, plough | 0.57 | | 0.57 | 0.87 |
| 2. Irrigation equipment: pipe, motor, sprinkler, drilling wells, tanks | 3.03 | | 3.03 | 4.62 |
| 3. Maintenance | 0.96 | | 0.96 | 1.46 |
| Total | 47.79 | 17.97 | 65.58 | 100.00 |

Note: *Explicit costs were the direct payments made to others in the course of running a business or agricultural production. In this case, it included all of money payments from coffee growers' own pocket which they used to invest for their coffee cultivation. Implicit costs were the opportunity cost equal to what a firm must give up in order to use factors which it neither purchases nor hires. In this study, it included the cost of family labor which farmers gave up alternative activities to spent time for taking care of their coffee farming. *1 USD = 21,276.6 VND (June, 2014)

Source: Survey, 2013

The medium and high adaptation group used the slightly different irrigation techniques (Figure 5.5), which spent lower fuel cost about 4.99 and 4.94 million VND per ha per year per household respectively. By applying these methods, the farmers expressed that they not only saved amount of water using, reduced demand for labor but also met mineral nutrient application for coffee when fertilizers was also mixed into tanks for irrigation. However, these irrigation approaches required high cost for irrigation equipment and farmers had to learn new skills related to irrigation management.

The medium adaptation groups responded that using the sprinkler system from up to down saved labor cost for irrigation, reduced amount of waste fertilizer and water was irrigated for the whole of leave surface which kept moisture for coffee trunks. However, this method spent more cost for irrigation equipment, lost water because of strong winds and also spent more fuel due to the high pressure of the taps. They spent 3.37 million VND per hectare per year per household for irrigation equipment while with the saving irrigation technique; the high adaptation group had the cost of irrigation equipment lower than about 3.03 million VND per hectare per year per household. The saving irrigation technique was designed through the pipe systems attaching sprinklers were fitted up on the ground surface, along the roots of coffee and fertilizers were mixed into tanks. The high adaptation groups explained that they declined labor cost for irrigation, raking tub and fertilizer application as well. Although this technique had positive benefits, it was still an autonomous approach, reactive rather than proactive through their experience, neighbors and lack of consultancy or training of experts and scientists.


Figure 5.5 New irrigation technique created by the medium and high adaptation coffee grower groups. Note: A, B, C is water saving irrigation technique. D is irrigation technique with sprinkler system from up to down.

Source: survey, 2013



The relatively low cost of pest and disease controls (1.00 - 1.60% of the total cost), farmers responded that they would spray wherever there were insect infestation. The low cost was explained that the farmers were awareness of the time control, relative amount or type of insecticides to be used. The cost of pest and disease controls for two groups of moderate and high adaptation was 1.18 and 0.65 million VND per hectare per year per household respectively.

The findings of Table 5.22, 5.23, 5.24 revealed that variable costs which related to labor and fertilizer for three adaptation levels, accounted the high percentage of the total cost.

However, the high and moderate adaptation groups spent more fixed cost for their coffee farming due to investing more machines and applying new irrigation techniques for dealing with climate pressure compared with the low adaptation group.

5.3.2 Profitability of coffee production

Gross margin was used to compare profitability of coffee production under different level of adaptation in the study area. The price of coffee bean was the farm-gate price that each household received.

The results in Table 5.25 indicated that the low adaptation households had the highest production variable cost among three groups with 77.54 million VND per hectare per year per household. This was explained by spending higher cost for fertilizer and labor through traditional irrigation technique. The average total variable cost of two groups of moderate and high adaptation was 69.2 and 61.2 million VND per hectare per year per household respectively.

Table 5.25 Average cost of coffee production in three adaptation levels

| Production cost (1,000,000VND/ha) | Low | Medium | High |
|---|---|---|---|
| TVC | 77.54 | 69.20 | 61.2 |
| Fertilizer | 28.6 | 25.42 | 24.99 |
| Pest and disease control | 1.07 | 1.18 | 0.65 |
| Fuel for irrigation pump | 5.25 | 4.99 | 4.94 |
| Labor | | | |
| - Family | 28.85 | 26.94 | 17.97 |
| - Hired | 13.77 | 10.67 | 12.65 |

Note: 1 USD = 21,276.6 (June, 2014)

Source: survey, 2013

Table 5.26 presented the average coffee yield, total variable costs, total revenue and gross margin of farmers with different levels of adaptation practices. The gross margin was varying with adaptation levels. The revenue/variable cost ratio of the farmer was found to be greater than one. It meant that the economic return from coffee production could pay of production variable costs. One unit increased in total variable cost of the low adaptation group would result in an increase about 1.32 unit of revenue, while the high adaptation group had the highest benefit/cost ratio; one unit increased of total variable cost increased 2.22 unit of benefit. The revenue of medium adaptation group increased 1.99 unit when the total variable cost went up one unit.

Table 5.26 Comparison of yield, TVC, total revenue of different adaptation groups

| (1,000,000VND/ha) | Low | Medium | High |
|---|---|---|---|
| TVC | 77.54 | 69.2 | 61.2 |
| Yield (tons/ha) | 2.59 | 3.48 | 3.39 |
| Price (1,000VND/kg) | 39.45 | 39.75 | 39.97 |
| Revenue | 102.17 | 137.85 | 135.71 |
| Gross margin | 24.63 | 68.65 | 74.51 |
| Revenue-TVC ratio | 1.32 | 1.99 | 2.22 |

Note: 1 USD = 21,276.6 (June, 2014). Source: survey, 2013

The findings in Table 5.27 showed that the farmers in the high adaptation group were able to obtain the highest averaged gross margin at 74.51 million VND per hectare per year per household. The negative minimum gross margin of the low adaptation group could be explained by high input costs and lower coffee price due to low quality. The low adaptation group focused their resources on the quantity of fertilizers and they expected that adding more fertilizer would help increasing coffee yield and improving soil fertility. This is the main reason for deteriorating and degrading coffee farms after harvesting seasons and carrying serious pests and diseases outbreaks. The gross margin of medium and high adaptation groups which were positive but had higher of standard deviation with 32.81 and 41.26 respectively compared with 24.7 of low adaptation group. This was explained that practicing of high techniques that enhanced coffee productivity, however required more knowledge, training skills and water availability in the case of applying water saving irrigation technique or sprinkler irrigation system.

Table 5.27 Gross margin of three different adaptation groups

| Gross margin (1,000,000 VND/ha) | Low | Medium | High |
|---|---|---|---|
| Average | 24.63 | 68.65 | 74.51 |
| Maximum | 89.65 | 133.69 | 179.29 |
| Minimum | -19.9 | 1.28 | 2.32 |
| Standard deviation | 24.70 | 32.81 | 41.26 |

Note: 1 USD = 21,276.6 (June, 2014). Source: survey, 2013

In conclusion, the group of high adaptation level obtained the highest profitability per hectare through selling coffee at a higher price, adapting efficient irrigation techniques and high knowledge for applying appropriate adaptation strategies for their coffee gardens.

# CHAPTER 6

## Conclusions and Recommendations

The foregoing discussion consolidates the insights from the study. It attempted to understand the farmers' perception about climate pressure, evaluate the adaptation options and determine the factors influencing the farmers' choices for adaptation options to deal with the climate pressure, and assess the coffee yield and profitability of farmer groups with different adaptation capacity levels. The study fulfilled the initial objectives and answered the research questions. This chapter also concludes the research results and briefly proposes further actions to build the well planned adaptation strategies for dealing with climate change.

### 6.1 Conclusion

This thesis presented the farmers' perception of climate pressure in Ea H'leo District, DakLak province, Central highland of Vietnam. The study attempted to confirm the farmers' perception of climate pressure through asking them about changing in temperature and rainfall, types of change of climate and compared with climate data recorded from 2001 to 2013 as well. It was used in interviews of 176 farm households in coffee production. Frequency and percentage of respondents were used to characterize farmers' perception of changes in temperature and precipitation.



The results indicated that there were 75% of respondents with the level of agree to change in temperature and rainfall. About 77.27% of the farmers perceived the temperature in the Ea H'leo District to be increasing and 66.48% of respondents observed a decrease trend in the annual amount of rainfall. The farmers' perception also appeared to be in accordance with the statistical record in the region. The statistical finding explored socio-economic variables included age, education, coffee growing experience, access to climate information, access to extension services and irrigation option had statistically significant impacts to farmers' perception about changing in temperature and rainfall at 1%, 5% level while gender, total income and access to credit are insignificant with effect relating to perceptions.

The adaptation options, which were selected for coping with climate pressure on their coffee farming included soil conservation, crop diversification and irrigation techniques. Through the Multi-Criteria Evaluation tools with five criteria, including effectiveness, economic efficiency, flexible, farmer implement ability and independent benefit, the ordinal adaptation strategies were ranged under the low, moderate and high adaptation levels respectively. The statistical output revealed that the estimated coefficients for education, coffee growing experience, coffee farming size, coffee income, non-coffee income, access to credit, access to climate information, access to extension service and irrigation option had statistically significant influence to level of adaptation dealing with climate pressure. The insignificant of age was explained that coffee was a perennial crop which required more experience and high education, ability for accessing techniques and training extension services. Moreover, the elders were limited by capacity about updating information and accessing new techniques as well.

The findings of gross margin analysis also shown that the group of high adaptation levels obtained the highest profitability per hectare per year per household through selling coffee at a higher price, adapting efficient irrigation techniques and high knowledge for applying appropriate adaptation strategies for their coffee gardens.



### 6.2 Recommendations

The analysis of the survey data exposes that these social, economic and institutional circumstances affect differently on the coffee growers' perception and the real adaptation strategies for dealing with climate pressure. These elements need special consideration in designing policies and programs in order to improve and increase the level of adaptation strategies for coffee production practices. Also, it is worth undertaking the relevant recommendations for maintaining sustainable coffee system and coping with climate pressure.

Daklak province in particular and central highland Vietnam in general, coffee is a dominant crop and the backbone income source for the whole farmers in here. Therefore, undertaking the proactive adaptation strategies is imperative for tackling climate pressure and maintaining sustainable coffee.

6.2.1 Low adaptation group

In order to reduce the risks of climate change pressure and enhance resilience of their coffee farms, the farmers adapted the adaptation strategies related to crop diversification by growing others crops such as durian, banana, cashew and black pepper and soil conservation technique parallel. They also applied more chemical fertilizers with aims to improve soil fertility and crop productivity. However, the farmers who selected these adaptation options adapted the basal irrigation method as well and spent more cost for fertilizers and labor. Therefore, application of organic matters in the form of crop residues, coffee leaf and coffee pulp will be potential resources to replace a part of chemical fertilizers using and improve soil water conservation regime as well as easily uptake of nutrients. Application of organic fertilizer will contribute to a stable and safe coffee production in the region.

Moreover, the findings of regression model also revealed that the farmers who had higher education level and more coffee growing experience had the negative probability of adapting this adaptation options. Selecting soil conservation by adding more chemical fertilizers or using basal irrigation method became ineffectively and poor encouragement for them. There is a need to emphasize the crucial role of extension services for providing information on better production techniques and training skills about applying new irrigation techniques that meet the water demand and enhance coffee productivity. Intercropping coffee based farming systems in the form of coffee-fruit trees, coffee-black pepper plays an essential role in properly using and protecting water resource for sustainable agriculture production. However, it is considerable to promote and educate the farmers strongly about knowledge and skills for applying new irrigation techniques under threats of climate change pressure.

6.2.2 Moderate adaptation group

The farmers got the positive gross margin, however they meet barriers about accessing to credit and investment in new techniques. Practicing the sprinkler irrigation system from up to down makes a water loss under strong wind and spend more fuel cost for irrigation due to water availability is limited. Improvement of irrigation system in the region is a crucial role for addressing the water shortage situation and enough water to allocate for irrigation.

This adaptation group includes the adaptation options relate to crop diversification, irrigation techniques with sprinkler system and soil conservation parallel. Application of organic fertilizers from crop residues is also a potential resource to reduce the chemical fertilizer cost and increase environmental friendly. Promoting of water saving irrigation technique combining to mix fertilizer into water is necessary for reducing investment of irrigation equipment, fuel cost by high pressure of pipe systems because of limited water availability and strong wind.

6.2.3 High adaptation group

The result of the multiple criteria evaluation indicated that the high adaptation group applied high irrigation techniques involving in water saving irrigation by mixing fertilizer into water or adapting irrigation technique combing with crop diversification adaptation parallel. The marginal effects shown the impacts of significant independent variables on the probability of selecting these adaptation options were high and positive. However, most of the adaptation measures implemented in the study area are reactive rather than proactive, autonomous rather than well-planned approaches under level of private agent. Therefore, it is essential to promote more and more efficiency technology transfer through extension services in associating with appropriate knowledge and technologies that could apply at average and small scale farms.

Extension on crop production, access to information on climate pressure and access to credit enhanced adaptation to climate variability. Consequently, policies aiming at promoting adaptation to climate variability need to emphasize the crucial role of providing information on better production techniques and creating the financial means through affordable credit schemes to enable farmers adapt to climate change. Policies should ensure that farmers have access to affordable credit, which will give them greater flexibility to modify their production strategies in response to climate change.

Although, the coffee farmers of this adaptation group get high gross margin, they meet difficulties relate to knowledge and skills for adapting new techniques and appropriate rate of kind of fertilizers that are mixed into water for irrigation. Hence, extension and irrigation officers should play an essential role in facilitating and guiding that there is an emerging need for effective management of the water resource. The greater investments in smart irrigation are needed for meeting irrigation demand of crops. In addition, access to climate information makes to increase the probability of adapting high adaptation strategies. At study site, the farmers get information from the contact farmers, neighbors, salesman, and through mass media etc., are very important sources. Those sources, however, farmers are not interested in approaching because they frequently lacked of the target group or location specificity and information was not up to date. It had better therefore in order to transfer the technological information through those channels should be hinged on farmers' needs and regional specify within different language, especially ethnic minority languages, for instance in Daklak province Ede and M'nong.

## 6.3 Suggestions for future research

Analyze the benefit and cost of adaptation strategies for dealing with climate change in coffee production under different levels including community and nation.



Application of crop diversification and water saving irrigation techniques parallel with well-planed adaptation for reducing the tremendous impacts of climate change in coffee farms.

An analysis of the agronomic and economic sustainability of organic coffee production.

Assessing the price risks and world coffee trade for small-scale farmers.

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# APPENDIX

**Appendix A Chi – square analysis with impacting of factors of farmers' perception for changing in temperature and rainfall**

Table A-1 Chi-square tests for age of head of household

| | Value | df | Asymp. Sig. (2-sided) |
|---|---|---|---|
| Pearson Chi-Square | 98.125[a] | 70 | .015 |
| Likelihood Ratio | 52.095 | 70 | .946 |
| Linear-by-Linear Association | 4.316 | 1 | .038 |
| N of Valid Cases | 176 | | |

Table A-2 Chi-square tests for gender of head of household

| | Value | df | Asymp. Sig. (2-sided) |
|---|---|---|---|
| Pearson Chi-Square | 3.469[a] | 2 | .176 |
| Likelihood Ratio | 3.171 | 2 | .205 |
| Linear-by-Linear Association | 3.268 | 1 | .071 |
| N of Valid Cases | 176 | | |

Table A-3 Chi-square tests for education of head of household

| | Value | df | Asymp. Sig. (2-sided) |
|---|---|---|---|
| Pearson Chi-Square | 1.292E2[a] | 22 | .000 |
| Likelihood Ratio | 77.676 | 22 | .000 |
| Linear-by-Linear Association | 51.982 | 1 | .000 |
| N of Valid Cases | 176 | | |

Table A-4 Chi-square tests for coffee growing experience

| | Value | df | Asymp. Sig. (2-sided) |
|---|---|---|---|
| Pearson Chi-Square | 1.476E2[a] | 54 | .000 |
| Likelihood Ratio | 68.187 | 54 | .093 |
| Linear-by-Linear Association | 4.346 | 1 | .037 |
| N of Valid Cases | 176 | | |

Table A-5 Chi-square tests for coffee farming size

| | Value | df | Asymp. Sig. (2-sided) |
|---|---|---|---|
| Pearson Chi-Square | 50.607[a] | 60 | .801 |
| Likelihood Ratio | 34.397 | 60 | .997 |
| Linear-by-Linear Association | 4.051 | 1 | .044 |
| N of Valid Cases | 176 | | |

Table A-6 Chi-square tests for total income

| | Value | df | Asymp. Sig. (2-sided) |
|---|---|---|---|
| Pearson Chi-Square | 2.010E2[a] | 242 | .975 |
| Likelihood Ratio | 97.038 | 242 | 1.000 |
| Linear-by-Linear Association | 3.581 | 1 | .058 |
| N of Valid Cases | 176 | | |



Table A-7 Chi-square tests for access to credit

| | Value | df | Asymp. Sig. (2-sided) |
|---|---|---|---|
| Pearson Chi-Square | 2.366[a] | 2 | .306 |
| Likelihood Ratio | 3.197 | 2 | .202 |
| Linear-by-Linear Association | 2.115 | 1 | .146 |
| N of Valid Cases | 176 | | |

Table A-8 Chi-square tests for access to climate information

| | Value | df | Asymp. Sig. (2-sided) |
|---|---|---|---|
| Pearson Chi-Square | 23.042[a] | 2 | .000 |
| Likelihood Ratio | 17.141 | 2 | .000 |
| Linear-by-Linear Association | 15.744 | 1 | .000 |
| N of Valid Cases | 176 | | |

Table A-9 Chi-square tests for access to extension service

| | Value | df | Asymp. Sig. (2-sided) |
|---|---|---|---|
| Pearson Chi-Square | 6.973[a] | 2 | .031 |
| Likelihood Ratio | 8.469 | 2 | .014 |
| Linear-by-Linear Association | 6.269 | 1 | .012 |
| N of Valid Cases | 176 | | |

Table A-10 Chi-square tests for irrigation option

| | Value | df | Asymp. Sig. (2-sided) |
|---|---|---|---|
| Pearson Chi-Square | 15.444[a] | 2 | .000 |
| Likelihood Ratio | 13.461 | 2 | .001 |
| Linear-by-Linear Association | 11.015 | 1 | .001 |
| N of Valid Cases | 176 | | |

**Appendix B Estimated result of ordered logit model**

```
--> ORDERED;Lhs=Y;Rhs=ONE,X1,X2,X3,X4,X5,X6,X7,X8,X9,X10,X11;marginal;$
Normal exit from iterations. Exit status=0.
+---------------------------------------------+
| Ordered Probability Model                   |
| Maximum Likelihood Estimates                |
| Model estimated: Apr 05, 2014 at 09:00:38PM.|
| Dependent variable                   Y1     |
| Weighting variable                 None     |
| Number of observations              176     |
| Iterations completed                 21     |
| Log likelihood function       -105.2697     |
| Number of parameters                 13     |
| Info. Criterion: AIC =          1.34397     |
|   Finite Sample: AIC =          1.35674     |
| Info. Criterion: BIC =          1.57816     |
| Info. Criterion:HQIC =          1.43896     |
| Restricted log likelihood     -189.6727     |
| McFadden Pseudo R-squared      .4449931     |
| Chi squared                    168.8061     |
| Degrees of freedom                   11     |
| Prob[ChiSqd > value] =         .0000000     |
| Underlying probabilities based on Normal    |
+---------------------------------------------+

+--------------------------------------------+
| Ordered Probability Model                  |
| Cell frequencies for outcomes              |
|  Y Count Freq  Y Count Freq  Y Count Freq  |
|  0    46 .261  1    75 .426  2    55 .312  |
+--------------------------------------------+
```

| Variable | Coefficient | Standard Error | b/St.Er. | P[\|Z\|>z] | Mean of X |
|---|---|---|---|---|---|
| Index function for probability | | | | | |
| Constant | -2.06236975 | .73251392 | -2.815 | .0049 | |
| X1 | -.01589737 | .01296174 | -1.226 | .2200 | 45.1875000 |
| X2 | -.29085066 | .23656904 | -1.229 | .2189 | .72159091 |
| X3 | .16444877 | .05707498 | 2.881 | .0040 | 9.21022727 |
| X4 | .04718851 | .02001131 | 2.358 | .0184 | 17.2954545 |
| X5 | .11644732 | .27429405 | 2.425 | .0671 | 1.37727273 |
| X6 | .01222707 | .00207223 | 2.040 | .0414 | 175.281250 |
| X7 | .00425042 | .00229067 | 1.856 | .0635 | 20.7514205 |
| X8 | .63688190 | .30458331 | 2.091 | .0365 | .19886364 |
| X9 | .76474926 | .28189294 | 2.713 | .0067 | .73863636 |
| X10 | .63815082 | .25429928 | 2.509 | .0121 | .55113636 |
| X11 | .97724140 | .29447604 | 3.319 | .0009 | .50568182 |
| Threshold parameters for index | | | | | |
| Mu(1) | 2.43014425 | .27185144 | 8.939 | .0000 | |

Summary of Marginal Effects for Ordered Probability Model (probit)

| Variable | Y=00 | Y=01 | Y=02 | Y=03 | Y=04 | Y=05 | Y=06 | Y=07 |
|---|---|---|---|---|---|---|---|---|
| X1 | .0025 | .0011 | -.0036 | | | | | |
| *X2 | .0416 | .0290 | -.0707 | | | | | |
| X3 | -.0257 | -.0117 | .0374 | | | | | |
| X4 | -.0074 | -.0034 | .0107 | | | | | |
| X5 | -.0082 | .0183 | .0265 | | | | | |
| X6 | -.0007 | -.0006 | .0020 | | | | | |
| X7 | -.0007 | -.0002 | .0010 | | | | | |
| *X8 | -.0768 | -.0967 | .1735 | | | | | |
| *X9 | -.1522 | .0094 | .1427 | | | | | |
| *X10 | -.1055 | -.0351 | .1405 | | | | | |
| *X11 | -.1586 | -.0632 | .2219 | | | | | |

Cross tabulation of predictions. Row is actual, column is predicted.
Model = Probit . Prediction is number of the most probable cell.

| Actual | Row Sum | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 46 | 38 | 8 | 0 | | | | | | | |
| 1 | 75 | 8 | 54 | 13 | | | | | | | |
| 2 | 55 | 0 | 14 | 41 | | | | | | | |
| Col Sum | 176 | 46 | 76 | 54 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

# CURRICULUM VITAE

| | |
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