School of Management and Marketing

Adoption and Impact of Conservation Agriculture on Maize Farming Households in Timor-Leste

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Declaration

To the best of my knowledge and belief this thesis contains no material previously published by any other person except where due acknowledgment has been made.

This thesis contains no material which has been accepted for the award of any other degree or diploma in any university.

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Abstract

Farmers in Timor-Leste experience risks related to climate change such as drought, floods, and extreme changes in precipitation. These events have reduced crop production and productivity. Farmers have been introduced to conservation agriculture as an adaptation strategy for climate change and also to improve productivity. However, no in-depth study has been undertaken in Timor-Leste to examine the impact of conservation agriculture on maize production, income, and workloads. The aim of this study is to examine the adoption and impact of conservation agriculture (CA) on maize farming households in Timor-Leste. The study was conducted in two municipalities (Manufahi and Manatuto). A mixed methods approach was used. Rapid rural appraisals and interviews with key government personnel were used to acquire basic information about the implementation of the CA program. Quantitative data was gathered through a survey of 465 farmers consisting of 176 CA farmers and 289 non-CA farmers selected using random sampling. Quasi-experimental approaches using propensity score matching techniques were applied to match the data and reduce selection bias. Descriptive analysis and logit regression were used to analyse data on production, income, and workloads of farmers as well as factors influencing farmers' adoption of conservation agriculture. The result of this study showed that farmers who implemented CA have significantly higher maize yields and income. Labour use was lower, but not significantly different. Age, experience, income, entrepreneurial traits, risk attitude of male, risk attitude of female, land type, credit, training on minimum tillage, training on leaving crop residue/mulch, drought, and information about new farming practices from national NGOs, neighbours and friends significantly influenced farmers' adoption of CA. This study generates new information on the impact of CA in Timor-Leste and practical contributions to the Timor-Leste government as a source of information to guide policy decisions on promoting CA as a strategy for climate change adaptation in Timor-Leste.

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Marcolino Estevão Fernandes E Brito

Table of Contents

List of Figures

List of Tables

GLOSSARY

AusAID	Australian Agency for International Development
CA	Conservation Agriculture
CIMMYT	International Maize and Wheat Improvement Centre
CSIRO	Commonwealth Scientific and Industrial Research Organisation
FAO	Food and Agriculture Organization of the United Nations
GoTL	Government of Timor-Leste
GTZ	Gesellschaft fuer Technische Zusammenarbeit (Germany Agency for Technical Cooperation) which is currently operated in Timor-Leste in terms of supporting technical assistance to farmers
GDP	Gross Domestic product
ha	Hectare
IR	Indica Rice
IPM	Integrated Pest Management
IMN	Integrated Nutrient Management
ICM	Integrated Crop Management
IPCC	Intergovernmental Panel on Climate Change
MT	Metric tonnes
MAFF	Ministry of Agriculture Forestry and Fisheries
NGOs	Non-Government Organisations
SPSS	Statistical Package for the Social Sciences
SAPT	*Sociedade Agricola Patria e Trabalho*
TL	Timor-Leste
UNTL	Universidade Nacional Timor Lorosa'e (National University of Timor Loro Sa'e)

UNFCC	United Nations Framework Convention on Climate Change
UNDP	United Nations Development Programmes
WFP	World Food Programme

Chapter 1

Introduction

1.1 Introduction

One of the key challenges the world currently faces is climate change. Climate change is described as the natural changing of temperature due to global warming (IPCC, 2014b; Schneider and Mastrandrea, 2010). This phenomenon is happening across geographic areas and economies globally. The agriculture sector is one of the sectors that is most vulnerable to climate change. This is because adverse precipitation, humidity, atmospheric circulation patterns and shortage of water availability could lead to crop failure, food insecurity, loss of property and life, mass migration and hence negative national income growth (Barnett, Dessai, and Jones, 2007; Scheider, Rosencranz, Mastrandrea, and Kuntz-Duriseti, 2010; Sivakumar and Hansen, 2007). Studies have shown that adverse climatic anomalies have increasingly decreased crop yields. For example, studies have shown that increasing temperature and decreasing precipitation events have negatively impacted wheat, rice, and maize yield in China (Chen, Chen, and JintaoXu, 2016; Wei, Cherry, Glomrød, and Zhang, 2014). Similarly, studies on wheat and maize undertaken by Gornott and Wechsung (2016) showed that crop yield decreased due to adverse climate conditions.

Climate change is occurring globally (IPCC, 2014a; Sivakumar and Hansen, 2007) including in Timor-Leste. According to the Australian Bureau of Meteorology and CSIRO (2014), Timor-Leste has experienced El Niño and La Niña in the last decade. Changing climate triggered flooding and drought that destroyed agricultural production and productivity as well as caused natural disasters through landslides and erosion across Timor-Leste (GoTL, 2010; UNDP, 2015). These have led to a decrease in agriculture production as well as damaged physical infrastructures (GoTL, 2010; Scheider et al., 2010; Sivakumar and Hansen, 2007).

Smallholder farmers in Timor-Leste have to overcome compound problems such as low input and traditional cropping methods in addition to facing climate change hazards which impacts negatively on agriculture production and productivity as well as human livelihoods which in turn leads to increased poverty (Australian Bureau of Meteorology and CSIRO, 2014; GoTL, 2010; UNDP, 2015). Currently, however, very little is known about the impact of climate change as well as farmers' coping mechanisms in Timor-Leste. According to the Government of Timor-Leste, more studies on climate change need to be undertaken in order to obtain critical information that will assist the Government to adapt to climate change (Australian Bureau of Meteorology and CSIRO, 2014; GoTL, 2010).

1.2 Conservation agriculture

One of the strategies being introduced in various countries in response to climate change is conservation agriculture (CA). Conservation agriculture is a method of land management which involves three principles - "minimum tillage and soil disturbance; permanent soil cover with crop residues and live mulches; and crop rotation and intercropping" (FAO, 2014). The aim of CA is to sustain management of agriculture lands by minimizing soil disturbance which benefits farmers and the non-farming rural population as well as conserving the environment (Friedrich and Kienzle, 2007).

Farmers have adopted and implemented CA practices around the world. This includes Latin America, Australia, USA, Europe, Asia and Africa. According to Calegari, Derpsch, and Lorenzatti (2008) and Derpsch and Friedrich (2009), in the USA and Latin America (i.e., Brazil, Paraguay and Argentina), farmers have implemented CA practices on millions of hectares. Reported benefits of CA include enhanced soil organic matter, reduced water evaporation, improved weed control, increased efficiency of using inputs, increased yields, saving time and labour, and minimizing soil erosion. However, implementation was limited by the number of advisory persons to disseminate CA methods to other small farmers; farmers also need to be involved proactively in order to understand CA methods properly. Overall, CA has generated economic and environmental benefits for farmers in the USA, Asia, Africa, and Latin America (Baker et al., 2007; Calegari et al., 2008; Hobbs, 2007; Islam and Reeder, 2014).

In Asia, for example, some farmers in China, Kazakhstan, DPR Korea and India have adopted and practiced CA. Some benefits of CA were achieved by the farmers through improved soil moisture, preserving soil chemical and biological properties, reduced soil evaporation and erosion, increased crop yield up to 10 to 31 per cent, and saved labour time although farmers do not have adequate equipment and lacked knowledge to undertake CA adequately (Huanwen, Karabayev, and Il, 2008). Generally, though CA has brought about increased farmers' income and livelihoods (Huanwen et al., 2008; Parihar et al., 2016).

Farmers in Australia and Spain have also adopted CA through no-tillage and maintaining soil cover. CA has resulted in increased yield, improved soil organic carbon, lessened evaporation, and enhanced water infiltration (Bellotti and Rochecouste, 2014). However, farmers have been reluctant to convert from their tillage machinery into appropriate machinery for CA perhaps because it takes time to increase crops yields and bring economic benefits to farmers under CA (Bellotti and Rochecouste, 2014; Carmona et al., 2015; Thomas, Titmarsh, Freebairn, and Radford, 2007). The main benefit of applying CA in crop farms is to improve farm resilience to climate change-related risks such as drought (Bellotti and Rochecouste, 2014).

In Africa such as in Kenya, Tanzania and Malawi, CA has likewise been applied. According to Okoba and Mariki (2008), CA has generated more benefits to farmers by boosting soil organic matter, enhancing crop yields, reducing cost of fertilisers, lessening labour workloads and decreasing fuel for tillage. In Malawi, for instance, farmers under CA obtained higher yield of maize (4.9 t/ha) as compared to conventional tillage (3.44 t/ha) (Ngwira, Aune, and Mkwinda, 2012). However, farmers have difficulty in accessing adequate input and equipment in the local market and also lacked markets to absorb their maize produce, which could discourage them to adopt CA. Despite these problems, farmers under CA have experienced an increase in crop yields and income (Ngwira et al., 2012; Okoba and Mariki, 2008).

Given the overall benefits of CA, there seems to be a strong rationale for introducing and promoting CA in Timor-Leste. Currently, farmers in Timor-Leste apply the conventional method of land tillage and land clearing prior to cultivating maize. This can damage soil structure, reduce soil moisture, and soil nutrients. Conservation agriculture is a suitable technique to apply for areas vulnerable to drought. However, it is important to recognise that adoption of a new technology is a complex process, especially in a situation where poverty is high such as in Timor-Leste. Thus, it is critical to examine the factors influencing adoption of CA in the country.

1.3 Research significance and research problem

Availability of food crops, particularly maize, for Timor-Leste is very important as the majority of the population consumes maize as a staple food. According to MAFF (2015b) and MAFF (2012a), about 63 per cent of households in Timor-Leste are engaged in crop production, with maize, cassava and vegetable being the most-produced crops. While rice is also a staple food, only 25 percent of households produce it. The cultivated area for maize was 36 961 ha in 2014 (MAFF, 2012b, 2015a) and currently, the average maize production is 2.81 t/ha. Maize is produced from non-irrigated and rainfed upland areas and mostly grown as a single crop per year (Keefer, 2000; MAFF, 2004). Other food crops grown in Timor-Leste are sweet potato, mung beans, peanut, and soybeans (MAFF, 2012b). Maize is mostly cultivated by the farmers as well as consumed as a main food by the population in Timor-Leste.

For this reason, the Timor-Leste government collaborated with international agencies such as GIZ, FAO and local NGOs in investing in food crops production through the delivery of technical assistance to farmers and distributing agricultural inputs such as seeds, tools, and tractors with the aim of increasing food crops production and productivity (FAO, 2011a; MAFF, 2012b). However, despite efforts on supporting farmers, the sector is still faced with challenges relating to climate change. For example, while maize production had increased in 2005 to 2009, it dropped in 2010 due to adverse weather (FAO, 2011a). The adverse effects of climate change, particularly drought and less precipitation have caused a decline in maize production in Timor-Leste (Barnett et al., 2007).

To address the climate change challenge, in 2013 the TL Government, through the Ministry of Agriculture and Fisheries, collaborated with FAO to introduce CA to maize farmers in Timor-Leste. According to FAO (2015), maize farmers in five municipalities (i.e., Baucau, Manatuto, Manufahi, Baucau and Ermera) have trialled

CA. Apart from benefiting smallholder farmers, in general, in terms of increased production, CA is expected to provide an opportunity for maize farmers household at which can contribute to develop maize farms and enhance production and income.

Adaptation strategies such as CA, however, do not merely depend on the government. Its success, to a large extent, depends on the adoption and adaptation decisions of farmer households (Barnett, Jones, and Dessai, 2003). While there have been many studies on technology adoption in developing countries, no in-depth study has yet been conducted on the adoption and impact of CA technologies on Timor-Leste. FAO (2015) has examined the impact of CA on trial farmers, but their approach is primarily descriptive. Moreover, they did not examine the factors influencing adoption, nor did they look into the extent of adoption. This study will address this gap and involve a rigorous analysis of the impacts of CA on maize farming households in TL and investigate the critical factors influencing adoption.

The main research questions we seek to answer are: RQ1: what are the climate change adaptation strategies of maize smallholder farmers in Timor-Leste?; RQ2: what is the extent of CA adoption?; RQ3: what factors influence adoption of conservation agriculture? RQ4: how does CA impact maize farming households? In particular, what are the impacts in terms of productivity, income, and workload? and RQ5: what are the barriers faced by farmers in adopting conservation agriculture and possible solutions to address these challenges?

1.4 Objectives

The general objective of this study is to examine the adoption and impact of CA on maize farming household in Timor-Leste.

The specific objectives of this study are to:

1. Determine the climate change adaptation strategies of farmers in Timor-Leste
2. Determine the extent and intensity of adoption of farmers on CA in Timor-Leste
3. Determine factors influencing adoption of CA in Timor-Leste
4. Determine the impact of CA on maize farm households

5. Identify barriers faced by farmers in adopting CA and possible solutions to address these challenges

1.5 Research contribution and implication

The expected outcomes of this research are new knowledge on the extent of adoption/ adaptation of conservation agriculture in Timor-Leste, information on the impact of conservation agriculture on maize farmers' households in Timor-Leste, better understanding of the factors that influence adoption. This study also introduced a new dimension in examining factors that influence adoption. No study has yet been conducted on the influence of entrepreneurial traits on the uptake of conservation agriculture. Hence, this study will have a theoretical contribution in this area.

In terms of practical contribution, this study will also provide an understanding of climate change adaptation strategies of maize farmers' households which will lead to a better understanding of how smallholder farmers adapt to climate change. It will also provide information on how effective conservation agriculture is and guide relevant supporting policies to adapt to climate change in Timor-Leste. It will also provide knowledge on the impact of conservation agriculture on maize farmers' households, hence, can be used to better improve farmers' welfare in the country. Understanding of factors influencing adoption/ adaptation will lead to better targeting and use of government investments. The Timor-Leste government spends millions of dollars in developing agricultural technology; if farmers do not have an appropriate understanding of climate change adaptation strategies such as CA, then investments could be wasted. This study will hopefully provide information that will assist in developing better policies on designing and promoting of conservation agriculture that would improve farmers maize production, income and food security. Finally, this study will also add to the academic literature in this field, and better inform development practitioners and international development organizations.

1.6 Structure of the thesis

This thesis is divided into eight chapters. Chapter 1 provides an introduction to the chapter while Chapter 2 provides a background of Timor-Leste agriculture and climate change and conservation agriculture. The conceptual framework and research approach are outlined in Chapter 3. The next four chapters present the results of the study, Chapter 4 presents climate change adaptation strategies of farmers in Timor-Leste, Chapter 5 illustrates the extent and intensity of conservation agriculture adoption and include the reasons for adoption/ adaptation and the barriers and constraints to CA adoption. Chapter 6 analyses the factors influencing conservation agriculture adoption, while Chapter 7 presents the impact of conservation agriculture adoption. Finally, Chapter 8 is devoted to the conclusion and implications.

The structure of the thesis is presented in Figure 1.1

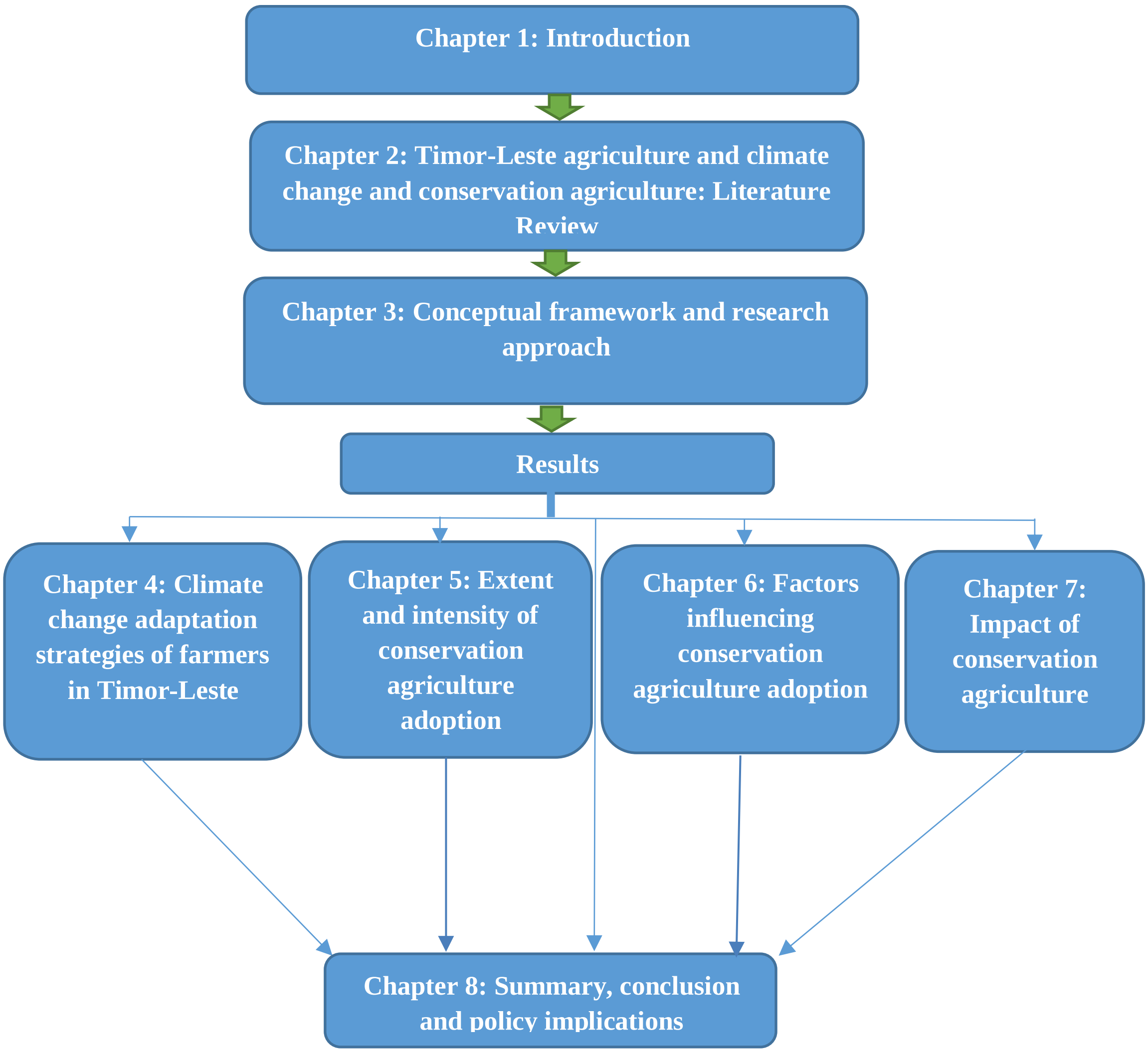


Figure 1.1: Thesis framework

Chapter 2

Timor-Leste Agriculture and Climate Change and Conservation Agriculture: Literature Review

2.1 Introduction

This chapter provides a background of Timor-Leste agriculture and a literature review of climate change and agriculture. This chapter is comprised of five sections. Section 2.1 provides an introduction to the chapter; Section 2.2 focusses on the agriculture sector in Timor-Leste while Section 2.3 describes the climate change challenge in Timor-Leste. Section 2.4 provides a review of literature of conservation agriculture, while Section 2.5 provides a summary of the chapter.

2.2 Agriculture sector in Timor-Leste

Timor-Leste is a country with a long history. It was colonised by Portugal around 350 years ago. Subsequently, it was occupied by Indonesia for another 24 years. The process of independence for Timor-Leste began with a referendum, with the majority of the population voting for independence and separation from Indonesia in 1999 under United Nations authority. Timor-Leste was recognised internationally as a country in 2002.

Timor-Leste (also known as East Timor) is located east of an island called Timor which, in the west, borders with Nusa Tenggara Timur (Indonesia province). To the north of Timor-Leste is Wetar and Savu Sea, and the southern part of the Timor Sea is Australia. Timor-Leste has one enclave and two islands including Oecussi enclave, located in the western part, as well as Atauro and Jaco islands. The national area of Timor-Leste measures around 14 500 sq. km (UNDP, 2002a; World Bank, 2011).

Administratively, Timor-Leste consists of 13 municipalities, 65 administrative post, 442 villages and 2225 sub-villages (GoTL, 2011). Its topography is largely mountainous, and the physical nature of the land has shaped its agricultural production and productivity. For example, in upland areas, farmers normally cultivate maize, cassava, and other root crops in soils with low fertility and poor soil moisture, while in the lowland areas farmers grow rice, maize and graze animals (MAFF, 2004).The climate conditions in relation to rainfall patterns are categorised into two groups: in the north, rainfall peaks in December and decreases in April, experiencing six months of the dry season. Rainfall in the south follows a bimodal rainfall pattern, with rainfall peaking in the May-June period, with three to five months of the dry season. The climate in Timor-Leste is warm, humid, and tropical throughout the dry season. The precipitation intensity is approximately 150 – 250 cm on the south coast during the wet season, with around 26°C temperature. In altitudes of more than 1300 m, the climate is cool, with an even distribution of rainfall of more than 300 cm (FAO/WFP, 2003b; Keefer, 2000b).

The population in Timor-Leste in 2010 was 1.066 million people, with the vast majority of the population, around 75 per cent, dwelling in rural areas. At about 42 per cent of them categorised poor. The growth rate of the population is 2.4 per cent annually with the density is 71 per sq. km. The current literacy rate is estimated to be 55.1 per cent (GoTL, 2011; World Bank, 2016).

Timor-Leste is categorized as a developing country situated in Southeast Asia. The leading economic sectors are oil and gas, and agriculture. These two sectors have generated income to sustain the development of the nation. The oil and gas sector is the main income source of the economy and contributes 90 per cent of the government expenses (World Bank, 2013). As a result, the government has utilized the oil and gas revenue to develop other sectors, such as agriculture, infrastructure, tourism, and to fund human capital development and private sector investment. In turn, this has gradually generated and created more job opportunities for the population in Timor-Leste as a means to promote economic growth and reduce poverty.

2.2.1 Portuguese era

The colony of Portugal resided in Timor-Leste in 1511 through Malaca in the early sixteenth century. The region was defined as less developed and remote, with substantial degradation to the environment. One of the key factors that underpinned the Portuguese occupation of Timor-Leste was the availability of sandalwood which had become the predominant economic activity in the region (Gonçalves, 1989; Meneses, 2008; Metzner, 1977). In addition to sandalwood, the Portuguese promoted and developed coffee as a leading product to export. As a result, the Governor of Portugal in Timor-Leste established Sociedade Agricola Patria e Trabalho (SAPT). This company expanded the area of the coffee plantation to cultivate more coffee, especially in regions such as Liquica, which was extended to the mountain of Ermera region (Silva, 1952; Smith, 1992). To implement the program of growing coffee, the company (SAPT) forced the population, particularly those who were rebellious, to grow coffee and coconuts (Saldanha and Costa, 1999a; Smith, 1992).

Portugal was not only engaged in coffee production but also involved in several commodities, such as copra, rubber, and others which had been exported in 1967 to 1968, as described in Table 2.1.

Table 2.1: The evolution of the importance of products exported in Timor-Leste from 1967 to 1968

Agriculture products	1967		1968	
	Quantity (t)	Share of export (%)	Quantity (t)	Share of export (%)
Coffee	3.59	79.3	2.92	86.7
Copra	1.53	9.6	1.01	6.6
Rubber	0.15	1.4	0.14	1.5
Others	2.10	9.7	0.54	5.2

Source: Secretariat of state (Portuguese), 1970

The production of coffee and other agriculture products, triggered economic growth. This was indicated by the GDP per capita at market prices which grew by 3 per cent per year, and the increase in trade volume which increased by 12 per cent. This development encouraged Portugal to develop other sectors, such as physical infrastructure, health, and communication, in order to boost economic growth. They not only developed these facilities but, finally, in the period between 1960 to 1975, which was called the Ethical Economy, the colonial government developed the welfare of the local inhabitants (Saldanha and Costa, 1999a).

The ethical economy underpinned the creation of the modern economy, such as the creation of infrastructure and trade promotion, and established financial institutions which had brought about development in Timor-Leste. As a result, purchasing power per capita in market price grew by 14.5 per cent annually in which agriculture, transportation, and education received the highest support from financial resources (Saldanha and Costa, 1999a).

Under the Portuguese colony, the development of agriculture had not only dealt with plantation crops but was also involved in crop production, such as rice and maize (Gonçalves, 1989; Metzner, 1977). The Portuguese introduced IR-5 and IR-8 rice varieties to the farmers in Timor-Leste (Gonçalves, 1989; Saldanha and Costa, 1999a). These two rice varieties had adapted well to the local conditions particularly in Viqueque and Baucau in the eastern part of Timor-Leste (Gonçalves, 1989).

2.2.2 Indonesian era

During the Indonesian era, the Indonesians launched programs extending agricultural production, plantations, livestock, and fisheries in the agriculture sector. For instance, extended rice areas and rehabilitated emergency irrigation channels for rice were established (Rio, 1999). Subsequently, strategic planning for the province for the agricultural sector was shifted to apply rice intensification and rehabilitation of agriculture infrastructures in most districts. This program brought about an increase in food stock, hence, during this period, the contribution of agriculture dominated other sectors in the economy (Pedersen and Arneberg, 1999; Rio, 1999). However, agriculture production in Timor-Leste under the Indonesia rule had not changed enormously, although there was a slight increase in production. Several factors hampered agricultural production such as low soil quality, the orientation on subsistence production and lack of inputs (Batterbury et al., 2015; Rio, 1999).

In spite of these constraints, development of the agriculture sector brought about changes in economic development, contributing to a 40 per cent rise of the GDP

(Costa, 2003). Consequently, rapid growth in public expenditure per capita fostered economic growth whereby GDP grew by 6 per cent annually, which resulted in rapid development in areas such as schooling, trade, and livestock production (Saldanha and Costa, 1999b).

On the other hand, this rapid economic development in Timor-Leste triggered social conflict. A large number of immigrants from other provinces in Indonesia came to occupy strategic economic areas and public sector positions which left many Timorese people without a job. This created social conflict between the Timorese people and Indonesian migrants due to inequalities in the distribution of income (Sherlock, 1996), further contributing to political instability in the region which had a negative impact on investors who became reluctant to invest in the territory (Alesina and Perotti, 1996).

Nonetheless, although socio-political conflict arose in Timor-Leste, development in the agricultural sector continued which enhanced economic growth. Shepherd claims that the Timorese people benefitted from being part of Indonesia, due to access to education for all Timorese and the availability of agricultural extension workers for each village. Indeed, during this period, there was further economic growth in Timor-Leste. The real GDP growth was 7.8 per cent during the period 1983 – 1990, and economic activity expanded to around 10 per cent GDP growth annually during the period 1990 – 1996 (UNDP, 2002b). This economic growth, which is reflected in the form of GDP in the economic sphere in Timor-Leste during the Indonesian rule, is noticeable in Table 2.2

Table 2.2: Timor-Leste real GDP by sector throughout the period 1995-1998 (% of total GDP)

Sector	1995	1996	1997	1998
Agriculture	27.5	24.0	24.2	24.9
Construction	21.8	23.2	22.1	21.7
Public administration and defence	21.4	22.3	22.4	22.1
Trade, hotel and restaurant	11.0	10.4	10.3	10.3
Transportation and communication	8.7	10.0	10.3	10.3
Finance and business services	3.9	3.9	4.5	4.0
Manufacturing industry	3.0	3.3	3.3	3.5
Personal, community services	1.2	1.2	1.1	1.2
Mining and quarrying	0.9	1.0	1.0	1.2
Electricity, gas and water	0.6	0.7	0.8	0.8

Source: UNDP 2002

These percentages are indicative of the total real GDP during the years 1995 – 1998, of which the agriculture sector contributed 27.5 per cent, although this gradually decreased in a stable mode from 1996 – 1998. Subsequently, the construction sphere made the second largest contribution to the real GDP in 1995 – 1998. The smallest contribution to the real GDP throughout the years 1995 – 1998 came from the electricity, gas and water sectors. Meanwhile, economic activity gradually went down. This was because the private sector (foreign and domestic) largely closed their businesses. Local and external businessmen were scared and reluctant to enter the province to invest in mid-1999 due to security issues (UNDP, 2002b).

2.2.3 Independence era

Earlier signs that the agricultural sector in Timor-Leste had potential for development materialised after Timor-Leste regained independence in 2002. The government in Timor-Leste, with support from the World Bank and other international agencies, established and formulated a first national development plan which included the agricultural sectors, along with other sectors in the medium-term (GoTL, 2002).

In the agricultural sector, several areas were identified to need more attention based on the objectives that were set up. The key indicators that needed to be addressed were increased food production, rural incomes and per capita nutritional intakes. However, the journey of developing the agricultural sector faces specific challenges, such as lack of farmers' knowledge, low inputs, shortage of agriculture materials, low soil fertility, lack of financial capacity, low crop productivity, and lack of market (FAO/WFP, 2007; GoTL, 2002). These factors contribute to reducing agricultural production and productivity. For instance, as reported by MAFF (2006) and FAO/WFP (2003a), crop production in Timor-Leste for rice was 1.5 tons per hectare, and maize at 1.3 tons per hectare. On the other hand, cassava is commonly planted as an intercrop with maize, with a total production of 41 526 tons (Table 2.3).

Table 2.3: Food crop production by district in 2003

District	**Paddy**			**Maize**			**Cassava**
	Area (ha)	**Production (tonnes)**	**Yield (t/ha)**	**Area (ha)**	**Production (tonnes)**	**Yield (t/ha)**	**Production (tonnes)**
Aileu	190	285	1.5	1 200	1 800	1.5	1 200
Ainaro	1 500	1 800	1.2	550	825	1.5	550
Baucau	8 000	14 400	1.8	6 600	9 900	1.5	6 600
Bobonaro	6 000	12 000	2.0	5 500	11 000	2.0	5 500
Covalima	2 000	2 400	1.2	7 750	11 625	1.5	7 750
Dili	120	180	1.5	750	1 125	1.5	750
Ermera	1 500	1 800	1.2	2 500	3 750	1.5	2 500
Lautem	2 000	3 000	1.5	4 000	6 000	1.5	4 000
Liquica	290	348	1.2	1 350	2 025	1.5	1 350
Manatuto	4 200	7 560	1.8	800	1 200	1.5	800
Manufahi	600	900	1.5	1 150	1 725	1.5	1 150
Oecussi	1 100	2 200	2.0	5 750	3 450	0.6	2 875
Viqueque	9 200	11 040	1.2	6 500	9 750	1.5	6 500
Upland	3 500	3500	1.0	-	-	-	-
Second crop	3 350	4 020	1.2	6 000	6 000	1.0	-
Total	**43 550**	**65 433**	**1.5**	**50 400**	**70 175**	**1.4**	**41 525**

Source: FAO/WFP 2003; MAFF 2006

These challenges not only exist with regards to food crops but also with livestock where, in mostly rural areas, farmers do not sell their livestock for commercial purposes as farmers in Timor-Leste owned small scale livestock. In addition, farmers do not develop their animals due to lack of animal husbandry skills, and they also use extensive methods in raising the animals (FAO/WFP, 2003a). The number of livestock is indicated in Table 2.4

Table 2.4: Number of livestock in 2001

Livestock	Number
Chicken	670 900
Pigs	343 100
Cattle	166 200
Buffalo	101 700
Goats	79 400
Horses	45 200
Sheep	23 700
Ducks	11 200

Source: FAO, 2003

The agricultural sector has only contributed 25 per cent of the GDP in Timor-Leste (UNDP, 2002b). For this reason, the government continues to work with stakeholders in order to enhance agricultural production and productivity. The department of crop production within the Ministry of Agriculture has addressed these issues and noted a gradual shift from subsistence farming to market-oriented farming (MAFF, 2004). The aim of this decision is to support farmers by providing training in improving agriculture production, and rehabilitation irrigation schemes in rice production areas. This is because agriculture not only provides food to the population but also enhances the GDP. The share of GDP by the agricultural sector is quite important (Table 2.5). While it was 43.2 per cent in 1999, it declined from 2000-2003, then increased again to 31.6 per cent in 2004. The second largest sector was public administration and defence, which was 24.5 per cent in 1999 and increased to 33.6 per cent in 2000 but decline again to 27.3 per cent in 2004. However, there is no data available in related to oil and gas sector from 1999 to 2004 (UNDP, 2006). On the other hand, the data was recently released by the Timorese government (2017) showed that the revenue from oil and gas was US$421.7 million. Currently, the income from oil and gas significantly contributes to the nation’s state capital.

Table 2.5: GDP share by industry and current prices (% to total GDP)

Sector	1999	2000	2001	2002	2003	2004
Agriculture	43.2	25.8	23.0	26.6	29.0	31.6
Public administration and defence	24.5	33.6	38.4	33.9	31.0	27.3
Construction	12.2	13.7	12.4	11.0	9.2	9.4
Trade, hotel and restaurant	5.6	7.8	7.1	7.1	7.5	7.5
Transportation and communication	5.4	7.2	7.1	8.2	9.3	9.4
Finance and business services	4.0	6.5	6.8	7.5	8.0	8.7
Manufacturing industry	2.8	2.8	3.1	3.3	3.6	3.7
Mining and quarrying	1.0	1.2	1.1	1.0	0.8	0.8
Electricity, gas and water	0.8	0.8	0.4	0.8	1.0	1.0
Personal, community services	0.6	0.6	0.5	0.6	0.6	0.6

Source: UNDP, 2006

The figures above reveal that the non-oil sectors still need to be developed in an appropriate fashion. Currently, economic growth in Timor-Leste is predominantly dependant on oil and gas revenues (GoTL, 2008). The Timorese government however recognises the importance of becoming pro-economic diverse and creating more opportunities to engage all economic sectors to grow in a suitable manner. Consequently, the government spent 67.6 million US dollars in 2008 to restore and promote economic diversity in order to contribute to GDP and jobs creation (GoTL, 2008).

2.2.4 Income and poverty in Timor-Leste

Poverty is related to a condition where an individual or society is deprived of resources and opportunities such as proper housing, knowledge, clean water and sanitation, nutrition, basic human rights, security, and power (UNDP, 2003). In simple terms poverty is associated with lack of income and a shortage of daily food (World Bank, 2003). These factors hinder a country’s development.

Timor-Leste is among the Southeast Asian nations categorised as impoverished, with a per capita GDP in 2001 of only $478 (UNDP, 2002b, 2006). The incidence of poverty is still high, with an estimated 42 per cent of the population considered poor (World Bank, 2016), and with two out five people poor (UNDP, 2003). The income of those people who live under the poverty line is less than one dollar per day (GoTL, 2011; UNDP, 2011). Below are some indicators that reveal the conditions within different work domains in Timor-Leste in 2010 (Table 2.6).

Table 2.6: Labour and poverty indicators in 2010

	2010
Population (000)	1 066
Labour force (000)	262
Employment (%)	
Agriculture, forestry, fisheries	50.9
Private industry	37.1
Government	10.3
Self-employed	0.9
International organizations	0.1
Poverty incidence (per cent below threshold)	
National poverty line	40
Less than USD 1 per day	37

Source: TL-LFS, 2010; TL-Census, 2010; TL-HIES, 2011

The incidence of poverty is mostly in rural areas, rather than within urban spheres. The population in rural areas experience food shortages during certain periods when maize is about to be harvested and the planting of rice has finished. These periods mostly occur from November until February for maize, and during the same periods farmers have cultivated rice (UNDP, 2006).

The population in rural areas are highly vulnerable to poverty which accounted for 38.5 per cent, as compared to the population in urban domains which accounted for 20 per cent (World Bank, 2003). This means that poverty is predominantly found within the rural spheres and is largely found in the west compared to the east (UNDP, 2003; World Bank, 2003). However, according to World Bank (2013), the figures related to the national poverty line showed that the poverty incidence in Timor-Leste slightly increased between 2001 and 2007 (from 36.6 per cent to 49.9 per cent, respectively).

Following the restoration of independence of Timor-Leste, the government outlined some strategies which they planned to implement to address poverty in Timor-Leste (GoTL, 2002). These points included reducing Timor-Leste's poverty in every municipality and promoting equitable economic development and guaranteeing that every person was entitled to a good education and high standard of health (GoTL, 2002).

The government in Timor-Leste set out to implement these strategies over five years with plans to reviewing these in another five years time, which emphasised enhancing social capital and the development of infrastructure which can lead to economic development (GoTL, 2010a). The government has strongly committed to reducing the number of the extreme poor. The budget allocated for building infrastructures in rural areas which was worth US 86.8 million in 2014 to US 70.3 in 2015 (GoTL, 2015). This commitment was put into real action by creating a rural project which involved people in rural areas working in order to obtain cash. This then elevated the purchasing power of the people in rural areas for their daily basic needs, including helping them to send their family to school, buy clothes and build houses. This government commitment is not merely invested in basic projects in rural areas, but also covers other sectors, such as education, providing safe drinking water, health, and other related infrastructures. Basic infrastructures are extremely important in providing people with better living standards (GoTL, 2010a; World Bank, 2015). Overall, the government in Timor-Leste continues to work in various economic sectors in order to reduce poverty in this country. Indeed, government efforts have reduced poverty at 42 per cent in 2014 compared to 49.9 per cent in 2007 (World Bank, 2016).

2.2.5 Timor-Leste farming system

Agriculture is important for producing food which is both sufficient in quantity as well as safe in quality. The provision of food is not only of the utmost importance, but so is providing jobs for the population within the rural spheres, where agriculture is essential to their livelihoods.

Agriculture occupied 174 000 ha for cultivation and about 124 000 ha area of bush garden. The total area which is utilised for agricultural purposes is approximately 600

000 ha (FAO/WFP, 2003b; Pedersen and Arneberg, 1999). These areas are utilised for different agriculture activities, such as cultivating food crops and livestock production.

Farmers have normally undertaken their farm's activity based on climate and topography. The farming system is classified into several domains, including those in lowland irrigated areas, upland rain-fed areas, commercial crops (e.g., coffee, coconut, candlenuts) and livestock (MAFF, 2004). However, agricultural land is less developed, in the sense that the agricultural production remains low. Moreover, the number of livestock is low, and the area of fishery is not yet fully explored. This situation is not keeping pace with the growing population in Timor-Leste which is increasing at 2.41 per cent per year (GoTL, 2010).

The reason why agricultural production is low is because most of the farmers in Timor-Leste are subsistence farmers (World Bank, 2011; Pedersen and Arneberg, 1999). Subsistence agriculture has typically low input, with farmers usually applying low levels of pesticides and fertilizers, and crops are cultivated using mainly traditional cropping methods. These practices plus conventional methods of raising livestock are a cause of low production and productivity (GoTL, 2010b; WFP, 2005). Farmers use existing methods to cultivate crops. Mixed cropping system is often practised by farmers such as planting maize mixed with legumes in the same area during the cropping season. The reason for doing mixed cropping is to obtain different crops for food security propose. Farmers always seek to secure their food crops to overcome difficult times including drought and flooding as coping mechanism to natural risks hazards. Also, farmers reserve their foods crop for the next planting season. They often run out of foods by the planting season as farmers use their food crop stock such as maize, beans, pumpkins as seeds for planting.

In this situation, it becomes more important to develop the agricultural sector in the right direction in order to increase agricultural production. To overcome the previously mentioned challenges, human capacity needs to be developed, as well as applying good agricultural practices and improving inputs (e.g., food crops varieties, fertilizer, animal breeding, machinery, credit, etc.) (World Bank, 2011). These strategies are essential to develop the agricultural sector and ensure that it becomes more efficient and effective, which can lead to enhancing agricultural production and productivity (GoTL, 2010b).

This notion requires certain endeavors from all entities, such as the government, private sectors, and farmers. World Bank (2015) and MAFF (2012) outline the number of interventions from the government and other agencies to help farmers increase their food crop production through various support mechanisms such as seed distribution, irrigation rehabilitation and training on improving agricultural methods and marketing as shown in Table 2.7 below:

Table 2.7: Interventions by the government and other agencies in the agriculture sector

Programme	**Number of interventions**	**Units**
Rehabilitate irrigation schemes	9 591	ha
Distribute tractors to farmers	2 591	units
Distribute rice seeds to farmers	180	tons
Distribute maize seeds to farmers	89	tons
Establish mini markets to enable farmers to trade agriculture produce	32	units

Source: World Bank, 2015; MAFF, 2012

These programs by the government and other agencies help and stimulate farmers to work more in the agricultural sector to enhance food crop production. MAFF (2015) reported that the productivity of food crops such as rice was 3.12 t/h, maize 2.81 t/h which is low when compared to other countries. For instance, in Vietnam, crop yields for rice is 4.87 t/h, maize 3.75 t/h, (World Bank, 2011). Therefore, development of the agriculture sector in Timor-Leste, in particular food crops, needs to be intensified to achieve yield potentials. According to GoTL (2010) farmers encounter various constraints including applying traditional methods, lack of knowledge and skills, low inputs, and poor agriculture infrastructure. Thus, the Timorese government is striving to invest more in agriculture by enhancing agriculture knowledge and skills, rehabilitating and building agriculture infrastructure as well as providing agriculture inputs to enhance agricultural production (GoTL, 2010).

2.2.6 Rice and maize production

Agricultural production in Timor-Leste is categorised broadly into four components – food crops, root crops, horticulture, livestock, forestry, and fishery. The major food crops are maize and rice. The other root crops, (e.g., cassava, sweet potato) and also legumes and horticulture are cultivated and consumed, with surplus traded in local markets by farmers. In addition, livestock, forestry and fishery contribute to the economic development in Timor-Leste.

2.2.6.1 Rice

Rice is one of the main diets for the population in Timor-Leste after maize, although only 25 per cent of the population consumes rice. According to MAFF (2006), the total land area in Timor-Leste utilised for the production of rice is 43 550 ha. Rice is mainly produced in four municipalities - Viqueque, Baucau, Bobonaro, and Manatuto (Rio, 1999). Rice is also mainly cultivated in lowland irrigated areas and in some rain-fed areas (MAFF, 2004, 2006). It is normally planted in December and harvested in May or June in the north, and August or September in the south, depending on the time of cultivation (MAFF, 2006).

There are various rice varieties due to the different administrations in Timor-Leste (i.e. Portuguese time and Indonesia time) and their policies in relation to rice cultivation. During the Portuguese time, for example, IR 8 and IR 5 was introduced and cultivated by the farmers (Saldanha and Costa, 1999a). On the other hand, the Indonesian regime in Timor-Leste also brought IR 64 and membramo rice varieties in the 1980s for farmers to cultivate (Oxfam, 2004). More, recently an improved rice variety named *Nakroma* was released to farmers in Timor-Leste (MAFF, 2013) to increase rice production and productivity. According to MAFF (2006), low rice productivity is due to several factors which hinder rice production, such as the shortage of agricultural inputs, farmers' lack of knowledge, and poor agricultural infrastructure (GoTL, 2010b; WFP, 2005).

Due to these problems, the Timor-Leste government partnered with GIZ and introduced integrated crop management and systems rice intensification to increase rice production and enhance farmers' knowledge of rice production. As Deichert, Barros, and Noltze (2009) claim, farmers under the system of rice intensification increased their rice production by 2.3 t/h. However, rice packet technology must be disseminated properly by involving farmers, extensions services and the government (Noltze, Schwarze, and Qaim, 2013) in order to achieve the potential for rice production. More recently, rice production in Timor-Leste reached 3.12 t/h in 2014 (MAFF, 2014). This is due to the government continuing to invest and commit to increasing rice production in Timor-Leste, with the aim of improving food security.

2.2.6.2 Maize

Maize is predominantly produced, consumed, as well as traded, to the local market by farmers across the region in Timor-Leste. It is considered one of the staple crops in Timor-Leste as it can be grown under East Timorese geographical conditions, which is characterised by mountainous topography, with steep slope areas (Keefer, 2000a). Unsurprisingly, over half of the total population in Timor-Leste consumes maize (MAFF, 2012) as a staple food.

Farmers normally cultivate maize from November and harvest in February (Keefer, 2000a), and they mostly cultivate maize in the upland rainfed areas. The area cultivated for maize covers 36 961 hectares, with average production of 2.81 t/h (MAFF, 2015). It is unclear which maize varieties are planted by the farmers in Timor-Leste. While farmers have several problems, such as lack of inputs, lack of knowledge, and poor infrastructure, maize varieties also need improvement (GoTL, 2010a). These issues exacerbate farmers' conditions and hinder them in increasing their maize production. Therefore, the government decided to work extensively on strengthening food security in Timor-Leste. Their policy addressed the agriculture sector, particularly maize, as one of the priorities, among the food crops (GoTL, 2010a; MAFF, 2012). The government worked together with the Seed of Life (Ausaid) program to improve maize varieties as well as maize storage to increase maize production and guarantee maize seed quality. The improved maize varieties are distributed to maize farmers in Timor-Leste, of which 37.7 tons were accounted for in 2013 (MAFF, 2014). As a result, many maize farmers in certain areas across the region in Timor-Leste cultivated improved maize varieties delivered by the Seed of Life program. MAFF (2014) reported that maize production increased with 2.81 t/h in 2014, as compared to previous maize production which was only 1.53 t/h in 2009 (MAFF, 2012).

2.3 The climate change challenge in Timor-Leste

Climate change can be described as the change in temperature and precipitation during a long period (i.e., a decade or century) that is occurring due to natural factors and processes or anthropogenic activities (IPCC, 2014; U.S. Environmental Protection Agency, 2014). Human activity contributes to the release of a significant number of gases included C_2O and NH_4 as well as N_2O in the atmosphere (IPCC, 2014; Schneider and Mastrandrea, 2010). The consequence of increasing concentration of these gases in the atmosphere (Griffin (2003), North (2003) and Schlesinger (2003) is increasing temperatures, which is known as global warming (IPCC, 2014).

Climate change affects Timor-Leste through changes to the El Niño and La Niña cycles, by increasing the severity of droughts and flooding (Barnett, Dessai, and Jones, 2007; Dolcemascolo, 2003; GoTL, 2013; World Bank, 2008). There is, however, a lack of historical data about climate variability in Timor-Leste owing to insufficient weather recorders, which should be addressed in order to generate reliable information on climate anomalies (Barnett et al., 2007). In Timor-Leste, the hazards cause by climate change will continue in the future (The Australian Bureau of Meteorology and CSIRO, 2014). Adverse weather can potentially have a pervasive effect on agricultural production and productivity in Timor-Leste.

This is because the high intensity of rainfall can cause soil erosion and landslides and less precipitation can generate drought (Barnett et al., 2007). For instance, crop production, particularly maize and rice which are the main food crops in Timor-Leste, are being damaged by the climate anomaly (FAO, 2011). This is due to farmers predominantly cultivating maize in steep terrain, which makes the land tremendously vulnerable to erosion and landslides (UNDP, 2015). In addition, maize production has severe problems due to dry spells, reducing production and productivity.

Climate variability not only destroys the main crops but also can affect other agricultural production, such as forestry, as a result of landslide and erosion (World Bank, 2008). Hence, adaptation and mitigation action in the agricultural sector should be undertaken, in order to sustain food security. An alternative to adapting to climate change in the agriculture sector is needed to help farmers in Timor-Leste (UNDP, 2006).

There are various approaches to reducing the impacts of climate change such as mitigation and adaptation regimes that help sustain human life, animal life and ecosystems (IPCC, 2014). However, adaptation methods need to be undertaken on whole sectors such as in the agricultural sector, infrastructure domains, marine areas, and manufacturing as these sectors require serious adaptation efforts in order to deal with climate variability (King, 2005). Moreover, real efforts to reduce impacts and adjust to climate anomalies should involve all entities, such as government bodies, the private sector, international agencies and communities around the world (Mace, 2010). As climate change is a global problem, it is not a simple problem that only belongs to certain communities. The mechanisms of action to overcome climate change-related risk have to be based on sound a policies and strategies to deal with the negative impacts of climate change (IPCC, 2014).

In the context of Timor-Leste, climate change is a national problem that needs to be dealt with urgently, because of adverse weather impacts on agricultural production. In response to this challenge, the Timorese government has established a climate change national communication under United Nations Framework Convention on Climate Change reporting on the development status of greenhouse gas emissions to the conference of the parties (GoTL, 2013). With this establishment of initial communication, there are several adaptation and mitigation activities which will be conducted in Timor-Leste to overcome climate variability. The mechanisms include building appropriate technology, research, training, public awareness and information diffusion (GoTL, 2013; UNDP, 2009).

Currently, little research has been conducted on climate change and its impact on socio-economic factors in Timor-Leste (GoTL, 2013). Given the agricultural sector’s vulnerability to climate change, it is increasingly important to do more research not only on climate-related hazards but also on adaptation strategies in Timor-Leste. In the agriculture realm, conservation agriculture is one of the methods utilised to deal with climate change impacts through enhancing carbon sequestration in the soil (Reicosky and Saxton, 2007). However, using CA requires good management to effectively elevate soil organic carbon in the soil (Powlson, Stirling, Thierfelder, White, and Jat, 2016).

2.4 Conservation agriculture

2.4.1 Background and definition of conservation agriculture

Conservation agriculture is one of the methods to preserve soil nutrients and water to support plant growth in a sustainable manner. CA is "a concept for resource-saving agricultural crop production that strives to achieve acceptable profits, high and sustained production levels while concurrently conserving the environment" (Friedrich and Kienzle, 2007, p. 3). The importance of applying conservation agriculture technique is to maintain soil nutrient, enhance water infiltration, increase soil organic matter as well as preserve the environment (Reicosky and Saxton, 2007). FAO describes conservation agriculture as a package of technologies that is composed of three principles including "minimum tillage and soil disturbance; permanent soil cover with crop residues; and live mulches, crop rotation and intercropping" (FAO, 2014, p. 1 - 3; Friedrich and Kienzle, 2007, p. 3). All these aspects are related to soil management to overcome drought risk caused by climate change (Kassam, Friedrich, and Derpsch, 2010).

Numerous farmers around the world including Latin America, Australia, USA, Europe, Asia and Africa have adopted and implemented conservation agriculture in their crop production. In the USA, Brazil, Paraguay and Argentina, over millions of hectares of lands has been dedicated to conservation agriculture (Calegari, Derpsch, and Lorenzatti, 2008; Derpsch and Friedrich, 2009). The impact revealed increased soil organic matter and soil fertility, reduced water evaporation, improved input use efficiency, better control of weeds, labour and time savings, controlled erosion as well as enhanced crops yield (Calegari et al., 2008; Hobbs, 2007). For instance, a study conducted in USA comparing tillage and no tillage production showed that minimum soil disturbance with crop residues retention in the soil had protected the soil from erosion and decreased CO2 loss (Reicosky, 2001). However, research in CA has not adequately responded to farmers' needs. There has also been limited support in disseminating CA information to other smallholder farmers (Calegari et al., 2008) Thus, collaboration between farmers, stakeholders and donors need to be improved to successfully implement conservation agriculture.

Farmers in Australia and Spain also practiced conservation agriculture due to extreme weather and variability of rainfall (Bellotti and Rochecouste, 2014). Impacts reported include increased crop yield, enhanced soil moisture and soil organic matter, reduced water evaporation and enhanced water infiltration (Bellotti and Rochecouste, 2014; Carmona et al., 2015; Thomas, Titmarsh, Freebairn, and Radford, 2007). However, in Queensland for instance, farmers raised concerns in converting the existing machinery to appropriate equipment for CA and soil cover crop with residues (Thomas et al., 2007). Despite these barriers, conservation agriculture method is beneficial in responding to climate variability risk such as drought and erosion (Bellotti and Rochecouste, 2014).

In Asia including China, Kazakhstan, DPR Korea and India, conservation agriculture method has been adopted and practiced by the farmers. Positive impacts include increased crops yield, improved soil moisture conditions, and reduced production cost in terms of labour, fuel and time (Huanwen, Karabayev, and Il, 2008; Parihar et al., 2016; Zheng et al., 2014). Zheng et al. (2014) reveals that CA significantly increased wheat and maize yields by 4.5 per cent and 9.4 percent, respectively compared to conventional tillage in China. They found that CA practices with crop retention is suitable for areas with a warm and dry climate pattern. Likewise, Rusinamhodzi et al. (2011) revealed that reduced tillage with crop rotation increased maize yield under dry conditions. Huang et al. (2011), however, found that there was no difference in rice yields between CA and conventional tillage. Further, a study by Paudel et al. (2014) in Nepal found that CA systems had resulted to reduced maize yield in comparison to conventional tillage. Also, Chen et al. (2011) indicated that maize yields reduced with CA method compared to conventional tillage. Overall, while many farmers under CA had a good opportunity to increase yield, income as well as preserve their environment (Rusinamhodzi et al., 2011; Zheng et al., 2014; Parihar et al., 2016; Zheng et al., 2014), it appears that in some situations, there was either no difference in performance or in some cases, reduced yields for CA farmers (Huang et al., 2011; Chen et al. 2011; Paudel, 2014). Moreover, appropriate equipment for conservation agriculture was limited to support smallholder farmers and government policy and extension system did not disseminate conservation agriculture information properly (Huanwen, Karabayev, and Il, 2008).

Some farmers in Africa (e.g., Kenya, Tanzania, Malawi and South Africa) have adopted and implemented conservation agriculture technique as well. Sithole, Magwaza, and Mafongoya (2016) reported that the implementation of CA has increased maize yields in South Africa. Also, some advantages of CA included timely sowing, increased input use efficiency, and weed control (Erenstein and Laxmi, 2008). This was reported by Okoba and Mariki (2008), who claimed that the advantage of CA was enhanced soil organic matter, reduced cost of fertilisers, saved labour and time, decreased fuel cost for tillage and boost crops yield. Farmers that implemented CA had higher yield of maize (4.9 t/ha) in comparison to conventional tillage (3.44 t/ha) in Malawi (Ngwira, Aune, and Mkwinda, 2012). However, it was difficult for smallholder farmers to integrate livestock and mixed cropping systems. Additionally, the local market did not provide particular equipment for CA. The limited supporting policies and implementing institutions was also an obstacle that hindered adoption of CA (Okoba and Mariki, 2008).

In terms of income, a study by Nawaz et al. (2017) in Pakistan found that the impact of CA was not only enhanced crop yield but also increased farmers' income. Mazvimavi (2010) reported that the introduction of CA programme to maize farmers in Zambia and Zimbabwe resulted in enhancing farmers' income in comparison to conventional tillage. Likewise, Kumar et al. (2018) found that the impact of applying CA based maize – wheat system was to increase farmers' income to up to 34 per cent and reduce production cost by about 13 – 15 per cent.

Labour utilisation was also reduced for about 30 per cent of farmers who applied CA in wheat crop production in India (Keil, D'souza, and McDonald, 2015). Similarly, a study in India found that CA adoption saved labour time in rice – wheat production systems along with reducing production costs due to lesser time in preparing the land

and crop establishment. As a result, farmers can do other agricultural operations, giving more time to tend livestock (Erenstein and Laxmi, 2008; Laxmi, Erenstein, and Gupta, 2007). However, a study by Habanyati et al. (2018) in Zambia found that farmers discontinued to adopt and practice CA due to high demand for labour during land preparation and weeding. On the other hand, Huang et al. (2011) reported that the average labour utilisation per hectare was lower in CA compared with that in conventional methods of rice crop production.

Given that the impact of CA varies across regions and places in relation to crop production, income and labour utilisation, it appears that CA is not a one-size fits all package. Hence, it is critical to examine the impact of CA in Timor-Leste to determine whether CA can be expanded in Timor-Leste to increase crop yield, income and reduce workload of farmers.

2.4.2 Conservation agriculture in Timor-Leste

As mentioned previously, in Timor-Leste, the agriculture sector is one of the important areas that contributes to economic development. It provides jobs for the Timor-Leste population (World Bank, 2018). Real action to develop the agricultural sector in Timor-Leste involves various entities such as the government, international agencies, NGOs, private sectors as well as farmers. In crop production in particular, the government has collaborated with FAO to introduce conservation agriculture in several municipalities including Manufahi municipality and Manatuto municipality in 2013 (FAO, 2015) following a long period of dry spell in the last decade which heavily impacted crop production.

The conservation agriculture program was introduced in Timor-Leste in 2013 targeted towards farmers who cultivated maize in selected areas in the country. At the initial stage, farmers were involved in farmers groups for ease of management and control. At the time, the Ministry of Agriculture and Fisheries also procured and distributed to farmers two recommended improved maize varieties (i.e., *sele* and *noi mutin*) to cultivate (FAO, 2015).

Farmers were included in farmer field schools to directly practice conservation agriculture and learn by doing. FAO staff and two NGO implementation partners guided farmers in carrying out the tasks including no burning and minimum tillage, soil cover or mulching and intercropping with legumes. Additionally, farmers not only concentrated on the agronomic parts on the practice of conservation agriculture technique but were also trained on how to operate and test appropriate conservation agriculture machineries and tools such as using the rolling crimper, jab planter and lii seeders to cut organic matters for mulch and cultivating maize (FAO, 2014).

Since the introduction of CA in Timor Leste, very few studies have been conducted on CA. Apart from the annual reports on the program produced by FAO (2015**)**, only one study, had been conducted on the effects of CA in Timor-Leste. Urdín (2016) used field experiments and focused on whether CA technology can increase farmers' efficiency in crop production and their adaptation capacity to variable climate conditions. Their results showed that CA reduced labour and fuel use as well as enhanced maize yield.

To date, there has been no rigorous study that examined the impact of CA on crop production, income and workloads in Timor-Leste. Hence, this study can contribute information to the academic literature in this field and will provide Timorese government valuable information to better inform policy on the promotion of CA to increase crop yield and income of farmers in Timor-Leste.

2.5 Summary and conclusion

Agriculture in Timor-Leste has a long history that can be traced back from the Portuguese regime, Indonesian time, and the independence era. Agriculture provides jobs for the population in Timor-Leste. However, the agricultural sector faces many problems particularly low production and productivity due to lack of inputs, shortages of agriculture infrastructure, and farmers' lack of knowledge and skills with regards to new agriculture methods. Along with this, farmers are reluctant to go into market-oriented production due to lack of credit and shortage of market to accommodate their agriculture produce.

To compound these issues, farmers are now encountering climate change in in the form of long dry period, flooding, soil erosion as well as landslide. These incidents are pushing farmers into a more vulnerable position. Climate adverse conditions can reduce agricultural production and productivity. Hence, appropriate adaptation mechanisms are needed. One such adaptation mechanism in response to climate change-related risk is conservation agriculture. Conservation agriculture applies certain methods which can preserve soil fertility, reduce evaporation and enhance soil organic carbon, with expected benefits in terms of better yield.

Conservation agriculture can, in theory, increase farmers' resilience to climate variability, as well as boost crop production. In its quest to adapt to climate change, conservation agriculture has been introduced to maize farmers in Timor-Leste. Maize is one of the main crops in Timor-Leste grown in both upland and lowland areas which rely mostly on rain for irrigation. While many studies around the world have shown potential benefits of conservation agriculture, no rigorous study has yet been conducted on the impacts of conservation on farming households in Timor-Leste, particularly on productivity, income and workloads. Moreover, the mixed results on the impacts of CA around the world, mean that what applies to other countries may not necessarily apply in Timor-Leste. Certain barriers including lack of inputs, availability of CA machinery, lack of knowledge, and other infrastructural and institutional barriers (as in the case of Timor-Leste) could also influence the impacts of CA as well as the adoption of CA. Hence, there is a need to examine the impacts of CA in Timor-Leste in areas where they have been introduced. To fill the gap, this study examines the extent and intensity of CA adoption in Timor-Leste, understand the factors influencing adoption, and examine the impacts of CA.

Chapter 3

Conceptual Framework and Research Methods

3.1 Introduction

This chapter is devoted to the research approach used in this study. The selection of the research method is outlined in Section 3.2, which starts with a discussion of alternative approaches available, followed by the approach chosen for the study. Section 3.3 presents the conceptual framework, while Section 3.4 defines the research design used in the study. Sections 3.5, 3.6 and 3.7 explain the preliminary procedures and as the in-depth survey as well as the data gathering. Research ethics and clearance is then presented in Section 3.8 and Section 3.9 data analysis and analytical techniques. Finally, the chapter ends with the organisation of the study in Section 3.10.

3.2 Selection of research method

New agricultural technology provides alternative solutions to respond to problems in production, cost, and income (Maredia, 2009). Implementation of agriculture innovation can drive change in agriculture to increase efficiency, improve productivity and increase profit. However, its impact has to be tested in order to understand whether it generates a positive impact on farmers' livelihoods or if it is not applicable in practice. Thus, the need for impact evaluation to assess the effects of new technology on the beneficiaries. This is to ensure the new technology has an advantage over the existing method and whether it can be expanded across different areas. Therefore, a suitable method of assessment is critical to evaluate program interventions.

3.2.1 Research approach

There are several approaches to studying the impacts of technology: qualitative methods, quantitative methods, and mixed methods.

Qualitative techniques are often used to collect data through in-depth investigation in order to obtain information about reasons, motivations, perceptions, beliefs and behaviours of people (Donley, 2012). Conducting qualitative research involves discussing the issues under investigation with participants and interpreting the phenomena being studied. This can be done by examining documents, observing behaviour, and interviewing participants (Creswell, 2007; Saunders, Lewis, and Thornhill, 2016). There are different interview techniques used to capture detailed information including focus group discussions, interviews with key informants, case study, rapid appraisals and participant observations (Creevey and Woller, 2006; Donley, 2012).

There are various studies on impact analysis using qualitative methods. A study conducted by Lalani, Dorward, Holloway, and Wauters (2016) in Mozambique, used qualitative techniques to measure farmers' perceptions of the impact of conservation agriculture in relation to productivity, labour, quality of soil, and weed incidence. They used qualitative techniques with 14 key informant interviews and two focus group discussions (Lalani, Dorward, Holloway, and Wauters (2016). A study in Germany used qualitative approaches to investigate the five main attributes (relative advantage, compatibility, complexity, trialability and observability) and to investigate farmers' perceptions on CA. The data was collected through case study method (Sattler and Nagel, 2010).

According to Johnson and Onwuegbuzie (2004), qualitative methods use the principles of induction, discovery, exploration, theory/hypothesis generation. Also, qualitative research does not generally use a standard statistical procedure to generate results for different settings. Research findings are used to explore uncontrolled event in real-life context-specific settings. (Harris et al., 2009). For example, data could be gathered and analysed from text, audio or visual settings (Harris et al., 2009; Saunders, Lewis, and Thornhill, 2016). The advantage of qualitative methods is that it allows observing and exploring the phenomena to build a theory. The researcher explores a phenomenon to understand better the nature of the issue instead of directly testing a hypothesis. Open-ended questions are used to engage participants' perspectives in order to obtain detailed information (Saunders, Lewis, and Thornhill, 2016).

The limitation of qualitative methods is that the research results are specific to the relatively few people that were involved in the study. Also, subjective interpretation of the results can lead to personal bias. It is also difficult to test a hypothesis and make quantitative predictions, and it is time-consuming to generate the results (Johnson and Onwuegbuzie, 2004).

Quantitative methods focus on a deductive approach, confirmation, theory/hypothesis testing, explanation, prediction, standardized data collection, and statistical analysis (Johnson and Onwuegbuzie, 2004; Saunders, Lewis, and Thornhill, 2016). Quantitative methods involve statistical procedures to generate statistical models using numerical data. Data can be gathered through a survey by using a structured questionnaire or close-ended questions to obtain variable specific data. Random sampling or probability sampling is often used to obtain a sample (Harris et al., 2009; Tashakkori, Teddlie, and Johnson, 2015). Standard statistical procedures such as econometric analyses and other parametric statistical analyses or non-parametric analyses are used to analyse the data (Saunders, Lewis, and Thornhill, 2016).

For example, quantitative technique was used to examine the effect of improved corn varieties on certain outcome variables such as crop income, household expenditure, poverty, and food sufficiency in Zambia (Khonje et al., 2015). Cross-sectional data on maize farming households was collected and analysed using econometric models such as logit regression. Likewise, Kassie, Shiferaw, and Muricho (2011) used a quantitative technique in examining the causes and effects of new types of groundnut on net income and poverty status in Uganda using cross-sectional data from groundnut farming households and analysed the data used parametric statistics including logit regression. Those empirical studies examined cause and effect relationships between variables.

The advantage of quantitative methods is that it is more likely to concentrate on using the data to test hypothesis or theory through statistical significance (Saunders, Lewis, and Thornhill, 2016). Johnson and Onwuegbuzie (2004) pointed out that hypotheses testing in quantitate research can be constructed prior to data collection. The result can be generalised and replicated to a large population. A researcher can assess and build models to examine cause-effect relationships credibly. Also, while data gathering can take time to conclude, it can provide precise numerical data.

The disadvantage of a quantitative approach is that researchers concentrate more on theory or hypothesis testing which can lead to a lack of understanding of the underlying phenomena for the study. Also, research findings directly reflect the specific local situations and context. Therefore, it is only limited capture to researcher interpretation and theories which reflects impersonal orientation (Johnson and Onwuegbuzie, 2004). Quantitative study can also be costly when it involves many respondents.

Alternatively, instead of using either qualitative or quantitative, a combination of the two research methods can complement each other. Employing mixed methods research is useful to undertake a more comprehensive study in order to capture issues adequately (Harris et al., 2009; Tashakkori, Teddlie, and Johnson, 2015). Mixed methods combine the best potential of qualitative and quantitative methods. It is designed to directly answer a multifaceted research question that cannot be answered by using only a single method (Tashakkori, Teddlie, and Johnson, 2015). For example, a study undertaken in Zimbabwe to examine household and institutional factors that affect adoption of sustainable agriculture among the farmer beneficiaries using mixed methods to gather the data and involving semi-structured interviews and focus group discussions (Mazvimavi and Twomlow, 2009).

The strength of mixed methods research is that it provides a better understanding of a phenomenon under investigation in a comprehensive manner. As Johnson and Onwuegbuzie (2004) pointed out, researchers can freely design and answer research questions more completely when not restricted to any single method or approach. This can lead to stronger evidence for a conclusion from divergent findings. Also, the result can be presented in different forms such as numbers, words, pictures, and narratives. Thus, mixed methods can reduce the weakness of both qualitative and quantitative to generate better evidence and conclusions from a study (Johnson and Onwuegbuzie, 2004; Tashakkori, Teddlie, and Johnson, 2015). On the other hand, mixed methods research is time consuming and relatively more expensive compared to using only a single method such as either a qualitative or quantitative method (Johnson and Onwuegbuzie, 2004).

3.2.2 Research approach chosen for the study

The research approach chosen for this study involves two techniques for data collection and included qualitative and quantitative methods to examine the impact of CA technology adoption. The qualitative approach was used to explore information about the influence of CA on maize farm households, also on how CA technology influences farmers' intentions and behaviour, which can affect their livelihoods.

Quantitative methods, on the other hand, gave the opportunity to the researcher to offer and measure, in detail, the quantitative impact of CA. There are two types of data in impact analysis which can be done either through longitudinal or cross-sectional surveys. A survey can be conducted in actual time or a single point in time (cross-sectional research) or over time (longitudinal study) such as comparing change or panel data over time (Creevey and Woller, 2006; Saunders, Lewis, and Thornhill, 2016). In a cross-sectional study, a comparison is made of beneficiary groups and non-beneficiary groups in actual time.

Program evaluation can still be conducted without baseline data to assess the difference in outcome between treatment groups and control groups (UNDP, 2002) using cross-sectional or longitudinal, which have different characteristics in regards to time. According to Heckman and Robb (1985), longitudinal data with smaller samples of estimators is less efficient compared to cross-sectional data or repeated cross-sectional data with large samples of estimators.

Impacts of agricultural technology can be examined through experimental designs and quasi-experimental designs. In experimental models, the target sample is randomly assigned to participate in a program intervention. This gives a chance to the researcher to observe the treatment effect based on similar characteristics. The advantage of using an experiment, according to Creevey and Woller (2006), is it is more scientific in nature, which minimizes selection bias.

Randomised sample selection allows evaluation of impacts between the average samples from the intervention group and non-intervention (control) group (Baker, 2000). The goal of randomised methods is to evaluate whether the effect on the participant is from the program intervention and not from other unobserved factors. The idea is to minimize selection bias as the treatment group and control group have the same opportunity to be selected (Khandker, B. Koolwal, and Samad, 2009). Sample treatment ensures that the effects occurred as a result of the intervention program and not from other confounding elements.

The disadvantage of an experiment using randomised design is that it is difficult to manage participants in the program. For example, actual program participation may not be entirely random. As a result, individuals or households in control areas may move to program areas, which can affect their result from exposure to the program. For instance, Baker (2000) pointed out that in certain practical conditions, randomised approaches may not occur smoothly due to the movement of the participants in and out of a program area which can contaminate the outcomes. Also, individuals may not directly participate in the program but may indirectly be affected by the program due to the effect of time variance (Khandker, B. Koolwal, and Samad, 2009; World Bank, 2006). Moreover, experimental design needs more time and budget when collecting new data.

An alternative is quasi-experimental design whereby comparison groups have similar observed characteristics to the treatment group. By doing this, several econometrics approaches can be applied such as matching methods, double-difference methods and instrumental variables methods, regression discontinuity and pipeline methods in order to determine the difference between treatment group and control group. These measurements are used after concluding program intervention without randomizing methods to select the treatment and comparison group (Baker, 2000; Khandker, B. Koolwal, and Samad, 2009).

A limitation of the quasi-experimental design is when the treatment group and control group do not have similar characteristic, which leads to selection bias (Creevey and Woller, 2006). Selection bias may also arise due to self-selection, when individuals or groups make the decision to participate in the program (Baker, 2000; World Bank, 2006). However, the advantage of quasi-experimental design is that it can be used after a program has been implemented and there is no baseline data.

This study was conducted after conservation agriculture technology had been implemented in the area. Hence, an experimental design and randomised control trial were not possible. Therefore, a quasi-experimental approach with matching methods was used. The population of both participant groups (CA farmers) and non-participant groups (non-CA farmers) were selected for the study sample using random sampling.

3.3 Conceptual framework

There are several empirical studies on adoption of agricultural innovations using adoption theories as a fundamental aspect to underpin adoption knowledge (Kessler, 2006; Sattler and Nagel, 2010; Sheikh, Rehman, and Yates, 2003). According to Tarhini et al. (2015) theories and models used in technology adoption include the Diffusion of Innovation theory (DOI) (Rogers, 1995), Social Cognitive Theory (SCT) (Bandura, 1986), Theory of Reasoned Action (TRA) (Ajzen and Fishbein, 1975), Theory of Planned Behaviour (TPB) (Ajzen, 1991), and the Technology Acceptance Model (TAM) (Davis, Bagozzi, and Warshaw, 1989).

Diffusion of innovation theory suggests members of a population within a social system often receive innovation from certain channel overtime (Rogers, 1995; Rogers and Shoemaker, 1971). According to this theory, the process of adopting innovation occurs in stages knowledge, persuasion, decision, implementation, and confirmation (Tarhini et al. 2015; Rogers, 1995; Rogers and Shoemaker, 1971). An individual can adopt or reject an innovation based on this decision-making process. The speed and rate of adoption also depends on the characteristics of the technology including relative advantage, compatibility, complexity, trialability and observability (Rogers, 1995). However, this theory does not go deep in terms of understanding decision-making attitudes about adoption of a new technology (Tarhini et al. 2015).

Social cognitive theory (SCT), on the other hand, investigates actions and reactions of people and recognises that individuals behave differently (Bandura, 1986 in Tarhini et al. 2015). SCT looks at three components in the diffusion of innovation and recognises the triadic relationship between behaviour, personal factors and environmental factors (Bandura, 1986).

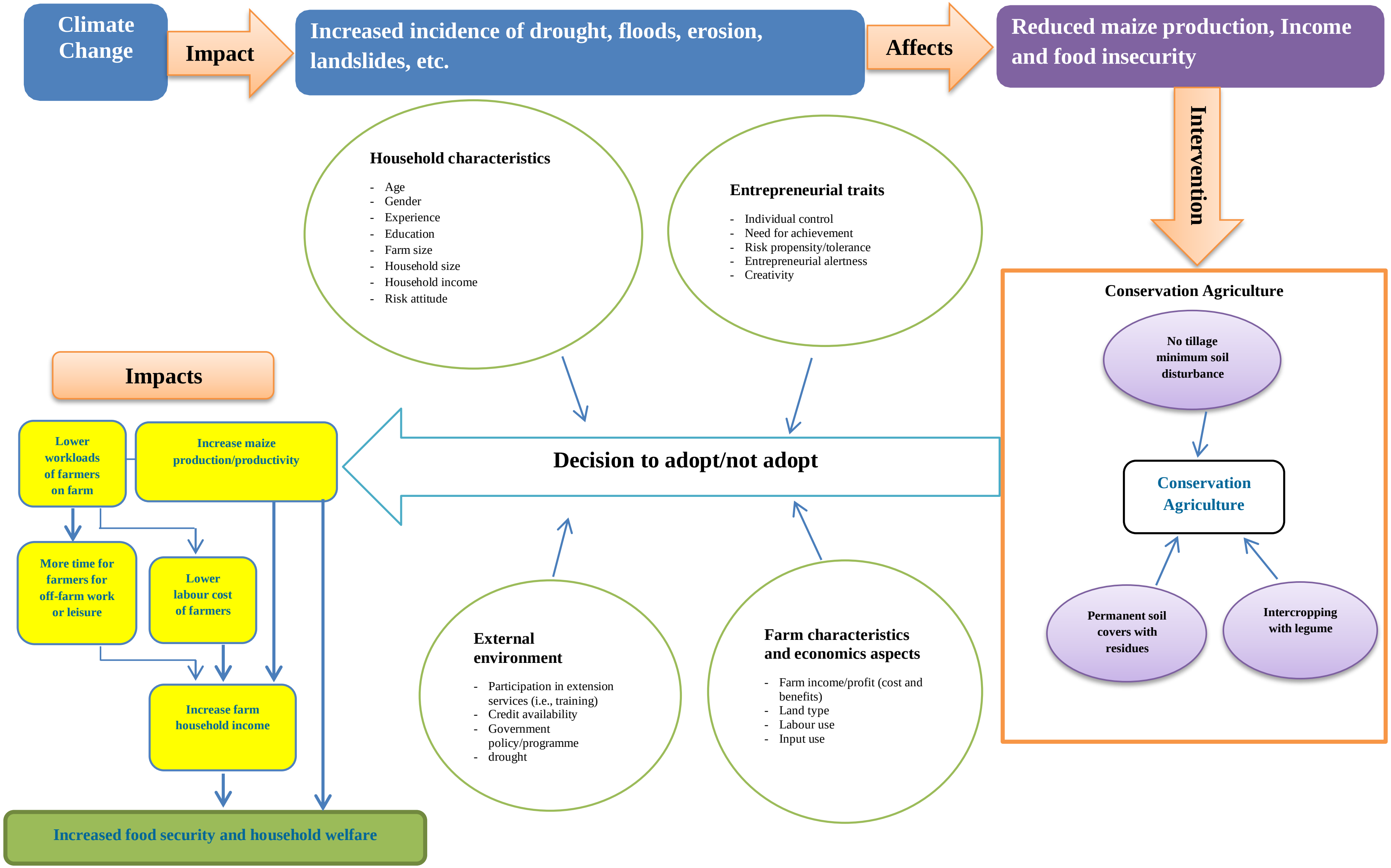
The theory of reasoned action (TRA) posits that generally, people think about the implications of their action prior to making any decisions or behaving in a certain manner (Ajzen and Fishbein, 1975). According to this theory, there are three key constructs that influence actual behaviour – behavioural intention, attitudes, and subjective norms, and that there is a significant relationship between a person's attitude towards behaviour and their intention (Sheppard, Hartwick, and Warshaw, 1988). TRA has been widely used (Ajzen, 1985, 1991), but has also been criticised in terms of its limitation on predicting individual behaviour in cases where intention is not known (Ajzen, 1985) and on predicting future usage behaviour (Foxall 1997; Ajzen and Fishbein 1980 in Tarhini 2015).

The theory of planned behaviour extends TRA and considers perceived behavioural control, defined as the perceived "ease or difficulty of performing a particular behaviour" (Ajzen, 1991, p 183). This theory allows a more in-depth understanding of the intricacies of human behaviour such that one can predict behaviours in specific contexts (Ajzen, 1991). Despite improvements of TPB over TRA, the theory still has limitations. As Ajzen pointed out, while there are relationships between the various components of the theory (e.g., behavioural beliefs and attitudes toward the behaviour), the nature of the relationship has not been fully resolved. It also does not consider habit, moral obligation and self-identity (Eagly and Chaiken 1993 in Tarhini 2015).

Another theory that to some extent addresses the limitations of TRA is the technology acceptance model (TAM). Specifically designed for information systems, TAM, allows tracking of the impact of attitudes, behavioural intention, perceived usefulness, perceived ease of use, internal beliefs, and external variables (Davis et al., 1989).

The study is based on adoption theory and brings elements of some of the theories mentioned above, as illustrated in Figure 3.1. As depicted in the figure, changing climatic conditions is bringing about increased flooding, drought and other climate-induced extreme conditions. This, in turn, is affecting agriculture, particularly crop production (Schneider and Mastrandrea, 2010). As a response, the government of Timor-Leste introduced conservation agriculture to maize farmers to adapt to climate change and enhance maize production.

Figure 3.1: Conceptual framework of the impact of climate change and CA adaptation strategies on maize farmers



The adoption of conservation agriculture by maize farmers is likely to be influenced by household characteristics, farm characteristics and economic aspects, psychological/behavioural aspects, entrepreneurial traits, and the external environment. The household characteristics hypothesised to influence CA adoption are age, gender, education, training, household size and household income. Farm characteristics and economic aspects consist of farm income/ profit (cost and benefits), land tenure, labour use, and input use, complementary technology (e.g., irrigation). The psychological/behavioural aspects include goals and motivations, interest in conservation agriculture technology, and risk attitude. Entrepreneurial traits include individual control, need for achievement, risk propensity/tolerance, entrepreneurial alertness, creativity. The external environment comprises of participation in extension services, credit availability, and government policy/programme.

The workload of maize farmers is also expected to decrease resulting in reduced labour cost as well as less time for farmers and other household members to work on their maize farm. This could lead to farmers having more time to work in off-farm activities or time to spend on social activities, leisure or engage in other income-generating activities. This, in turn, will increase farm-household income and ultimately, food security and household welfare.

3.4 Study design

Three data gathering methods were applied in this study consisting of qualitative and quantitative approaches – rapid rural appraisals, in-depth interviews, and a survey. A literature review was also conducted.

Rapid rural appraisals and preliminary interviews with key personnel from various agencies were applied to acquire basic information on the implementation of the conservation agriculture program in Timor-Leste. During this stage, secondary data were collected from different entities including from government and non-government agencies and international agencies working in Timor-Leste. To understand the Timor-Leste context, reports on agriculture and the Timor-Leste economy, as well as the implementation of conservation agriculture in Timor-Leste, were collected. The literature review incorporated secondary data and background information. Quantitative information was gathered from in-depth surveys. The target sample for this survey was maize farmers residing in two municipalities in Timor-Leste.

3.5 Preliminary interviews and secondary data gathering

Semi-structured questionnaires were used in the preliminary interviews and discussions with government staff from government agencies and with an international agency, Mercy Corps, which was involved in the implementation of conservation agriculture in Timor-Leste. To understand detailed information from government partners involved in the agriculture sector in Timor-Leste, key persons from FAO and local NGO were also interviewed. For rapid rural appraisals, community leaders, local government officers, and key farmers in the target municipality were involved to have an initial general idea of the program and its impact on farmers in the municipality. Key farmers were included in this initial informal interview to have an overview about the CA program in Timor-Leste.

The information obtained from secondary data included agricultural production, inputs, and background information and reports on government policies and programs related to agricultural and rural development in Timor-Leste. This information was collected from The Ministry of Agriculture, Fisheries and Forestry as well as other partners such as FAO and the World Bank. This inter-related information was important and helpful to enrich the understanding of agriculture in Timor-Leste. The information also included background on the implementation of conservation agriculture and its impact on agricultural production in the implemented areas. This information provided valuable insights and helped in selecting the municipalities and administrative posts to carry out the in-depth survey. The preliminary data collection was undertaken in June 2017.

3.6 In-depth survey

The in-depth survey was conducted in two municipalities, Manufahi and Manatuto. Manufahi municipality is in the Southern region, while Manatuto municipality is in the Northern region. Five villages were selected, three villages in Manufahi and two villages in Manatuto. The selection of sites was based on preliminary consultations and discussions with staff from MAFF, FAO, international agencies, and a local NGO involved in the introduction of conservation agriculture in Timor-Leste.

Manufahi and Manatuto are centres of crop production (e.g., maize, rice and legumes) where conservation agriculture practices were first introduced in Timor-Leste. Manufahi municipality is in the southern slopes, with altitudes of 100–500 m, average temperatures from 22°C to 26°C and annual rainfall is 1500 – 2000 mm on average. November to April is the wet season and May to July is the second wet season wet season is (Keefer, 2000). Manatuto municipality is in the north, extending across the centre of the country. It has a mono-modal rainfall pattern, with average annual rainfall >1000 mm, and average temperatures from 25°C to 29°C. Most rain occurs in the 4–5 months from November until March (Keefer, 2000). Both municipalities are characterised by mixed farming systems where farmers grow crops and raise livestock (e.g., mixed crops of maize, cassava, sweet potatoes, beans, pumpkins) and cattle, buffalo, goats, sheep, pigs and poultry. Farmers are mostly subsistence farmers, and agriculture heavily depends on rainfall (Keefer, 2000; MAFF, 2012). The location of the study sites are shown in Figure 3.2.

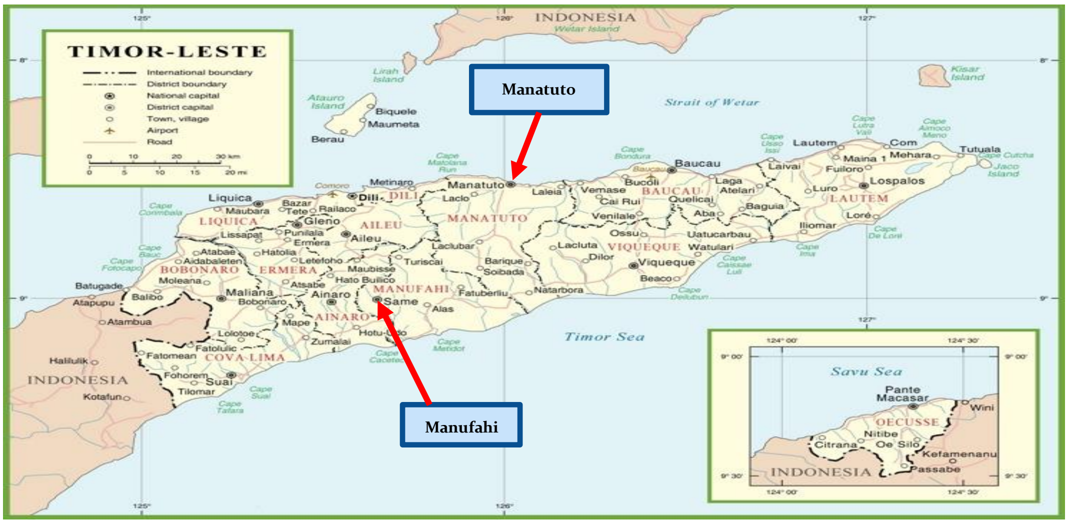


Figure 3.2: Map of the study area

The reasons for the choice of Manufahi and Manatuto municipalities were:

1. The three villages have high potential for agricultural production, particularly maize production.
2. Conservation agriculture has been introduced in these areas; initially with Manufahi, and then more recently in Manatuto.
3. Farmers in these respective areas often receive assistance and support from the government to develop agricultural production, including inputs, training, and information.
4. Farmers have also experienced climate change-related risk such as drought.

The target sample was maize farmers who practiced conservation agriculture and those that did not use conservation agriculture. Farmers were randomly selected from the population in the selected areas. The survey was undertaken in June – September 2017.

A total of 465 farmers were surveyed; 248 farmers from three villages in Manufahi and 217 farmers from two villages in Manatuto. Of these, 130 farmers had implemented CA and 118 farmers had not applied CA in Manufahi; while in Manatuto, 46 farmers practiced CA and 171 farmers were non-CA farmers.

3.6.1 Design and development of the questionnaire

A structured questionnaire was developed for the survey. The original questionnaire was written in English. The questionnaire was translated from English to the local language, namely Tetum. Tetum language is widely spoken by farmers and almost the entire people of Timor-Lest. Tetum is also considered as the official language alongside Portuguese language. The term, conservation agriculture was socialised by the extensionist agents to the farmers in the field. Thus, the target farmers understood the conservation agriculture. The term, conservation agriculture technique was also translated into tetum, i.e., *la fila rai no la sunu rai*. Hence, the researcher merely introduced the meaning of conservation agriculture and its importance prior to working on the questionnaire. The questionnaire used in the survey comprised of eight sections as follows:

1. General information about the farmer
2. Farm characteristics
3. Maize production and marketing
4. Impact and components of conservation agriculture
5. Behavioural aspects
6. Risk attitudes
7. Entrepreneurial traits
8. External environment

Demographic variables such as gender, age, education attainment, farmer experience, number of family members, income sources of the family, total average income of the family and household expenses were included in the general information section of the questionnaire.

Questions on farm characteristics included size of the entire farm, the maize farm area, the type of maize farm, tenure status, crops planted, cropping pattern, source of irrigation water, and application of irrigation water.

Questions in regards to maize production and marketing include the land use for maize planting; type of maize varieties farmers normally cultivate in their farms; inputs such as fertiliser, pesticides and seeds, which farmers utilise for their maize cultivation; use of labour and machinery in their maize farm; maize production, marketing and disposal of output; markets where farmers normally sell their maize production; reason why farmers do not sell or sell their maize production; factors that enable farmers to produce more maize to sell to the market; problems encountered by farmers when selling maize to the market; the type of climate change-related risks that happen in farmers places; the problems or issues that affect farmers maize production in the last five years; and the adaptation strategies that farmers use to overcome natural risk hazards in maize production.

Questions in relation to impact and components of conservation agriculture technology included farmers' observations about conservation agriculture practices in maize production; when they commenced use of CA; method and components of CA that farmers apply; reasons for using or not using each component of CA; the impact of CA on production, cost, income, and workload.

Questions associated with behavioural aspects covered farmers first use and trialling of CA in maize farming; their motivation for trying CA; impressions about use or non-use of CA, the decision criteria used by farmers to adopt or not adopt CA; farmers' adoption decision after applying CA on either continuing to utilise or stop applying CA in their maize production; issues or constraints farmers encounter in using CA; and the intention of farmers to use CA in the future.

Risk attitude questions concerned risks in maize production; the type of risks that farmers experience or face in maize production; the types of preferences farmers opt on to overcome risks in maize production; and the extent of risks that farmers are willing to take.

Entrepreneurial traits addressed related to farmer confidence in modifying events in the environment (individual locus of control); farmer intention to carry out tasks (need for achievement); farmers concern about risk (risk propensity/tolerance); farmers alertness to try new agricultural technology; farmers creativity in the farm business.

For the external environment, the questions covered the usual source of inputs (e.g., fertilizer, pesticide and herbicide) that farmers access to obtain inputs for maize production; farmers reaction to the CA technology when they first heard about it; external constraints in adoption of CA; source of information that farmers access to get information about new technology, climate change information and farming practices; the types of mass media that farmers utilize to get information about new innovation and farming practices; the usual source of technology that farmers use to acquire agricultural technology; the source of credit that farmers access to get money to buy inputs; the reasons farmers use the source to get the credit and the purpose of loan; membership of groups farmers access to extension services such as training, information; the main information sources; the infrastructure conditions in farmers places (e.g., road, market place); period of insufficiency farmers experience in the last 12 months; and factors that constrain farmers in their maize production and solutions for these problems.

3.7 Data gathering: conducting the in-depth survey

Pre-testing of the questionnaire was undertaken in June 2017 with six respondents. This was to assess whether the questionnaire is clear, check the flow of the questions, diagnose whether all relevant questions were incorporated, and address any information lacking in the questionnaire. The suggestions from the respondents regarding the wording and layout were incorporated in the final questionnaire.

Prior to conducting the survey, the researcher recruited and selected enumerators by interviewing the enumerators about their basic skills in conducting a survey. Subsequently, all selected enumerators participated in a training to familiarise them with the questionnaire and to ensure they had a similar and consistent interpretation of the questions in the survey. Once all the activities in relation to the recruitment of the enumerators and training were concluded, the researcher contacted the relevant municipality agriculture extension office and other agencies' staff in the field and requested to inform the respondents about the coming survey.

Farmers interviewed were classified into two groups: 'with' and 'without'. The 'with' group were individuals who practice CA (in this study, referred to as CA farmers) and 'without' were persons who do not apply CA (in this study, defined as non-CA farmers). For current CA farmers, data was gathered 'before and after situations.

3.8 Research ethics and clearance

The fieldwork survey involved participation of farmers, government officials, international agencies, and local NGOs, hence the researcher applied for ethics approval from Curtin University to conduct the fieldwork research in Timor-Leste. Locally, an official letter was prepared by the researcher for the Ministry of Agriculture, Fisheries and Forestry and other relevant entities to ask for their permission prior to carrying out fieldwork activities.

Several administration procedures were used to ask permission for the fieldwork activities in Timor-Leste.

1. The researcher works as a lecturer at the National University of Timor Lorosa'e, hence, an informal audience with the Dean of the Faculty of Agriculture was held to inform the Dean of the nature of fieldwork activities.
2. An endorsement letter was signed by the Dean of the Agriculture Faculty. The letter was addressed to the Crop Production Department at the Ministry of Agriculture, Fisheries and Forestry; the local government at the municipality level in the fieldwork areas; international agencies and the local NGO.
3. For security reasons, an official letter was also sent to the local police in the fieldwork areas.
4. The researcher also obtained a letter from the supervisor which explained the purpose of the fieldwork survey. The supervisor letter was presented to the government and other relevant agencies to facilitate data gathering.
5. After delivering the permissions letter and obtaining approvals, the researcher was then able to conduct the fieldwork activities.

3.9 Data analysis and analytical techniques

Techniques for data analysis included statistical and econometric analysis. Analytical techniques include descriptive analysis such as means, mode, median, standard deviation; and multivariate statistical analysis such as logit regression model to determine factors influencing the adoption of CA. To determine the implication of applying CA on maize production, income and farmers' workload, quasi-experimental methods and propensity score matching were used as no baseline data of CA had been collected. Propensity score matching is a suitable technique to examine treatment groups and control groups by matching them based on the observed characteristic and nature of the experiment to minimize sample bias (Khandker, B. Koolwal, and Samad, 2009; Saunders, Lewis, and Thornhill, 2016). The data analysis techniques are presented in Table 3.1.

Table 3.1: Techniques for data analysis

Research objectives	Type of analysis
Determine the climate change adaptation strategies of farmers in Timor-Leste	Descriptive analyses, t-test, and factor analysis
Determine the extent and intensity of adoption of farmers on CA in Timor-Leste	Descriptive analyses and Qualitative analysis
Determine factors influencing adoption of CA in Timor-Leste	Econometrics analysis (logit regression), Descriptive analyses, Statistical analysis
Determine the impact of CA on maize farm households	Descriptive analyses, Quasi-experimental analysis, propensity score analysis
Identify barriers faced by farmers in adopting CA and possible solutions to address these challenges	Qualitative (descriptive analysis, content analysis)

3.9.1 Analysis of climate change adaptation strategies

The data on climate change adaptation strategies were investigate by applying SPSS software version 25 Statistical descriptions were provided to describe the demographic background of farmers and climate-change-related risks. T-test was applied to the responses of CA farmers (sample group 1) and non-CA farmers (sample group 2) to determine whether the strategies used by CA farmers to respond to climate change differ from those of non-CA farmers. To assess whether two means differed significantly, the degrees of freedom for the t-test of the two independent samples were computed with probabilities that correspond to the two-tailed significant values (Rietveld and van Hout, 2017; Sheskin, 2003).

3.9.2 Analysis of extent/intensity of adoption of farmers on CA in Timor-Leste

To understand the extent/intensity of conservation agriculture adoption, descriptive statistics were used. The number of components of CA adopted (no tillage or minimum soil disturbance, permanent soil cover with crop residues, and intercropping was recorded. This procedure was used to examine both the number of CA components applied by farmers and the proportion of farmers applying different components of conservation agriculture. Cross-tabular analysis were applied to analyse their reasons for adoption or non-adoption of conservation agriculture. Barriers and constraints to adoption of conservation agriculture were described with 11 statements, and farmers agreement were asking by using a 5 items likert scale from strongly agree to not agree at all. Statistical Package for the Social Sciences (SPSS) version 25 was applied to examine the data.

3.9.3 Analysis of aspects that determine adoption of CA in Timor-Leste

To investigate the factors affecting uptake of CA in Timor-Leste, logistic regression was used. Logistic models enable researchers to explore how explanatory variables affect the probability of events occurring (Long, Long, and Freese, 2006). Logit regression model can be used in two types of analyses which are in the form of a binary variable or multinomial variable. In binary analysis, dependent variables are classified into 1 and 0 outcomes while multinomial applies to more than one of the categorical dependent covariates. According to Agresti and Kateri (2011), logit regression is used to examine several independent variables regressed to a binomial or multinomial variable in linear form which means that the interpretation of the causal and effect of the variables is based on linear association.

This study considered those who had implemented at least one of the components of conservation agriculture as “adopters”; while “non-adopters” were farmers who did not practice any of the components of conservation agriculture. The dependent variable is dichotomous, with 1 referring to adoption and 0 to non-adoption. The logistic probability distribution of u_i appears in the logit model (Gujarati 2011). The model is specified below.

$$P_i = \frac{1}{1+e^{-Zi}} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \textit{(Equation 3.1)}$$

Where: P_i = probability of adoption of conservation agriculture ($Y_i = 1$) is given by

$$Z_i = BX + \mathrm{u_i} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \textit{(Equation 3.2)}$$

The probability of non-adoption of conservation agriculture ($Y = 0$) is given by

$$1 - P_i = \frac{1}{1+e^{Zi}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \textit{(Equation 3.3)}$$

Where: Z_i is composed of a set of explanatory variables X_i, the estimated probability always lies in the 0 to 1 interval and the relationship between P_i and X_i is nonlinear (Gujarati 2011). Thus, the logit model to estimate the propensity of an individual farmer to adopt conservation agriculture is:

$$P(D_i = 1) = \alpha_0 + \sum_{i=1}^{22} \alpha_i \; Z_i + e_i) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \textit{(Equation 3.4)}$$

$$P(Di = 1) = \alpha + \alpha_1 Z_1 + \alpha_2 Z_2 + \alpha_3 Z_3 + \alpha_4 Z_4 + \alpha_5 Z_5 + \alpha_6 Z_6 + \alpha_7 Z_7 + \alpha_8 Z_8 + \alpha_9 Z_9 + \alpha_{10} Z_{10} + \alpha_{11} Z_{11} + \alpha_{12} Z_{12} + \alpha_{13} Z_{13} + \alpha_{14} Z_{14} + \alpha_{15} Z_{15} + \alpha_{16} Z_{16} + \alpha_{17} Z_{17} + \alpha_{18} Z_{18} + \alpha_{19} Z_{19} + \alpha_{20} Z_{20} + \alpha_{21} Z_{21} + \alpha_{22} Z_{22} + e_i$$

Where $\hat{Y}$ = adoption (1 = CA adopter, 0 = CA non-adopter); α = intercept; X_1 is gender (dummy 1 = female, 0 = male); X_2 is age (years); X_3 is education (years); X_4 is household size (number of members in the household); X_5 is experience of spouse (years); X_6 is experience (years of experience in maize farming); X_7 is farm size (maize area in hectares); X_8 is labour (hours/hectare); X_9 is fertilizer (unit/ha); X_{10} is herbicide (unit/hectare); X_{11} is net income ($); X_{12} is entrepreneur traits (1 = *not agree at all*, 5 = *strongly agree*); X_{13} is risk attitude of male (1 = farmer unwilling to take risks, 5 = farmer fully willing to take risks); X_{14} is risk attitude of female (1 = farmer unwilling to take risk, 5 = farmer fully willing to take risk); X_{15} is land type (lowland rain-fed dummy); X_{16} is credit (dummy); X_{17} is training in minimum tillage (dummy); X_{18} is training on leaving crop residue/mulch); X_{19} is improved maize variety (dummy); X_{20} is remittance (dummy); X_{21} is drought (dummy); X_{22} is source of new information (dummy); α_0 to Z_{22} represents the estimation coefficients and u_i is other variables not included in the analysis.

3.9.4 Analysis of impact of CA on maize farm households

A multi-stage method was applied to look at the effect of conservation agriculture in Timor-Leste. This research did not include a before and after or with and without design but compared beneficiaries and non-beneficiaries in the effect of technology adoption on maize yields, income, and farmers' workloads. To match treated and untreated group, propensity score matching was used, and it is based on the similar characteristic of the participants to avoid sample bias (Khandker, Koolwal, and Samad, 2009; Rosenbaum and Rubin, 1983).

Every individual in the target population had the potential to be exposed to the treatment. By defining the outcome variables as Y_i for the individual farmer, the difference between the outcomes of farmers is associated with the average treatment effect. There are two conditions to examine the average of treatment effect (Rosenbaum and Rubin, 1983; Caliendo and Kopeinig, 2008; and Wu, Ding, Pandey and Tao, 2010): (i) T=1 is farmer uptake the technology and (ii) T=0 is farmer does no uptake the technology. The treated group refers to CA adopters and the untreated group is the non-CA adopters. The expectation of the treatment effects across all in the sample is known as the average treatment effect, hence:

$$ATE = E[Y_{i1}|T = 1] - E[Y_{i0}|T = 0] \tag{1}$$

In non-experimental data, we merely observed one of these treatments, either Y_{i1} or Y_{i0} but not both for individual farmers at the same time. To minimise selection bias, the counterfactual variables need to be identified for comparison treatment effect. This can be done through probability function (P) based on equation (1) as described as:

$$ATE = P[E(Y_{i1}|T = 1) - E(Y_{i0}|T = 1)] + (1 - P)[E(Y_{i1}|T = 0) - E(Y_{i0}|T = 0) \tag{2}$$

The ATE in equation (2) indicates that the weight average of whole sample for the adopters and non-adopters apply treatment effect (Becerril and Abdulai, 2010; Wu et al., 2010). For the comparison between $E(Y_{i0}|T = 1)$ and $E(Y_{i1}|T = 0)$, each individual farmers has to have the same characteristic. To understand the effect in adopters $E(Y_{i0}|T = 1)$, treatment effect on treated (ATET) is another method to be applied as:

$$ATET = [E(Y_{i1}|T = 1) - E(Y_{i0}|T = 1)] \tag{3}$$

Equation (3) does not incorporate counterfactual effects but only focuses on the treatment group. It is important to include counterfactual data for the comparison outcome effect (Wu et al., 2010). The participation of individual farmers in the program is another matter in non-experimental settings related to self-selection bias. The instrument variable (IV) is another way to address sample selection bias. As the outcome associated with the program placement, it is not affected by the unobserved variables. This is due to self-selection of the participant in the program in different time frames (Khandker et al., 2009).

Using propensity score matching (PSM), according to Rosenbaum and Rubin (1983), similar characteristics of the treated group and the untreated group are matched regardless of the effect of the program. The determination of a balancing score for the treated group incorporates variables of farmers' household and farm-level characteristics. The probability of adoption of CA is determined by Z variables in a binary decision model. The appropriate measure indicator is used to match adopter farmers with non-adopter farmers. There are certain conditions required in propensity score matching for comparison between the treated group and untreated group (Caliendo and Kopeinig, 2008). Any CA farmers with a propensity score below the minimum or above the maximum for the non-CA farmers is taken out of the sample (Caliendo and Kopeinig, 2008). The average treatment effect on the treated (ATET) sample, for outcome variable, Y, can be expressed as:

$$ATET = [E(Y_{i1}|T = 1, Z) - E(Y_{i0}|T = 1, Z)] \quad (4)$$

Propensity score matching includes several alternatives for matching algorithms. This includes nearest neighbour matching (NNM), nearest neighbour matching with caliper and radius (NNM-CR) and kernel density (KD) (Wu et al., 2010). There are two types of matching method used in nearest neighbour matching (NNM), matching with and without replacing. The same non-CA farmers can be matched with different CA adopters appears in matching with replacing. Meanwhile, matching with an equal number of CA adopters and non-CA adopters involves matching without replacing (Khandker et al., 2009).

The risk of using NNM is if there is no matching neighbour close by Thus, NNM-CR is preferable in that it provides a maximum level that can be tolerated in the difference in propensity scores. Hence, all farmers that fall within the caliper or radius are selected. Kernel density matching applies weighted averages of all farmers in the control group (CA adopters) to construct the counterfactual outcome (Wu et al., 2010). All estimation procedures were performed using Stata 14.

The next chapter, Chapter 4, is the first results chapter and focuses on the problems and adaptation strategies associated with natural risk hazards in maize production in Timor-Leste.

Chapter 4

Climate Change Adaptation Strategies of Smallholder Farmers in Timor-Leste

4.1 Introduction

One of the objectives of this study is to examine the adaptation strategies in maize production in Timor-Leste. This chapter presents and discusses the results on farmer adaptation strategies in Timor-Leste. Section 4.2 first presents the demographic information about the farmers. Section 4.3 covers farmers' perception on the climate-change-related risks in the study area. Section 4.4 presents the types of adaptation strategies by farmers, while Section 4.5 outlines the conclusion and implications.

4.2 Demographic background of farmers

The gender distributions of the farmers interviewed are shown in Table 4.1. Of the 240 farmers interviewed in Manufahi, 171 (69%) were male and 77 (31%) were female. Of the 217 farmers interviewed in Manatuto, 144 (66%) were male and 73 (34%) were female.

This survey focused on the person responsible for maize production. Hence, the number of females was lower than the number of males because maize farming requires physical strength, particularly in land preparation and pest control.

Table 4.1: Number of farmers by gender in two municipalities

Gender	Manufahi municipality		Manatuto municipality		Total	
	No. of farmers	%	No. farmers	%	No. of farmers	%
Male	171	69	144	66.4	315	67.7
Female	77	31	73	33.6	150	32.3
Total	240	100	217	100	465	100

In the Manufahi municipality, the average age of farmers was 45.6 years, farmers had 4.3 years of schooling, and household incomes averaged about US$1114. In the Manatuto municipality, the average age was 47.2 years, farmers had 4.8 years of schooling, and the household incomes averaged about US$1731 (Table 4.2).

Farmers in both municipalities mostly had only basic education. Indeed, farmers need additional training and assistance from different entities (e.g., extension staff, NGOs) in the field. Training and other assistance can elevate farmer knowledge and capacity to better handle agricultural activities.

Table 4.2: Households demographic information

	Manufahi municipality			**Manatuto municipality**		
	No. of farmers	**Range**	**Average**	**No. of farmers**	**Range**	**Average**
Age (years)	248	18–75	45.6	217	19–75	47.2
Education (years)	248	0–12	4.3	217	0–12	4.8
Household income (USD)	248	136–7182	1114	217	105–10454	1731

The average household income in Manufahi municipality (USD1114) was slightly lower than those in Manatuto municipality (USD1731). Farmer income came from various sources, including agriculture and other economic activities and remittances from household members.

Farm size and area sown to maize are shown in Table 4.3. The average land area of farmers is relatively small at less than one hectare (0.84 ha for Manufahi and 0.94 ha for Manatuto). In both municipalities, almost all the area was used to grow maize. Farmers undertake crop production in these areas for household food supplies and to generate income.

Table 4.3: Farm size and area sown to maize in Manufahi and Manatuto municipalities

	Manufahi municipality			Manatuto municipality		
	Range	**Average**	**SD**	**Range**	**Average**	**SD**
Farm size (ha)	0.09–3.75	0.84	0.463	0.25–4	0.94	0.577
Maize area (ha)	0.09–3.50	0.82	0.458	0.25–4	0.89	0.504

4.3 Climate-change-related risks in the study area

The climate change problems expressed by farmers in the Manufahi and Manatuto municipalities included drought, flooding, soil erosion and landslides (Table 4.4). In Manufahi, 68.5 per cent had experienced drought, 23.8 per cent flooding, and 9.3 per cent soil erosion. In Manatuto, 72.4 per cent had encountered drought. 36.9 per cent flooding, 5.2 per cent landslides and 1.4 per cent soil erosion (Table 4.4). The most concerning issues for farmers in these areas are drought and flooding. Barnett, Dessai, and Jones (2007) reported that El-Nino had reduced rainfall in Timor-Leste. Likewise, MAFF (2012) showed that prolonged dry seasons had an adverse impact on crop production in Timor-Leste.

Table 4.4: Farmer perceptions of climate-change-related risks

Municipality	Climate-change-related risks	No. of farmers	Percentage affirmative (yes)
Manufahi	Drought	170	68.5
	Flooding	59	23.8
	Soil erosion	23	9.3
	Landslides	13	5.2
Manatuto	Drought	157	72.4
	Flooding	80	36.9
	Soil erosion	3	1.4
	Landslides	–	–

Farmers also lack the knowledge to use improved methods of crop production, face shortages of agricultural inputs, and lack improved seeds and agricultural infrastructure (MAFF, 2012). Additionally, limited extension services are available for farmers to enhance their knowledge on appropriate methods for crop production (GoTL, 2010c; MAFF, 2012). Therefore, it is important that new agricultural methods are introduced to farmers to help them adapt to climate change, rehabilitate agricultural infrastructure, and make financial support and agricultural inputs available.

Flooding also affected agricultural production. According to the Australian Bureau of Meteorology and CSIRO (2014), La-Nina causes more frequent extreme rains that trigger flooding and destroy agricultural production, which affects farmer income and food security.

Indeed, soil erosion has changed soil properties and damaged crops. According to Barnett et al. (2007), soil erosion is caused by more intense rainfall and damages crop production; however only 9.3 per cent of the households in Manufahi and 1.4 per cent in Manatuto perceived soil erosion as a problem. A small percentage of surveyed farmers have experienced landslides on slopes as a result of the increased intensity of rainfall.

4.4 Types of adaptation strategies

Table 4.5 shows that farmers in the sample in both the Manufahi and Manatuto municipalities have adopted a number of adaptation strategies to overcome natural risk hazards. In Manufahi, almost half of the farmers (47%) have diversified their crops, plots, and livestock, 47 per cent have adopted new plant varieties, 44 per cent have incorporated stress-tolerant crops and 41 per cent have used substitute crops and intercropping as important adaptation strategies for natural hazard risks (Table 4.5).

Also, 44 per cent of farmers had increased their seeding rate, 43 per cent had sown crops early and 40 per cent had sown stress-tolerant varieties as adaptation strategies to natural hazard risks. Only a small percentage of farmers (2.4%) had practiced contouring or implemented terracing (0.4%).

In Manatuto, farmers have increased their seeding rates (31%), rotated crops (30%), adopted new seed varieties (30%), planted early (29%), diversified crops, plots and livestock (27%), used substitute crops and intercropping (25%) and planted stress-tolerant varieties (22%) (Table 4.5). A small proportion of farmers (0.5%) have used terracing and contouring as adaptation strategies for natural hazard risks.

Farmers in Manufahi have mostly diversified their crops, plots, and livestock; adopted new seed varieties; planted stress-tolerant crops and increased their seeding rates; while those in Manatuto have increased their seeding rate; rotated crops; adopted new seed varieties; and planted early (Table 4.5). This indicates that both municipalities apply particular adaptive strategies to overcome natural hazard risk in their agricultural production. Very few farmers use contouring and terracing. Most farmers in Timor-Leste experience natural hazard risks. For example, drought occurs as a result of El-Nino event (Australian Bureau of Meteorology and CSIRO 2014). With this situation, many farmers apply a number of adaptation strategies to cope with drought by planting new seed varieties and using of conservation agriculture (FAO, 2014b).

Farmers often use existing techniques such as planting maize, beans in one hole and intercrop with cassava to obtain their food. This method has existed over generations. The idea is to guard against crop failure. As time for harvesting crops is different (for example, maize and beans are often harvested at first, followed by cassava), having different harvest seasons for different crops, contributes to safeguarding farmers from food shortage. Also, this strategy may provide sufficient food to prepare for difficult times such as drought and floods, as a coping mechanism to natural risk hazards. Also, farmers reserve their food crop for the next planting season. They normally run out of food when the planting season arrives, as farmers use their food crop stock such as maize, beans, pumpkins as seeds for planting.

Table 4.5: Ratings for adaptation strategies of natural risk hazards in maize production by municipality

Rate of importance: 1 = not at all important, 5 = very important

Manufahi municipality

Category	Mean score	1 No	1 %	2 No	2 %	3 No	3 %	4 No	4 %	5 No	5 %	Total No	Total %
Diversify crops, plot, livestock	4.29	3	1.2	6	2.4	24	9.7	99	39.9	116	46.8	248	100
Adaptation of new seed variety	4.25	4	1.6	11	4.4	20	8.1	97	39.1	116	46.8	248	100
Plant stress-tolerant crops	4.25	5	2.0	8	3.2	18	7.3	107	43.1	110	44.4	248	100
Substitute crops	4.24	6	2.4	4	1.6	16	6.5	120	48.4	102	41.1	248	100
Intercropping	4.23	4	1.6	8	3.2	19	7.7	114	46	103	41.5	248	100
Increase seed rate	4.23	6	2.4	9	3.6	17	6.9	106	42.7	110	44.4	248	100
Plant early	4.21	3	1.2	6	2.4	35	14.1	97	39.1	107	43.1	248	100
Plant stress-tolerant varieties	4.21	6	2.4	5	2.0	21	8.5	116	46.8	100	40.3	248	100
Plant pest/disease-tolerant varieties	4.18	2	0.8	6	2.4	35	14.1	107	43.1	98	39.5	248	100
Use crop residue as soil cover	4.17	3	1.2	14	5.6	22	8.9	108	43.5	101	40.7	248	100
Reduce tillage	4.13	5	2.0	15	6.0	33	13.3	86	34.7	109	44	248	100
Crop rotation	4.10	4	1.6	15	6.0	26	10.5	110	44.4	93	37.5	248	100
Reduce fertiliser use	3.97	7	2.8	21	8.5	32	12.9	101	40.7	87	35.1	248	100
Use manure	3.91	11	4.4	13	5.2	46	18.5	95	38.3	83	33.5	248	100
Laser land levelling	3.87	4	1.6	21	8.5	50	20.2	101	40.7	72	29	248	100
ZT maize	3.71	13	5.2	34	13.7	41	16.5	83	33.5	77	31	248	100
Site-specific nutrient management	3.39	19	7.7	39	15.7	49	19.8	109	44	32	12.9	248	100
Bed planting	3.32	14	5.6	46	18.5	76	30.6	70	28.2	42	16.9	248	100
Use other chemical inputs	3.25	24	9.7	64	25.8	44	17.7	57	23	59	23.8	248	100
Residue management	3.17	23	9.3	54	21.8	54	21.8	91	36.7	26	10.5	248	100
Rotavator	2.99	19	7.7	77	31	64	25.8	64	25.8	24	9.7	248	100
Contouring	2.13	70	28.2	99	39.9	63	25.4	10	4.0	6	2.4	248	100
Terracing	2.05	67	27	114	46	55	22.2	11	4.4	1	0.4	248	100

Rate of importance: 1 = not at all important, 5 = very important

Manatuto municipality

Category	Mean score	1 No	1 %	2 No	2 %	3 No	3 %	4 No	4 %	5 No	5 %	Total No	Total %
Increase seed rate	4.18	1	0.5	5	2.3	14	6.5	130	59.9	67	30.9	217	100
Crop rotation	4.15	-	-	6	2.8	21	9.7	125	57.6	65	30	217	100
Adaptation of new seed variety	4.13	-	-	4	1.8	27	12.4	122	56.2	64	29.5	217	100
Plant early	4.12	-	-	4	1.8	28	12.9	122	56.2	63	29	217	100
Diversify crops, plot, livestock	4.08	-	-	2	0.9	37	17.1	120	55.3	58	26.7	217	100
Substitute crops	4.03	-	-	2	0.9	44	20.3	116	53.5	55	25.3	217	100
Intercropping	4.02	1	0.5	3	1.4	43	19.8	114	52.5	56	25.8	217	100
Plant stress-tolerant varieties	3.99	-	-	2	0.9	47	21.7	120	55.3	48	22.1	217	100
Plant stress-tolerant crops	3.97	-	-	2	0.9	48	22.1	121	55.8	46	21.2	217	100
Plant pest/disease-tolerant varieties	3.95	-	-	6	2.8	41	18.9	128	59	42	19.4	217	100
Use crop residue as soil cover	3.94	-	-	11	5.1	46	21.2	104	47.9	56	25.8	217	100
Reduce tillage	3.91	-	-	17	7.8	34	15.7	117	53.9	49	22.6	217	100
Laser land levelling	3.83	1	0.5	15	6.9	41	18.9	123	56.7	37	17.1	217	100
Reduce fertiliser use	3.78	1	0.5	20	9.2	44	20.3	112	51.6	40	18.4	217	100
Use manure	3.62	-	-	28	12.9	46	21.2	123	56.7	20	9.2	217	100
ZT maize	3.54	5	2.3	32	14.7	60	27.6	81	37.3	39	18	217	100
Site-specific nutrient management	3.39	22	10.1	34	15.7	28	12.9	103	47.5	30	13.8	217	100
Bed planting	3.12	6	2.8	50	23	82	37.8	71	32.7	8	3.7	217	100
Use other chemical inputs	3.07	13	6.0	65	30	47	21.7	78	35.9	14	6.5	217	100
Residue management	2.94	26	12	69	31.8	46	21.2	43	19.8	33	15.2	217	100
Rotavator	2.75	15	6.9	85	39.2	65	30	44	20.3	8	3.7	217	100
Terracing	1.91	60	28	114	53.3	39	18.2	1	0.5	-	-	214	100
Contouring	1.88	69	31.8	107	49.3	40	18.4	1	0.5	-	-	217	100

Overall, 38 per cent of farmers have increased their seeding rate, 39 per cent have adopted a new crop variety, 37 per cent have diversified their crops, plots, and livestock and 37 per cent have planted early (Table 4.6). Also, 34 per cent of farmers have used substitute crops, intercropping or crop rotation or planted stress-tolerant varieties as adaptation strategies to confront natural hazard risks (Table 4.6).

The data demonstrates that most of the farmers used adaptation strategies including increased seed rates, use of new more stress tolerant crop varieties, diversifying cropping, plot, livestock and early planting, use of crop rotations and intercropping. These adaptation strategies have been implemented by farmers both municipalities.

These adaptation approaches are also practiced by farmers elsewhere. For example, Trinh et al. (2018) reported that 66 per cent of farmers in Vietnam changed crop varieties and 28 per cent adjusted their farming calendar as adaptation strategies to extreme weather events in agricultural production. Tun Oo et al. (2017) reported that 45 per cent of farmers in Myanmar confronting natural hazards changed crop/livestock type, changed crop varieties, adopted crop diversification.

The implementation of adaptation strategies by farmers to tackle natural hazard risks is influenced by a number of factors including household characteristics, socio-economic, external factors and temperature as well as precipitation. A study by Abdur Rashid Sarker et al. (2013) in Bangladesh found that gender, age, education, income, experience, climate change information, obtaining information from extension, credit availability were all positively correlated with adaptation strategies such as growing period of rice, alternation of planting date, applying different crop varieties. Similarly, Abid et al. (2015) found that experience, education, household size, landholding, information on weather forecasting and access to market were positively associated with changing crop type. Also, Gebrehiwot and van der Veen (2013) showed that gender, education, farm size, extension services and information on climate change to be positively related to soil conservation.

Table 4.6: Ratings of adaptation strategies of natural hazard risk in maize production in two municipalities

Rate of importance: 1 = not at all important, 5 = very important													
Category		**1**		**2**		**3**		**4**		**5**		**Total**	
	Mean score	**No**	**%**	**No**	**%**	**No**	**%**	**No**	**%**	**No**	**%**	**No**	**%**
Increase seed rate	4.21	7	1.5	14	3.0	31	6.7	236	50.8	177	38.1	465	100
Adaptation of new seed variety	4.20	4	0.9	15	3.2	47	10.1	219	47.1	180	38.7	465	100
Diversify crops, plot, livestock	4.19	3	0.6	8	1.7	61	13.1	219	47.1	174	37.4	465	100
Plant early	4.17	3	0.6	10	2.2	63	13.5	219	47.1	170	36.6	465	100
Substitute crops	4.14	6	1.3	6	1.3	60	12.9	236	50.8	157	33.8	465	100
Intercropping	4.13	5	1.1	11	2.4	62	13.3	228	49	159	34.2	465	100
Crop rotation	4.12	4	0.9	21	4.5	47	10.1	235	50.5	158	34	465	100
Plant stress-tolerant crops	4.12	5	1.1	10	2.2	66	14.2	228	49	156	33.5	465	100
Plant stress-tolerant varieties	4.10	6	1.3	7	1.5	68	14.6	236	50.8	148	31.8	465	100
Plant pest/disease-tolerant varieties	4.07	2	0.4	12	2.6	76	16.3	235	50.5	140	30.1	465	100
Use crop residue as soil cover	4.06	3	0.6	25	5.4	68	14.6	212	45.6	157	33.8	465	100
Reduce tillage	4.03	5	1.1	32	6.9	67	14.4	203	43.7	158	34	465	100
Reduce fertiliser use	3.88	8	1.7	41	8.8	76	16.3	213	45.8	127	27.3	465	100
Laser land levelling	3.85	5	1.1	36	7.7	91	19.6	224	48.2	109	23.4	465	100
Use manure	3.78	11	2.4	41	8.8	92	19.8	218	46.9	103	22.2	465	100
ZT maize	3.63	18	3.9	66	14.2	101	21.7	164	35.3	116	24.9	465	100
Site-specific nutrient management	3.39	41	8.8	73	15.7	77	16.6	212	45.6	62	13.3	465	100
Bed planting	3.23	20	4.3	96	20.6	158	34	141	30.3	50	10.8	465	100
Use other chemical inputs	3.17	37	8.0	129	27.7	91	19.6	135	29	73	15.7	465	100
Residue management	3.07	49	10.5	123	26.5	100	21.5	134	28.8	59	12.7	465	100
Rotavator	2.88	34	7.3	162	34.8	129	27.7	108	23.2	32	6.9	465	100
Contouring	2.00	139	29.9	206	44.3	103	22.2	11	2.4	6	1.3	465	100
Terracing	1.99	127	27.5	228	49.4	94	20.3	12	2.6	1	0.2	462	100

Adaptation strategies for natural hazard risks used by CA farmers include using crop residues as soil cover (50%), reduced tillage (48%), adopting new seed varieties (48%), planting early (49%), sowing stress-tolerant varieties (41%), intercropping (43%), planting stress-tolerant crops (38%) and substitute crops (40%) (Table 4.7). A small number of CA farmers have implemented contouring (0.3%) and terracing (0.6%) to overcome soil erosion (Table 4.7). Adaptation strategies for natural hazard risks used by non-CA farmers include increasing their seeding rate (36%), diversifying crops, plots, and livestock (36%), adopting new seed varieties (33%), substitute crops (30%), planting stress-tolerant crops (31%), planting stress-tolerant varieties (26%) and planting pest/disease-tolerant varieties (26%) (Table 4.7). A small percentage of farmers practiced contouring (0.3%).

This result shows that CA farmers have implemented several adaptation strategies related to conservation agriculture, such as reduced tillage, zero tillage, soil cover with crop residues, planting early, intercropping, crop rotations, bed planting, laser land levelling, fertiliser management and crop/farm management practices. Meanwhile, non-CA farmers applied some crop/farm management practices including increased seeding rates, diversified crops, plots and livestock, new seed varieties, substitute crops, and planting stress-tolerant crops, stress-tolerant varieties and pest/disease-tolerant varieties. The two groups of farmers used different adaptation strategies to overcome natural hazard risks and these differences were highly significant at $P \leq 0.01$. This means that CA farmers are more likely to practise conservation agriculture, while non-CA farmers apply crop/farm management to adapt to natural hazard risks (Table 4.8).

Farmers elsewhere have used several adaptation strategies to tackle natural hazard risks. Jiri et al. (2017) reported that farmers in Zimbabwe planted drought-tolerant crops with short-season varieties and used CA to cope with drought. Gomez (2015) showed that farmers in Philippines changed crop varieties, intercropped, and used mulch in response to long-term perceived changes in climate. Likewise, farmers in Nepal are using several adaptation strategies in response to climate change impacts such as drought-tolerant and short-duration varieties, increased seeding rates, altering sowing/harvest dates, soil conservation techniques and reduced tillage (Khanal et al., 2018).

Table 4.7: Ratings of adaptation strategies of natural risk hazard in maize production by CA farmers and non-CA farmers

Rate of importance: 1 = not at all important, 5 = very important

CA farmers

Category	Mean score	1 No	1 %	2 No	2 %	3 No	3 %	4 No	4 %	5 No	5 %	Total No	Total %
Use crop residue as soil cover	4.39	1	0.6	2	1.1	13	7.4	72	40.9	88	50	176	100
Reduce tillage	4.38	-	-	1	0.6	15	8.5	76	43.2	84	47.7	176	100
Adaptation of new seed variety	4.36	1	0.6	4	2.3	11	6.3	75	42.6	85	48.3	176	100
Plant early	4.32	1	0.6	1	0.6	24	13.6	64	36.4	86	48.9	176	100
Plant stress-tolerant varieties	4.30	3	1.7	-	-	11	6.3	90	51.1	72	40.9	176	100
Intercropping	4.28	1	0.6	5	2.8	13	7.4	82	46.6	75	42.6	176	100
Plant stress-tolerant crops	4.27	1	0.6	3	1.7	11	6.3	94	53.4	67	38.1	176	100
Substitute crops	4.26	2	1.1	2	1.1	15	8.5	87	49.4	70	39.8	176	100
Plant pest/disease-tolerant varieties	4.26	1	0.6	2	1.1	12	6.8	97	55.1	64	36.4	176	100
Increase seed rate	4.25	3	1.7	6	3.4	9	5.1	84	47.7	74	42	176	100
Diversify crops, plot, livestock	4.25	1	0.6	3	1.7	17	9.7	85	48.3	70	39.8	176	100
Crop rotation	4.22	1	0.6	7	4.0	12	6.8	88	50	68	38.6	176	100
Reduce fertiliser use	4.14	2	1.1	7	4.0	22	12.5	79	44.9	66	37.5	176	100
Laser land levelling	4.08	1	0.6	6	3.4	21	11.9	98	55.7	50	28.4	176	100
Use manure	4.07	3	1.7	4	2.3	28	15.9	84	47.7	57	32.4	176	100
ZT maize	4.03	4	2.3	11	6.3	19	10.8	83	47.2	59	33.5	176	100
Site-specific nutrient management	3.60	6	3.4	26	14.8	33	18.8	81	46	30	17	176	100
Bed planting	3.38	7	4.0	41	23.3	39	22.2	56	31.8	33	18.8	176	100
Residue management	3.40	9	5.1	33	18.8	38	21.6	70	39.8	26	14.8	176	100
Use other chemical inputs	3.20	12	6.8	51	29	35	19.9	45	25.6	33	18.8	176	100
Rotavator	3.17	10	5.7	47	26.7	45	25.6	51	29	23	13.1	176	100
Contouring	2.10	49	27.8	76	43.2	40	22.7	6	3.4	5	2.8	176	100
Terracing	2.03	49	27.8	79	44.9	42	23.9	5	2.8	1	0.6	176	100

Rate of importance: 1 = not at all important, 5 = very important

Non-CA farmers

Category	Mean score	1 No	1 %	2 No	2 %	3 No	3 %	4 No	4 %	5 No	5 %	Total No	Total %
Increase seed rate	4.18	4	1.4	8	2.8	22	7.6	152	52.6	103	35.6	289	100
Diversify crops, plot, livestock	4.15	2	0.7	5	1.7	44	15.2	134	46.4	104	36	289	100
Adaptation of new seed variety	4.10	3	1.0	11	3.8	36	12.5	144	49.8	95	32.9	289	100
Substitute crops	4.08	4	1.4	4	1.4	45	15.6	149	51.6	87	30.1	289	100
Plant stress-tolerant crops	4.03	4	1.4	7	2.4	55	19	134	46.4	89	30.8	289	100
Plant stress-tolerant varieties	3.99	3	1.0	7	2.4	57	19.7	146	50.5	76	26.3	289	100
Plant pest/disease-tolerant varieties	3.96	1	0.3	10	30.5	64	22.1	138	47.8	76	26.3	289	100
Reduce fertiliser use	3.73	6	2.1	34	11.8	54	18.7	134	46.4	61	21.1	289	100
Use manure	3.60	8	2.8	37	12.8	64	22.1	134	46.4	46	15.9	289	100
Site-specific nutrient management	3.27	35	12.1	47	16.3	44	15.2	131	45.3	32	11.1	289	100
Use other chemical inputs	3.15	25	8.7	78	27	56	19.4	90	31.1	40	13.8	289	100
Residue management	2.86	40	13.8	90	31.1	62	21.1	64	22.1	33	11.4	289	100
Rotavator	2.70	24	8.3	115	39.8	84	29.1	57	19.7	9	3.1	289	100
Bed planting	2.35	38	13.1	128	44.3	106	36.7	17	5.9	-	-	289	100
Laser land levelling	2.12	63	21.8	142	49.18	70	24.2	14	4.8	-	-	289	100
Terracing	1.96	78	27.3	149	52.1	52	18.2	7	2.4	-	-	289	100
Contouring	1.95	90	31.1	130	45	63	21.8	5	1.7	1	0.3	289	100
Intercropping	1.86	89	30.8	151	52.2	49	17	-	-	-	-	289	100
Crop rotation	1.80	93	32.2	161	55.7	35	12.1	-	-	-	-	289	100
Plant early	1.71	135	46.7	103	35.6	49	17	2	0.7	-	-	289	100
Use crop residue as soil cover	1.57	123	42.6	166	57.4	-	-	-	-	-	-	289	100
Reduce tillage	1.17	240	83	49	17	-	-	-	-	-	-	286	100
ZT maize	1.00	288	99.7	1	0.3	-	-	-	-	-	-	289	100

Table 4.8: Adaptation strategies by CA farmers and non-CA farmers

Rate of importance: 1 = not at all important, 5 = very important								
CA farmers				**Non-CA farmers**				
Strategy	**Mean score**	**SD**	**Total**		**Mean score**	**SD**	**Total**	***P-value***
Use crop residue as soil cover	4.39	0.724	176	Increase seed rate	4.18	0.798	289	0.000***
Reduce tillage	4.38	0.665	176	Diversify crops, plot, livestock	4.15	0.789	289	0.000***
Adaptation of new seed variety	4.36	0.750	176	Adaptation of new seed variety	4.10	0.832	289	0.001***
Plant early	4.32	0.773	176	Substitute crops	4.08	0.796	289	0.001***
Plant stress-tolerant varieties	4.30	0.735	176	Plant stress-tolerant crops	4.03	0.849	289	0.000***
Intercropping	4.28	0.769	176	Plant stress-tolerant varieties	3.99	0.808	289	0.000***
Plant stress-tolerant crops	4.27	0.703	176	Plant pest/disease-tolerant varieties	3.96	0.809	289	0.002**
Substitute crops	4.26	0.754	176	Reduce fertiliser use	3.73	0.992	289	0.016**
Plant pest/disease-tolerant varieties	4.26	0.682	176	Use manure	3.60	0.992	289	0.000***
Increase seed rate	4.25	0.838	176	Site-specific nutrient management	3.27	1.215	289	0.392
Diversify crops, plot, livestock	4.25	0.745	176	Use other chemical inputs	3.15	1.210	289	0.186
Crop rotation	4.22	0.787	176	Residue management	2.86	1.237	289	0.000***
Reduce fertiliser use	4.14	0.864	176	Rotavator	2.70	0.981	289	0.000***
Laser land levelling	4.08	0.767	176	Bed planting	2.35	0.782	289	0.000***
Use manure	4.07	0.852	176	Laser land levelling	2.12	0.801	289	0.000***
ZT maize	4.03	0.949	176	Terracing	1.96	0.743	289	0.000***
Site-specific nutrient management	3.60	1.044	176	Contouring	1.95	0.793	289	0.004**
Bed planting	3.44	1.150	176	Intercropping	1.86	0.678	289	0.000***
Residue management	3.40	1.107	176	Crop rotation	1.80	0.636	289	0.000***
Use other chemical inputs	3.20	1.239	176	Plant early	1.71	0.765	289	0.612
Rotavator	3.17	1.134	176	Use crop residue as soil cover	1.57	0.495	289	0.000***
Contouring	2.10	0.945	176	Reduce tillage	1.17	0.376	289	0.078*
Terracing	2.03	0.827	176	ZT maize	1.00	0.059	289	0.307

*SD (standard deviation); t = *significant at 10% level; **significant at 5% level; ***significant at 1% level*

4.5 Conclusions and implications

Drought is a major concern for farmers in the Manufahi and Manatuto municipalities. This natural hazard risk can reduce crop production, which threatens household food supplies and farmer income. To minimise the effects of natural hazard risks, farmers in Manufahi practice crop, plot and livestock diversification, adopt new seed varieties, plant stress-tolerant crops, substitute crops and intercrop, while those in Manatuto increase seeding rates, rotate crops, adopt new seed varieties, plant crops early and diversify crops, plots and livestock. Overall, farmers increase seeding rates, adopt new seed varieties, diversify crops, plots and livestock and plant early as adaptation strategies.

Both CA farmers and non-CA farmers have implemented different ways to adapt to unfavourable climate changes. CA farmers use reduced tillage, zero tillage maize, crop residues as soil cover, laser land levelling, intercropping, reduced fertiliser use, manure application, adopt new seed varieties, and plant stress-tolerant crops, stress-tolerant varieties and pest/disease-tolerant varieties to tackle the natural risk hazards. Non-CA farmers increase seeding rates, diversify crops, plots and livestock, adopt new seed varieties, use substitute crops and plant stress-tolerant crops to adapt to the natural hazard risks.

Several key factors identified in this study were correlated with CA, including reduced tillage, use of crop residues as soil cover, zero tillage maize, crop rotation, intercropping, planting early and bed planting as adaptation strategies to natural hazard risk.

The identification of adaptation strategies is important for making better decisions related to natural hazards and to enhance crop production in Timor-Leste. The ultimate solution is to identify problems and adaptation strategies for crop production. This study offers practical information to the Timorese government that can assist in decision making regarding adaptation strategies for tackling natural hazards in crop production in Timor-Leste.

Chapter 5

Extent and Intensity of Conservation Agriculture Adoption

5.1 Introduction

Although conservation agriculture techniques have been promoted in Timor-Leste, it is unclear as to what extent/intensity farmers are adopting conservation agriculture. In this chapter, the results of the extent/intensity of the adoption of CA in Timor-Leste is presented. There are three components of conservation agriculture practised by farmers in Timor Leste. The term extent and intensity of conservation agriculture adoption here are used interchangeably to refer to the number of CA components adopted by farmers.

Following this introductory section, Section 5.2 presents the demographic background of CA and non-CA farmers. Section 5.3 examines the extent/intensity of conservation agriculture adopted by farmers in the study area while Section 5.4 presents the reasons for adoption and non-adoption of conservation agriculture. Section 5.5 then discusses barriers and constraints for conservation agriculture adoption. Section 5.6 is devoted to the conclusion and policy implications.

5.2 Demographic background of CA and Non-CA farmers

The average age of farmers practising conservation agriculture (45.5 years) was similar to that of non-adopting farmers (45.6 years) (Table 5.1).

Regarding educational attainment, CA farmers had an average of 4.7 years of schooling versus 4.4 years for non-CA farmers. It appears that on average, both groups did not finish primary education and achieved only a basic education level.

Table 5.1: Demographic information of study participants

Characteristics	CA farmers			Non-CA farmers		
	No. of farmers	Range	Average	No. of farmers	Range	Average
Age (years)	176	22–75	46	289	18–75	46.5
Education (years)	176	0–12	4.7	289	0–12	4.4
Household income (USD)	176	163–9686	1277	289	105–10453	1619

In terms of household income, CA farmers earned US$1277 on average while non-CA farmers received an average of US$1619 (Table 5.1). The difference in household income between CA farmers and non-CA farmers is $342. Farmers' incomes was derived from various sources, including agriculture, small household industry, commerce, paid labour, and transfer payments from the government.

5.3 Extent/intensity of conservation agriculture adopted in the study area

As mentioned above, the term extent and intensity of conservation agriculture adoption here are used interchangeably to refer to the quantity of CA components adopted by farmers amongst the three CA components: no-tillage or minimum soil disturbance; permanent soil cover with crop residues; and crop rotation or intercropping.

Table 5.2: Extent and intensity of conservation agriculture adoption by farmers adopting one or more components

No. of conservation agriculture components practised	Conservation agriculture components	No. of farmers	%
Farmers practised one CA component	Intercropping with other crops	36	7.7
	Permanent soil cover	22	4.7
Total		58	12.4
Farmers practised two CA components	Permanent soil cover and intercropping with other crops	49	10.5
	No-tillage or minimum soil disturbance and permanent soil cover	15	3.2
	No-tillage or minimum soil disturbance and intercropping with other crops	6	1.3
Total		70	15
Farmers fully practised CA components	No-tillage or minimum soil disturbance, permanent soil cover and intercropping with other crops	48	10.3
No adoption		289	62.2
Total		465	100

Farmers applying one CA component accounted for 12.4 per cent, which comprised 7.7 per cent practising intercropping with other crops and 4.7 per cent applying permanent soil cover (Table 5.2). The proportion of farmers using any two CA components was 15 per cent: 10.5 per cent implemented permanent soil cover and intercropping with other crops; 3.2 per cent practised no tillage or minimum soil disturbance and permanent soil cover and 1.3 per cent applied no-tillage or minimum soil disturbance and intercropping with other crops (Table 5.2). Farmers fully implementing all three CA elements totalled 10.3 per cent, while 62.2 per cent of farmers interviewed did not apply CA (Table 5.2).

The results show that more than a quarter of farmers surveyed practised only one or two components of CA in their crop production (Table 5.2) Farmers applied intercropping through mixed-crop cultivation of maize and cassava. This allows farmers to harvest two food crops at different times, increasing their yield and food security. In contrast, in Zambia, Arslan et al. (2014) reported that only about 3 per cent of farmers practised crop rotation and intercropping with legumes. However, the implementation of this CA element alone cannot guarantee the sustainability of land management.

In the study area, only a small percentage of farmers fully implement CA in their farms. We need to identify why farmers are reluctant to practise all the components of CA. FAO (2018) reported that, several factors constrain CA implementation. For example, livestock may freely graze on the farm. In addition, farmers have practised traditional methods such as slash and burning over generations, which makes it difficult to change their mindset. Wildfires occur because farmers traditionally clear their land by burning vegetation before ploughing, digging or hoeing.

Many farmers practised various combinations of components of CA. Farmers tended to move forward to engage further with other CA elements. This implies that the decision to apply CA is based on the perceptions and goals of farmers. According to Pannell et al. (2006), farmers objectives can determine the decision to adopt agricultural innovation. Farmers often consider the benefits of new agricultural innovation prior to adopting it. Resource-poor farmers are more likely to look for agricultural innovations which can fulfil their household domestic consumption which corresponds to their benefits and costs (Pannell et al., 2006).

Farmers may compare new agricultural innovations with their current practice. If they consider the benefits of the new technology outweigh those of their previous practice, they will consider adopting it. If farmers are presented with more than one agricultural innovation, it may be difficult for them to make a decision. For example, an Ethiopian study examined the adoption of several agricultural innovations: improved seeds, organic fertilizer, irrigation, and chemical fertilizer. Crop yield positively correlated with using organic fertilizer; organic fertilizer involves less financial expense. Adoption of chemical fertiliser, irrigation and improved seeds were not correlated with crop yield. These innovations require more household resources. Hence, farmers may have been less likely to invest in these capital-intensive technologies (Gebremariam and Tesfaye, 2018).

Adoption of agricultural technology involves both benefits and costs. Farmers are often interested in agricultural innovations that increase agricultural production at a reasonable cost. Naturally, they are attracted to agricultural innovations when costs are minimal. Gebremariam and Tesfaye (2018) noted that farmers with limited resources are reluctant to apply new technologies with high capital investment. However, the potential benefits of implementing CA are increased crop production and reduced costs (Pannell, Llewellyn, and Corbeels, 2014). Likewise, risk and uncertainty also influence the adoption of technology innovations and must be considered. Marra, Pannell, and Ghadim (2003) stated that it is important to understand farmers' perceptions and attitudes towards risks and the effect of training and learning in adoption decisions as well as the effect of delaying adoption. For instance, farmers with high risk aversion probably will not try a new technology and are more likely to maintain their existing practices. Pannell, Llewellyn, and Corbeels (2014) stressed that risk corresponds to the distribution of outcomes that includes production and monetary risk. The current study found that many farmers only partially applied CA components. Their adoption decision may have likely been a reflection of their perceptions about production risk and financial risk.

CA offers new techniques to farmers and have been found to be beneficial. For instance, Thierfelder et al. (2016) reported a positive effect of applying minimum tillage, which increased farmers' maize production. Permanent soil cover with crop residue as mulch can reduce soil evaporation, maintain soil moisture, and increase soil organic carbon, all important to assist plant growth (Li Liu et al., 2017).

Not applying one of CA components such as no-tillage or minimum soil disturbance will affect soil conditions and crop production. According to Vezzani et al. (2018), applying minimum soil disturbance improves soil content (e.g., nitrogen and soil organic matter). These changes can help maintain soil structure, which in turn increases the rate of water infiltration. For example, Thierfelder et al. (2015) found that the water infiltration rate is increased in maize production by applying minimum soil disturbance. Applying minimum tillage can also reduce damage to soil structure (Verhulst et al., 2010).

No-tillage or minimum soil disturbance is a new technique for Timor-Leste farmers as they normally till their land to prepare for cultivation. Intercropping with other crops is a suitable method for farmers vulnerable to food scarcity because this technique can produce more food crops. But, the implementation of CA elements depends on the farmers' needs and farmers are free to choose what CA components suit their needs. A good understanding of the importance of practising all components of CA is required to encourage full adoption. This means that there is a need for more information related to the benefit of practicing CA so farmers can better understand CA and its impacts.

5.4 Reasons for adoption and non-adoption of conservation agriculture

Farmers mentioned several reasons for adopting or not adopting conservation agriculture (Table 5.3). Some farmers (26.1%) remarked that no-tillage or minimum soil disturbance maintains soil nutrients; 13.3 per cent said it maintained soil structure; and 4.8 per cent stated that it reduced production costs.

Table 5.3: Reasons for adoption and non-adoption of conservation agriculture

CA components	Reasons	No. of farmers	%
No tillage or minimum soil disturbance	**Reason for adoption**		
	Maintains soil nutrients	43	26.1
	Maintains soil structure	22	13.3
	Reduces production cost	8	4.8
	Reason for non-adoption		
	Land tillage used to soften the soil	52	31.5
	Land tillage prevents weeds	24	14.5
	Land tillage is often practised by farmers	16	9.7
Total		165	100
Permanent soil cover with residues	**Reason for adoption**		
	Enhances soil nutrients	77	48.4
	Controls soil moisture	37	23.3
	Reduces weed infestation	11	6.9

CA components	Reasons	No. of farmers	%
	Reason for non-adoption		
	Clearing crop residues from the land	30	18.9
	Lack of information	4	2.5
Total		159	100
Intercropping with other crops	**Reason for adoption**		
	Intercropping enhances food production	69	49.3
	Planting maize intercropping with legumes reduces weeds and increases soil fertility	25	17.9
	Planting maize intercrops with cassava	17	12.1
	Intercropping increases income	8	5.7
	Planting maize intercrops with cassava and beans	5	3.6
	Planting maize intercrops with cassava and sweet potato	5	3.6
	Reason for not adoption		
	Shortage of legumes	11	7.9
Total		140	100

About one-third (31.5%) of all farmers (and who did not practise no-tillage or minimum soil disturbance) remarked that tilling the land can soften the soil. Others (14.5%) remarked that ploughing the land prevented weeds. Some (9.7 %) said that they have always tilled the land before cultivating crops (Table 5.3).

Regarding permanent soil cover with crop residues, nearly half of the farmers (48.4%) reported that it increased soil fertility and 23.3 per cent said it maintained soil moisture (Table 5.3). A few (6.9%) indicated reducing weed infestation as a reason.

The main reason farmers gave for not using permanent soil cover with crop residues (18.9%) was that they have traditionally removed crop residues from the land. A few farmers (2.5%) remarked they did not have much information on conservation agriculture (Table 5.3).

The main reasons farmers gave for intercropping with other crops were increased food production (49.3%), decreased weeds and increased soil nutrients (17.9%), that they planted maize intercropped with cassava (12.1%), to increase income (5.7%), and that they intercropped with cassava, sweet potatoes, and beans (3.6%). The only reason given for non-adoption (7.9%) was a shortage of legumes (Table 5.3).

The results indicate that farmers adopt no-tillage or minimum soil disturbance to maintain soil nutrients and soil structure and reduce production costs. Farmers apparently recognized that conservation agriculture technology helps them manage their land better for higher income generation. Most farmers also expressed that leaving crop residues to permanently cover the soil have boosted land fertility, conserved soil moisture and reduced weeds infestation. This finding shows farmers think this technique can help them with problems of water shortage and lack of crop matter in the soil. Turmel, Speratti, Baudron, Verhulst, and Govaerts (2015) noted that decays of unprocessed crop residues in the soil become humus and form a pool of carbon storage. In addition, covering soil with crop residues lowers soil evaporation, which produces more soil moisture (Li Liu et al., 2017).

However, a proportion of farmers argued that they habitually ploughed the land to soften the soil and avoid weed invasion, indicating long-embedded practices. This result agrees with FAO (2018), which reported that one of the challenges in implementing conservation agriculture is that farmers are used to the practice of slashing and burning crop residues and tilling the land for land preparation.

Some of the farmers still remove crop residues from their land, as traditionally practised. This practice can reduce soil organic matter, resulting in unfertile soil. Lemke et al. (2010) noted that removing crop residues without adding fertilizers can affect soil nutrients. Some farmers said they lacked information on the importance of crop residues to manage the land.

Another compounding factor is that the Timor-Leste Government decided to support farmers to increase agricultural production by delivering tractors to plough the land (GoTL, 2010). In contrast, minimum tillage is a technique that encourage farmers not to overexploit the soil and preserve the land for sustainable use (Baker & Saxton, 2007).

The other element of conservation agriculture is intercropping. Farmers reported that applying intercropping can boost food production, reduce weeds, and improve soil fertility, as well as increase income. Farmers stated that they intercropped maize with cassava, sweet potatoes, and beans. Thus, a driver of the adoption intercropping is that it directly responds to farmer's needs. Indeed, farmers are enthusiastic about intercropping maize with other crops to maintain food availability.

A study by Hu et al. (2017) reported that intercropping wheat with maize increased both grain yield and efficiency of water use, particularly in dry areas. Also, a study by Thierfelder et al. (2012) examined the rotational and intercropping benefits on crop yield. The result indicated that applying intercropped maize with cowpea was elevated crop yield in comparison with sole maize. Improved crop production is important in Timor-Leste because farmers often run out of food before the next cultivation season. According to UNDP (2006), food insufficiency occurs when maize is about to be harvested and the planting of rice has finished. A few farmers remarked that they did not have enough legumes to intercrop with maize, suggesting they are willing to cultivate legumes but lack inputs. Consequently, farmers can only plant maize. Thus, making the necessary inputs available is likely to have a bearing on the adoption of intercropping.

5.5 Barriers and constraints for conservation agriculture adoption

Farmers identified a number of factors as constraining adoption of conservation agriculture. Farmers strongly agreed that these factors constrained CA use: lack of knowledge and skills related to CA (29%), level of education (35.8%), cultural factors (31.8% farmers), information availability (24.4%), capital (23.3%), cost of CA tools/machinery (23.9%), costs of inputs (21.6%), availability of inputs (16.5%), availability of CA tools/machinery (15.9%), availability of irrigation (15.3%), and cost of irrigation (12.5%) (Table 5.4).

Table 5.4: Barriers and constraints for conservation agriculture (CA) adoption

Rate of agreement: 1 = not agree at all, 5 = strongly agree													
Farmers													
	Mean	1		2		3		4		5			
	Score	No	%	No	%	No	%	No	%	No	%	Total	%
Knowledge/skills about CA	3.95	-	-	12	6.8	36	20.5	77	43.8	51	29	176	100
Level of education	3.95	-	-	20	11.4	32	18.2	61	34.7	63	35.8	176	100
Cultural factors	3.93	2	1.1	7	4.0	49	27.8	62	35.2	56	31.8	176	100
Information availability	3.88	-	-	10	5.7	44	25	79	44.9	43	24.4	176	100
Capital	3.83	-	-	23	13.1	25	14.2	87	49.4	41	23.3	176	100
Cost of CA tools/machinery	3.78	-	-	12	6.8	56	31.8	66	37.5	42	23.9	176	100
Costs of inputs	3.77	-	-	22	12.5	34	19.3	82	46.6	38	21.6	176	100
Availability of inputs	3.70	-	-	17	9.7	48	27.3	82	46.6	29	16.5	176	100
Availability of CA tools/machinery	3.60	-	-	20	11.4	58	33	70	39.8	28	15.9	176	100
Availability of irrigation	3.20	5	2.8	50	28.4	52	29.5	42	23.9	27	15.3	176	100
Cost of irrigation	3.10	8	4.5	52	29.5	53	30.1	41	23.3	22	12.5	176	100

This study found that farmers' limited knowledge or skills about CA, level of education, cultural factors, information availability, and capital are important barriers in CA adoption. These constraints must be considered in order to properly understand farmers' conditions. Findings from this study are consistent with, (Harper et al., 2018) who found that lack extension advisers means farmers may not know about CA or improve their skills in CA and soil cultivation. Similarly, Loria and Bhardwaj (2016) reported that farmers' limited knowledge on adaptation measures constrained their response to risks related to climate change.

Farmers' level of education was also a factor perceived to effect adoption of conservation agriculture in this study. Education is fundamental in helping farmers understand the benefits of CA. Arslan et al. (2014) also found that education was positively correlated with adoption of conservation agriculture; farmers with higher average education were more likely to apply crop rotation. A study by D'Souza and Mishra (2018) similarly demonstrated that education was positively associated with adoption of conservation agriculture. Knowledgeable farmers are less likely to abandon practising conservation agriculture (D'Souza and Mishra 2018). Knowledge, skills, and education are interrelated; and failing to improve education levels can limit farmers' understanding of CA.

Another issue perceived by farmers to hinder adoption is cultural factors. People have their own beliefs and ways of thinking and behaviour. Knowing about this is critical to understanding people a particular place. Cultural factors can affect farmers' attitudes towards rejecting or receiving new innovations. According to Ajzen (1991), farmers' attitudes reflect their intention to perform something if they believe in it. Persuading farmers to accept new innovations is difficult in the short term; farmers may ignore the ability of CA to improve on the traditional methods. Harper et al. (2018) described that land tillage practices people have been used to is a barrier to moving to conservation agriculture. Thus, traditional cultural agricultural practices must be considered before disseminating information about CA.

Farmers agreed that lack of available of information is a factor constraining CA application. Farmers dwelling in rural areas sometimes find it difficult to access information, or there is no information outreach to farmers. Farmers most commonly communicate about agriculture and other issues via simple farmer-to-farmer interaction. Information should be given to farmers in appropriate ways, so they best understand the message.

Capital is another factor limiting farmers' use of conservation agriculture. A shortage of money and other resources (e.g., lack of agriculture inputs) hinders agricultural activities and adoption of new technologies. Farmers often find it difficult to access credit for funding agricultural activities and other needs. This finding is similar to Van et al.'s (2015) study that lack of capital constrained farmers' practice of adaptation strategies to climate variability in Vietnam. Similarly, Gebrehiwot and van der Veen (2013) reported that lack of finance limited farmers' implementation of adaptation strategies to climate change. MAFF (2012) also reported a lack of private investment as a constraint that farmers must overcome in their agricultural production.

Farmers also have concerns about the cost of CA tools and machinery. Farmers must obtain CA tools/machinery from the FAO (FAO, 2015), which procures and delivers the equipment. Also, farmers do not know what the cost will be if the equipment is damaged in the future. Hence, information about the cost must be made clear to the farmers to allow them to plan a budget for the next cropping season.

Farmers also face obstacles in the availability of inputs, which are required to secure outputs. This is similar to Tun Oo et al. (2017) study where they reported that farmers in Myanmar face shortages of farm inputs that hinder their implementation of adaptation strategies to climate variability. The Timorese Government has given farmers seeds, fertilizer, and pesticides (MAFF, 2015) to help them improve crop production, but the inputs should be easily and promptly available to the farmers at affordable prices.

The availability of CA tools/machinery also concerned farmers. Easy and affordable access to tools used for CA is important. To strengthen the implementation of conservation agriculture, farmers have received CA tools (e.g., lee seeders, jab planters, rotavators) from the FAO. However, only those integrated into farmers' groups have been provided with these materials. Hence, increasing availability of tools could help CA adoption.

Finally, this study also showed that farmers were moderately concerned about irrigation water. The surveyed farmers mostly plant their maize under lowland rain-fed conditions. lack of access to irrigation facilities was also found by Loria and Bhardwaj (2016) to limit farmers in practising adaptation strategies to climate change. Yang et al. (2011) also reported that improved irrigation methods resulted in improved water use efficiency in intercropping systems such as wheat with maize as well as elevate crop yield.

5.6 Conclusion and implications

The Timor-Leste Government continues to strive to assure sufficient food for the population. Providing appropriate agricultural technology to farmers is vital. Introducing new innovations to farmers is one of the avenues to increase crop production. Because of the importance of food production and food security, the introduction of conservation agriculture is an alternative solution to stop overexploitation of soil nutrients and increase crop production while tackling the adverse effects of climate change. Various entities such as the government, international agencies and local NGOs have offered different approaches to finding a suitable method for addressing the problems of agriculture in Timor-Leste. Also, the Timorese Government is starting to support farmers by distributing improved maize varieties and other inputs to the farmers.

Although some farmers in the study area did apply conservation agriculture, the extent/ intensity of adoption was varied. About 15 per cent of farmers adopted two components of conservation agriculture and 12 per cent adopted one component. Only 10 per cent of the farmers had applied all three CA components. This finding indicates farmers are only partially adopting CA. Farmers most frequently used permanent soil cover, followed by intercropping with other crops and no-tillage or minimum soil disturbance. These findings indicate that farmers still considered no-till as a new approach to land management. Given that traditionally, farmers tilled the land before cultivating crops, adoption of this technique will take time and understanding of the advantages of CA is important.

A number of factors influenced whether or not farmers apply conservation agriculture. For instance, farmers who practised CA described that practising no-till or minimum soil disturbance helps maintain soil structure and lessens production costs. Likewise, they decided to retain crop residues to increase soil fertility, control soil moisture and reduce weed infestation. Further, they said that applying intercropping of maize with other crops such as cassava, sweet potatoes and beans leads to increased food production. Reasons farmers gave for not using conservation agriculture were that land tilling softens the soil and prevents weeds, that they are used to removing crop residues from their land, that they lack information about CA, and that they have limited access to legumes.

Farmers indicated that barriers and obstacles to adopting CA include lack of knowledge/skills related to conservation agriculture, poor education, cultural factors, and lack of information and capital. The availability and cost of irrigation were regarded as moderate problems.

Many farmers in Timor Leste have not yet adopted CA. Non-adopters use existing methods such as ploughing the land, clearing the land through slash and burn of crops residues, and using indigenous knowledge to manage the land for crop production. In particular, slash and burn are prevalent in Timor-Leste when farmers begin preparing the land for the next planting season (Egashira, Gusmao, & Kurosawa (2006). Slashing and burning out the crop residue are also used for easy weed control. Also, many farmers cultivate crops once a year, during the rainy season. During the fallow period, farmers graze their livestock on the fields because they do not have any alternative source of vegetation. Consequently, all crop stubbles are removed and no mulch remains on the soil.

Given these factors, widespread application of conservation agriculture in Timor-Leste may need time as farmers need first to understand the essence of conservation agriculture and the benefits it offers to them. To improve adoption, promoting the advantages of CA to farmers (such as reduced labour time, enhance soil humus, soil moisture conservation, enhance water infiltration into the soil, and increased crop yield (Baker and Saxton, 2007) is vital to enable farmers to understand the CA technique and its benefits. Support for CA including procuring equipment and materials appropriate for CA is also needed. Comprehensive approaches, such as providing materials and technical assistance to the farmers combined with understanding farmers' behaviour, can lead to better CA adoption.

Conservation agriculture is composed of minimum tillage and soil disturbance, permanent soil cover with crop residues, and live mulches, crop rotation and intercropping (FAO, 2014). These methods are used to manage soil nutrients retain soil moisture while preserving the environment. For areas exposed to drought, conservation agriculture may be a suitable technique to keep soil moisture, reduce soil evaporation and water run-off. However, for conservation agriculture to be fully beneficial, it has to be done together with other good agriculture management practices such as water management, pest management, and crop management. For example, in areas vulnerable to flooding, water management should be applied to control water drainage. Hence, the benefits from conservation agriculture, can be maximised if done in conjunction with other good agriculture management techniques and if it is suitable for the area.

Finally, while the spread of conservation agriculture in Timor-Leste is promising, appropriate support must be provided to help farmers implement CA. These supports include providing inputs and adequate training to farmers, as well as access to capital and other CA technologies. Overcoming the barriers will encourage farmers to apply conservation agriculture to more land.

Chapter 6

Factors Influencing Conservation Agriculture Adoption in Timor-Leste

6.1 Introduction

Conservation agriculture promotes the wise use of agricultural resources to maximise profits, sustain production and conserve the environment (Friedrich and Kienzle, 2007). As alluded to previously, CA has many benefits, yet not everyone adopts the technology. This chapter examines factors influencing the adoption of conservation agriculture in Timor-Leste. Section 6.2 starts with a description of the variables used in the logit model. Section 6.3 presents the factors affecting the uptake of CA as found in the study. Section 6.4 covers farmers' motivation for applying conservation agriculture, while Section 6.5 presents the findings on farmers' decision to adopt conservation agriculture. Finally, Section 6.6 concludes the chapter and outlines the implications of the results.

6.2 Description of variables used in logit model

The summary descriptive statistics of the explanatory variables are presented in Table 6.1. The results showed that the average age of both farmers who adopted CA and farmers who did not adopt CA was 46.0 years. Educational level was measured as years of schooling of the household head. Adopter farmers had an average of 4.7 years of schooling, while non-adopter farmers had an average age of 4.5 years. The average number of members living in the households was 6.6 for adopter households and 6.2 for non-adopter households.

Farmers in the study cohort had, on average, slightly more than two decades of experience working in maize farming, with very little difference between adopters and non-adopters. Farmers who applied the conservation agriculture method had previously applied traditional maize farming; conservation agriculture was introduced to farmers in 2013.

Table 6.1: Explanatory variables used in the logit model

		Total farmers (n = 465)		Adopters (n = 176)		Non-Adopters (n = 289)	
Variable	**Description**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
GENDER (Z_1)	Dummy: 1 if farmer is male	0.68	0.47	0.74	0.44	0.64	0.48
AGE (Z_2)	Age of farmer (years)	46.35	13.50	46.01	13.46	46.56	13.55
EDUCATION (Z_3)	Years of schooling of household head	4.57	4.10	4.73	4.51	4.46	3.84
HHSIZE (Z_4)	Number of members in the household	6.38	2.56	6.64	2.62	6.21	2.51
EXPERISPOUSE (Z_5)	Years of experience of spouse in maize farming	20.42	13.25	19.84	13.77	20.81	12.89
EXPERIENCE (Z_6)	Years of experience in maize farming	23.40	13.76	23.31	13.59	23.45	13.89
FARMMAIZESIZE (Z_7)	Maize area (ha)	0.85	0.48	0.89	0.56	0.83	0.43
LABOUR (Z_8)	Labour (h/ha)	104.79	54.91	99.45	53.44	108.04	55.62
ERTILIZER (Z_9)	Fertilizer (unit/ha)	0.78	3.03	1.66	4.48	0.24	1.36
HERBICIDE (Z_{10})	Herbicide (unit/ha)	0.44	1.50	0.40	1.28	0.46	1.63
NETINCOME (Z_{11})	Income from maize farming ($/ha)	154.80	214.96	244.05	254.69	100.45	164.93
ENTREPRETRAIT (Z_{12})	Entrepreneurial traits (1 = *not agree at all*, 5 = *strongly agree*)	3.52	0.35	3.63	0.31	3.45	0.36
RISKATTIMALE (Z_{13})	Risk attitude of male (1 = *farmer unwilling to take risk*, 5 = *farmer fully willing to take risk*)	3.18	1.25	4.07	0.85	2.63	1.14
RISKATTITUDEFEMALE (Z_{14})	Risk attitude of female (1 = *farmer unwilling to take risk*, 5 = *farmer fully willing to take risk*)	0.68	0.47	0.74	0.44	0.64	0.48
LANDTYPE (Z_{15})	Dummy: 1 if farm is under lowland rain-fed and 0 otherwise	46.35	13.50	46.01	13.46	46.56	13.55

		Total farmers (n = 465)		Adopters (n = 176)		Non-Adopters (n = 289)	
Variable	**Description**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
CREDIT (Z_{16})	1 if farmer access to credit and 0 otherwise	4.57	4.10	4.73	4.51	4.46	3.84
TRAINMINTILL (Z_{17})	1 if farmer participated in training on minimum tillage and 0 otherwise	6.38	2.56	6.64	2.62	6.21	2.51
TRAINCOVCROP (Z_{18})	1 if farmer participated in training on leaving crop residue/mulch	20.42	13.25	19.84	13.77	20.81	12.89
IMPROVEMAIZEVAR (Z_{19})	1 if farmer cultivated improved maize varieties *sele* and 0 otherwise	23.40	13.76	23.31	13.59	23.45	13.89
REMITTANCE (Z_{20})	1 if farmer income earned remittances from abroad and 0 otherwise	0.85	0.48	0.89	0.56	0.83	0.43
DROUGHT (Z_{21})	1 if drought occurs in farmer place and 0 otherwise	104.79	54.91	99.45	53.44	108.04	55.62
NATIONGONEIGHFRIENDS (Z_{22})	1 if farmer received information about new farming practices from national NGOs, neighbours and friends and 0 otherwise	0.78	3.03	1.66	4.48	0.24	1.36

The area under maize cultivation was measured in hectares (ha), which averaged 0.89 ha for adopters and 0.83 ha non-adopters.

Labour use was defined as time spent in maize farming per hectare: an average of 99.5 hours per hectare for adopters and 108.0 hours for non-adopters. Allocation of fertilizer to maize crop production was measured in kilograms per hectare: an average of 1.66 kg per hectare for adopters and 0.24 kg per hectare for non-adopters.

Herbicide used to control weed infestation was measured in litres per hectare: an average of 0.40 li per ha for adopters and 0.46 li per ha for non-adopters.

6.3 Factors influencing adoption of conservation agriculture

Table 6.2 presents the results of the estimated logit models, which represents the propensity of maize farmers' households to adopt conservation agriculture. The independent variables age, experience, net income, entrepreneurial traits, risk attitude of males, risk attitude of females, land type, credit, training in minimum tillage, training in cover-crop residues, drought, and information access were significantly correlated with conservation agriculture adoption. The chi-square (X^2) of 346.95 was highly statistically significant ($P \leq 0.01$). The log likelihood (–99.36) indicated that the variables included in the logit model are important for determining adoption of conservation agriculture.

Table 6.2: Factors affecting the decision of farmers to adopt conservation agriculture

	Logistic regression			
Variable	**Coefficient**	**SD**	**Odds ratio**	***P* value**
Constant	–14.848	3.546	-13.848	0.000***
GENDER	0.350	0.536	1.350	0.514
AGE	–0.069	0.034	0.931	0.041**
EDUCATION	–0.032	0.050	0.968	0.531
HHSIZE	0.057	0.070	1.057	0.412
EXPERISPOUSE	0.010	0.025	1.010	0.696
EXPERIENCE	0.070	0.036	1.070	0.052*
FARMAIZESIZE	–0.661	0.431	0.339	0.125

Logistic regression				
Variable	**Coefficient**	**SD**	**Odds ratio**	***P* value**
LABOUR	–0.002	0.004	0.998	0.683
FERTILISER	0.096	0.108	1.096	0.375
HERBICIDE	0.017	0.093	1.017	0.858
NETINCOME	0.004	0.001	1.004	0.001***
ENTREPRETRAIT	1.425	0.737	2.425	0.053*
RISKATTIMALE	1.159	0.249	2.159	0.000***
RISKATTITUDEFEMALE	0.493	0.221	1.493	0.025**
LANDTYPE	1.151	0.578	2.151	0.047**
CREDIT	1.369	0.641	2.369	0.033**
TRAINMINTILL	1.225	0.462	2.225	0.008**
TRAINCOVCROP	3.011	0.553	4.011	0.000***
IMPROVEMAIZEVAR	0.601	0.393	1.601	0.126
REMITTANCE	1.395	2.650	2.395	0.599
DROUGHT	1.596	0.534	2.596	0.003**
NATIONGONEIGHFRIENDS	3.838	0.966	4.838	0.000***

§ Pseudo-R^2 = 0.636, LLF = –99.36; *significant at 10% level; **significant at 5% level; ***significant at 1 % level

This study found that age negatively affected famers' adoption of conservation agriculture ($P \leq 0.05$). The odds ratio (ψ) = 0.93 which indicates that as age increases by one year, the probability of adoption of conservation agriculture goes down by 0.93 times. This is perhaps because younger farmers are more likely to apply conservation agriculture. Older farmers tend to use existing agricultural methods instead of shifting to new agricultural techniques. This finding is similar to Becerill (2010) and Joshi et al. (2017) who also found age negatively influenced farmers' adoption of mulching to conserve soil moisture and apply improved maize varieties. It appears that younger farmers are more likely to take up CA technology.

In contrast, the level of experience positively influenced farmers to adopt conservation agriculture ($P \leq 0.10$). The odds ratio (ψ) = 1.07 reveals that as farmers' experience increases by one year, the probability adoption of conservation agriculture increases by 1.07 times which implies that farmers that have more experience in farming are more likely to apply conservation agriculture. Probably more experienced farmers better understand this technique and its benefits. This finding is consistent with previous findings that farmers with more experience have a higher probability of adopting new agriculture methods (Kumar et al., 2010; Laxmi and Mishra, 2007). Hence, farmers' experience in practising new technologies can make them more confident to apply the technologies over the long term.

Net income positively influences farmers to apply conservation agriculture ($P \leq 0.01$). The odds ratio (ψ) = 1.00 which means that as net income increases by one unit, the probability of adopting conservation agriculture goes up by 1 time. That is, farmers with higher net income from their agriculture production were more likely to adopt conservation agriculture. Net income in this study refers to income farmers obtain after deducting expenses. Previously, Abdur Rashid Sarker et al. (2013) also showed that farm income positively and significantly influenced farmers to take up new adaptive strategies such as cultivating short-duration rice. In addition, McNamara et al. (1991) found farm income positively affected farmers to implement integrated pest management. Other studies that also found household income to positively influence farmers to apply no tillage are (Ntshangase et al., 2018) and Sheikh et al., (2003). In contrast, Jiri, Mafongoya, and Chivenge (2017) claimed that farmers who obtained high income from conventional agricultural systems were reluctant to adopt other alternatives to adapt to climate change.

Entrepreneurial traits positively influenced farmers to uptake conservation agriculture ($P \leq 0.10$) with an odds ratio (ψ) = 2.43. This finding indicates that farmers with who are more entrepreneurial are more likely to adopt conservation agriculture techniques. In this regard, surveyed farmers were willing to engage in the market to trade their agricultural produce. Although this aspect has not been examined in the agriculture literature, entrepreneurial traits have been studied in the business context. As noted by Zhao and Seibert (2006), entrepreneurial intention is a fundamental trait that encourages a person to start a business. However, the outcome depends on both personal attributes (internal factors) and external factors. Internal factors can motivate a person to make an entrepreneurial decision. People who have a strong internal locus of control are more likely to take risks and establish businesses (Hansemark, 1998; Mueller and Thomas, 2001). Nevertheless, external factors beyond an individual's control can also influence their decision (Espíritu-Olmos and Sastre-Castillo, 2015; Karabulut, 2016).

The above finding shows that farmers in the study area exhibited characteristics of internal locus of control. However, to encourage and support farmers to more actively participate in the agriculture business, external factors such as availability of agricultural inputs, and access to credit, information, training and markets are critical. Factors such as farmers' inadequate road access to markets and insufficient facilities for value addition such as storeroom, promoting and selling products and distribution can hinder participation (MAFF, 2013). Hence, the Timorese Government's strategic plan for agriculture to tackle issues related to increasing agricultural production and engaging in markets is likely to support farmers efforts and also influence their technology adoption decisions (GoTL, 2010).

The findings of this study on entrepreneurial traits provide valuable information for the government about agricultural production and market orientation. Surveyed farmers with strong entrepreneurial traits were more likely to participate in the market to sell their produce. People with internal locus of control are more likely to have entrepreneurial intentions and be enthusiastic about succeeding in competitive markets (Karabulut, 2016). This behaviour can enable individuals to take risks and be alert to opportunities (Jain and Ali, 2013; Kaish and Gilad, 1991).

This study also examined the risk attitude of both males and females as an influencing variable to CA adoption. The risk attitude of males was positively related with uptake of conservation agriculture ($P \leq 0.01$). That is, a higher risk preference of male farmers were most probably to apply conservation agriculture. The odds ratio (ψ) = 2.16 which implies that as male risk preference increases by one unit, the probability of adopting conservation agriculture increases by 2.16 times. Likewise, the risk attitude of females predicted their uptake of conservation agriculture ($P \leq 0.05$), with odds ratio (ψ) = 1.49 it indicates that as female risk attitude enhances by one, the probability of adopting conservation agriculture increases by 1. 49 times. This finding in line with that of Yorobe and Quicoy (2006) who found that risk-takers were more likely to use improved maize varieties such as Bt corn.

Farmers with risk aversion do not direct to adopt a new technology (Marra, Pannell, and Ghadim 2003). Ervin and Ervin (1982) found that farmers with risk aversion tended to need more technical information programs in order to adopt conservation tillage. Hence, in order to increase farmers' adoption of CA, adequate technical information about conservation agriculture and its benefits is critical.

Land type was a dummy variable included in the model that emphasized farm location under lowland rain-fed conditions. This variable positively influenced farmers' adoption of conservation agriculture ($P \leq 0.05$), with odds ratio (ψ) = 2.15. That is, farmers under lowland rain-fed conditions were more likely to apply conservation agriculture methods. Similarly, Ghimire, Wen-chi, and Shrestha (2015) found that land under lowland was positively associated with adoption of improved rice varieties.

Farmers under lowland rain-fed conditions are probably favourable towards conservation agriculture because the management methods include preserving soil cover with crop residues. This technique reduces evaporation from the soil and retains soil moisture. This aspect of CA particularly benefits dry areas with limited water to support plant growth (Li Liu et al., 2017).

Credit (dummy for credit accessibility) positively encouraged farmers' adoption of conservation agriculture ($P \leq 0.05$); in other words, the accessibility of credit by farmers were most probably to adopt conservation agriculture, with odds ratio (ψ) = 2.37. Other studies have also shown that credit accessibility positively affects farmers' adoption of improved rice varieties (Chandio and Yuansheng, 2018). Also, Mariano, Villano, and Fleming, (2012) found access to credit influence farmers to apply integrated crop management. Credit availability supports farmers with capital difficulties in undertaking farming activities such as purchasing agricultural inputs, as well as helping with household expenditures.

Minimum tillage training was a dummy for participation in training on minimum tillage. This variable found to positively influenced farmers' uptake of conservation agriculture ($P \leq 0.05$), implying that farmers who take part in training on minimum tillage are more likely to apply conservation agriculture, the odds ratio (ψ) = 2.23 showing that an additional training in minimum tillage will likely increase adoption of conservation agriculture by 2.23 times. Other studies had similar findings; farmers participating in training were positively influenced to adopt integrated crop management and to apply improved maize varieties (Yorobe and Quicoy, 2006; Mariano, Villano, and Fleming, 2012).

Training on soil cover with crop residues/mulch was a dummy variable for participation in training on mulching. This variable positively affected farmers' adoption of conservation agriculture ($P \leq 0.01$), indicating that farmers who participated in the training on soil cover with crop residues are most likely to take up CA. The odds ratio (ψ) = 4.01 indicates that a training on soil cover with crop residues enhances the probability of adoption of conservation agriculture by 4.01 times.

Minimum soil disturbance and mulching are methods integrated into conservation agriculture. Minimum tillage increases soil carbon content in the surface layer, which affects the physical properties of the soil (Huang, Liang, Wang, and Zhou, 2015). It also conserves soil macro-aggregates and maintains soil organic carbon and soil nitrogen, which promotes microbial biomass (Vezzani et al., 2018).

Mulching maintains soil moisture, soil nutrients and soil organic carbon (Liu, Herbert, Hashemi, Zhang, and Ding, 2006). Farmers in the study area attended these training programs held by NGOs and extension service staff in the field. As reported by FAO (2015), farmers are encouraged to attend training before implementing conservation agriculture in order to improve their knowledge about and skills in conservation agriculture. The training helps farmers to understand the benefits of conservation agriculture and thus increases adoption.

Drought was the model's dummy variable for drought occurrence in farmers' areas. Drought positively affected farmers in applying conservation agriculture ($P \leq 0.05$); experiencing dry periods, a climate change-related risk, was more likely to encourage farmers to apply conservation agriculture, with odds ratio (ψ) = 2.60 which implies that as drought event increases by one, this can probably enhance adoption of conservation agriculture by 2.60 times.

Adaptation to dry periods is critical to minimise crop failure. Khanal, Wilson, Hoang, and Lee (2018) found that drought reduced rice yield. Likewise, Thinh, Rañola, Camacho, and Simelton (2018) reported that farmers had difficulty in cultivating rice as water levels decreased through drought. Conservation agriculture is an option for tackling the effects of drought (Reicosky and Saxton 2007).

Access to information was a dummy variable for farmers receiving information about new farming practices from national NGOs, neighbours, and friends. Access to information positively influenced farmers' adoption of conservation agriculture ($P \leq 0.01$), indicating that farmers need to acquire information from various sources to adopt conservation agriculture. The odds ratio (ψ) = 4.84 which implies that increasing access to information by one, increases the probability of adoption of conservation agriculture by 4.84 times.

Surveyed farmers obtained information about conservation agriculture from NGOs, with government support (FAO 2015). The Timorese Government is involved in disseminating information about conservation agriculture. This support forms part of the government program to introduce conservation agriculture to farmers to improve crop production and land management.

The remaining variables examined – gender, education, household size, spouse's farming experience, labour, fertilizer, herbicide, improved maize varieties and remittance did not significantly affecting uptake of CA methods in this study.

6.4 Farmers' motivation for applying conservation agriculture

Understanding the factors that motivated farmers to use conservation agriculture methods is important. Hence, this study investigated these factors (Table 6.3). Of the farmers adopting conservation agriculture, almost 73 per cent strongly agreed that drought mitigation motivated them to adopt the techniques. Other very important factors were reduced labour time (59.1%), more time for off-farm work (57.4%), higher yield (56.3%), and participating in training and observation of peers (54.5%) had motivated them to adopt conservation agriculture (Table 6.3).

Moreover, farmers agreed that improving maize production and productivity (50.6%), saving water (51.1%), saving input costs (48.9%), adapting to climate change (52.3%), working with other members of the family (48.3%), increasing income (48.3%), selling surplus to market (50%) and safeguarding income for the future (46%) had encouraged them to implement conservation agriculture technique (Table 6.3).

As shown above, farmers strongly agreed on several factors that motivated them to apply conservation agriculture methods: drought mitigation, reduce labour time, more time for off-farm work, and higher yield. The conservation agriculture technique is an option for both responding to climate change–related risk and preserving land. With the benefits of this method, farmers can increase their maize production while adapting to climate change, which could affect their livelihoods. Thus, effective approaches to support farmers to improve their land management and crop production are required.

Table 6.3: Farmers' motivation for applying conservation agriculture

Rate of agreement: 1 = not agree at all, 5 = strongly agree														
Farmers														
	Mean	1		2		3		4		5		Total		
Reason	Score	No	%	No	%	No	%	No	%	No	%	No	%
Drought mitigation	4.73	-	-	-	-	-	-	48	27.3	128	72.7	176	100
Reduced labour time	4.57	-	-	-	-	3	1.7	69	39.2	104	59.1	176	100
More time for off-farm work	4.55	-	-	1	0.6	2	1.1	72	40.9	101	57.4	176	100
Higher yield	4.54	-	-	-	-	4	2.3	73	41.5	99	56.3	176	100
Participation in training and observation of peers	4.52	-	-	1	0.6	3	1.7	76	43.2	96	54.5	176	100
Save water	4.47	-	-	-	-	8	4.5	78	44.3	90	51.1	176	100
Improve maize production and productivity	4.47	-	-	-	-	2	1.1	89	50.6	85	48.3	176	100
Save input costs	4.46	-	-	1	0.6	4	2.3	85	48.3	86	48.9	176	100
Adapt to climate change	4.43	-	-	-	-	4	2.3	92	52.3	80	45.5	176	100
Work with other members of the family	4.38	-	-	1	0.6	11	6.3	85	48.3	79	44.9	176	100
Increase income	4.37	-	-	2	1.1	16	9.1	73	41.5	85	48.3	176	100
Sell surplus to market	4.29	-	-	1	0.6	17	9.7	88	50.0	70	39.8	176	100
Safeguard income for the future	4.28	-	-	-	-	23	13.1	81	46.0	72	40.9	176	100

6.5 Farmers' decision to adopt conservation agriculture

Table 6.4 shows the criteria that affected farmers' decision to practise conservation agriculture for crop production. Understanding these decision criteria is essential for providing effective support to adopt the techniques.

Labour saving was the criterion cited by about 69 per cent of farmers as very important for their decision to practise conservation agriculture (Table 6.4). Other very important criteria were time saving/timely sowing of next crop (50%), cost effectiveness/cost saving or advantage (52.8%), enhance yield/crop production/productivity (49.4%), soil conservation health/management fertility (50% farmers), and less irrigation/water requirement/saving (46.6% farmers). Easy management/operational use (54.5% farmers), early maturity/cropping frequency/timelines (48.9% farmers), land levelling or good field/soil condition (52.3% farmers), weed control /herbicide use/availability (45.5% farmers) and machine availability (49.4% farmers) were also important criteria for farmers deciding to implement conservation agriculture (Table 6.4).

These findings indicate that by applying conservation agriculture farmers expected to reduce their labour input and cultivate their crops in a timely manner, which in turn can save productions costs. They also expected to increase crop production and productivity, better maintain soil nutrients, and use less water.

Labour saving can reduce the number of farm workers required. Farmers often experience labour shortages, particularly during land preparation. In addition, time saved by the conservation agriculture method may allow farmers to do more off-farm work and so earn additional income. Further, increasing crop yield means farmers can provide more food for their households, while increasing soil nutrients and reducing the need for irrigation which improves farmers' resilience in tackling the effects of drought.

Table 6.4: Criteria for farmers' decision to adopt conservation agriculture

Rate of importance: 1 = not at all important, 5 = very important														
Farmers														
	Mean	**1**		**2**		**3**		**4**		**5**		**Total**	
	Score	**No**	**%**	**No**	**%**	**No**	**%**	**No**	**%**	**No**	**%**	**No**	**%**
Labour saving	4.68	-	-	-	-	3	1.7	51	29	122	69.3	176	100
Time saving/timely sowing of next crop	4.48	-	-	-	-	4	2.3	84	47.7	88	50	176	100
Cost effectiveness/cost saving/advantage	4.46	-	-	-	-	1	0.6	93	52.8	82	46.6	176	100
Enhance yield/crop production/productivity	4.44	-	-	-	-	6	3.4	87	49.4	83	47.2	176	100
Soil conservation/health/manage fertility	4.44	-	-	1	0.6	4	2.3	88	50	83	47.2	176	100
Less irrigation/water requirement/saving	4.38	1	0.6	-	-	12	6.8	82	46.6	81	46	176	100
Easy management/operational use	4.35	-	-	1	0.6	8	4.5	96	54.5	71	40.3	176	100
Early maturity/cropping frequency/timelines	4.34	-	-	1	0.6	14	8	86	48.9	75	42.6	176	100
Land levelling/good field/soil condition	4.30	1	0.6	1	0.6	12	6.8	92	52.3	70	39.8	176	100
Weed control/herbicide use/availability	4.22	1	0.6	2	1.1	24	13.6	80	45.5	69	39.2	176	100
Machine availability	4.20	1	0.6	4	2.3	19	10.8	87	49.4	65	36.9	176	100

The decision criteria in Table 6.4 are important elements for engaging farmers in applying conservation agriculture. Hence, support for enabling farmers to make positive decisions to apply CA should address these aspects because of CA's significant potential to increase crop production and preserving the environment.

6.6 Conclusion and implications

Good agricultural practice incorporates a variety of approaches to plant nutrient, pest, weed and water management (FAO, 2011; Friedrich et al., 2012). Conservation agriculture embraces several of the components of good agricultural practices; it tackles deficient soil nutrients, water scarcity and weed problems. Conservation agriculture was introduced in 2013 in Timor-Leste and has been implemented by some farmers. However, the factors that influence farmers to adopt conservation agriculture were unclear.

This study examined several aspects which might affect the uptake of conservation agriculture: household characteristics, farm characteristics and economic factors, entrepreneurial traits, and the external environment. Household characteristics significantly affecting adoption were age (negative effect), farmers' experience, area under lowland rainfed maize cultivation, and risk attitudes of males and females (positive effects). Entrepreneurial traits also positively affected adoption. Farm characteristics and economic factors affecting adoption were net income, labour use, and inputs (positive effects). External environmental factors affecting adoption were training, credit, information received (from NGOs, neighbours, and friends), and drought.

Drought mitigation, reduced labour time, more time for off-farm work, and higher yield strongly motivated farmers to use conservation agriculture. Further, labour saving, time saving/timely sowing of next crop, cost effectiveness/cost saving/advantage, enhanced yield/crop production/productivity, and soil conservation/health/manage fertility were important factors in farmers' decision to practise conservation agriculture.

The findings of the study provide detailed information that helps in the understanding of the factors affecting farmers' uptake of CA in Timor-Leste. The study found entrepreneurial traits positively influenced farmers to adopt conservation agriculture. No previous studies have examined entrepreneurial traits as a factor determining whether farmers take up agricultural technology. Hence, this study delivers new insights on the role of entrepreneurial traits on adoption of agricultural innovations, and thus, adds to the academic literature in this field. In addition, this study contributes valuable information for the Timor-Leste government in considering support for scaling implementation of conservation agriculture in other parts of Timor-Leste. The findings can also better inform practitioners in agricultural development and international development organizations working in Timor-Leste.

Chapter 7

Impact of Conservation Agriculture

7.1 Introduction

Currently, there are four municipalities currently where conservation agriculture has been introduced, with plans to expand to the other nine municipalities in Timor-Leste. However, it is important to access the effect of this program on farmers in the intervention areas and assess whether farmers have benefited from this program or not. This chapter is aimed to examine the effect of conservation agriculture on maize production, income and workloads.

This chapter commences with this introductory section. Section 7.2 then presents the of propensity score matching analysis. Section 7.3 elaborates the result and the effect of CA adoption on yield, income and workloads. Finally, Section 7.4 concludes the chapter and discusses implications of the results.

7.2 Propensity score matching

To obtain matched groups of CA and non-CA farmers, propensity score matching was used. A total of 176 of CA farmers and 284 of non-CA farmers was generated from the matching. Table 7.1 presents statistical description and units of the *Z* variables used in the propensity score matching. The demographic characteristics (age, education, household size, experience) and total area operated are those typically included in most technology adoption.

Table 7.1: Descriptive statistics of both CA farmers' and non-CA farmers

		Both (N = 465)		Adopter (N = 176)		Non-Adopter (N = 289)	
Variable	**Description**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
Gender	Dummy: 1 if farmer is male	0.68	0.47	0.74	0.44	0.64	0.48
Age	Age of farmer (years)	46.35	13.50	46.00	13.46	46.56	13.55
Education	Years of schooling of head of household	4.57	4.10	4.73	4.51	4.46	3.84
Experience	Years of experience in rice farming	23.40	13.76	23.31	13.59	23.45	13.89
Household size	Number of household members	6.38	2.56	6.64	2.62	6.21	2.51
Area	Total area operated (ha)	0.85	0.48	0.89	0.48	0.83	0.43
Market access	Dummy: 1 if farmers accessed market	0.29	0.45	0.36	0.48	0.25	0.43
Credit access	Dummy: 1 if farmer accessed credit	0.10	0.30	0.15	0.36	0.07	0.25

The region of common support for the PSM was between 0.166 and 0.794. The indicators of matching are shown in Table 7. 2. The mean of the absolute bias before matching was 14 and was found to be significantly different from zero. This valued decreased after matching and found to be not significant different from zero. After matching, the pseude-R^2 was low at 0.004 which indicates that the covariates X are distributed randomly between the two groups.

Table 7.2: Matching quality indicators

Item	Unmatched	Matched
No. of observations		
Treated	176	176
Control	289	284
Absolute bias		
Mean	14	4.2
Std. deviation	13.9	4.6
Chi-square	27.34	1.83
P>Chi-square	0.001	0.986
Pseudo-R^2	0.044	0.004

Prior to determining the effects of CA on maize farming households, the balance test was used to check that the observable characteristics of adopters and non-adopter groups are equal on average. Table 7.3 showed that the means of the observed characteristics for farmers practicing CA and farmers who are not practicing CA after matching are not significant at the 5% level of significance. Therefore, the results of the tests indicate that the matched samples can be used for representing the missing counterfactuals. Thus, the effect of applying CA can be measured.

Table 7.3: Balancing tests for the observed variables unmatched and matched sample data

		Mean		% Reduction		t-test	
Variable	**Data**	**Treated**	**Control**	**%bias**	**In bias**	**T**	**p>t**
GENDER	Unmatched	0.739	0.640	21.4		2.21	0.028
	Matched	0.739	0.716	4.9	76.9	0.48	0.633
AGE	Unmatched	46.006	46.557	-4.1		-0.43	0.670
	Matched	46.006	45.432	4.2	-4.1	0.41	0.685
EDUCATION	Unmatched	4.733	4.464	6.4		0.69	0.493
	Matched	4.733	4.756	-0.5	91.6	-0.05	0.960
EXPERIENCE	Unmatched	23.313	23.45	-1.0		-0.10	0.917
	Matched	23.313	23.028	2.1	-106.9	0.20	0.845
HHSIZE	Unmatched	6.642	6.215	16.7		1.75	0.080
	Matched	6.642	6.511	5.1	69.4	0.46	0.645
AREA	Unmatched	0.887	0.831	11.1		1.20	0.230
	Matched	0.887	0.838	9.9	11.1	0.97	0.335
DACCESSMARKET	Unmatched	0.358	0.246	24.6		2.61	0.009
	Matched	0.358	0.381	-5.0	79.8	-0.44	0.660
DCREDIT	Unmatched	0.148	0.066	26.7		2.92	0.004
	Matched	0.148	0.153	-1.9	93.1	-0.15	0.882

7.3 Impacts of conservation agriculture adoption

A thorough analysis was conducted to examine the differences in maize production, income and workload which are due to the CA program intervention and not from other confounding factors. Two propensity score matching techniques were used for this study: the nearest- neighbour matching and kernel density matching. The results are shown in Table 7.4.

Table 7.4: Impact of CA adoption on maize production

Variable	Unit	Nearest neighbour matching §		Kernel density matching §§	
		ATET	Std. error	ATET	Std. error
Yield	kg/ha	296.65***	84.41	264.40***	32.61
Value of maize output	US$/ha	108.56***	38.38	105.20***	22.06
Income	US$/ha	157.00***	27.55	153.60***	22.89
Labour utilisation	h/ha	-7.08	10.95	-6.93	4.76

§ Number of observations (treated = 176; control = 284); the balancing property is satisfied and the region of common support is (0.166, 0.794).
§§ Number of observations (treated = 176; control = 284); bandwidth of 0.06 was used 5 replications to compute the standard errors of ATET.
***$p < 0.01$.

7.3.1 Effect on maize yields

Conservation agriculture resulted to higher maize production. As shown in Table 7.4, the average maize yield of CA farms was 296.65 kilograms per hectare (28%) higher than that of non-CA farmers. It was statistically significant at 99 per cent confidence level. As both measures produced similar results, farmers who applied CA were more likely to have obtained higher maize yields. This indicates that there is a significant advantage for farmers in the surveyed areas in applying CA technology.

This finding is aligned with Zheng et al. (2014) who found that CA boosted the yield of food crops such as rice, wheat, and maize. Likewise, Islam and Reeder (2014) found that utilising residue plant materials after harvesting to cover the soil helped to enhance maize yield and soil quality.

Similar results were found in Mafongoya et al.'s (2016) study in Zimbabwe, where the maize yield of CA adopters was found to be higher than that of non-CA farmers. Also, Sun et al. (2018) found that CA farmers obtained a yield of 9.1 per cent more maize than non-CA farmers. The better maize yield under CA technology was due to several factors. Prior to implementing the CA technique, farmers were equipped with knowledge and skills about CA and its importance. For example, CA farmers do not burn crop residues but use them as mulch to cover soil. Farmers use traditional methods with low inputs as well as lack of knowledge to manage soil. With the CA technique, farmers often do not till the land but directly seed and cover the soil with crop residue left over from the previous season as well as use intercropping. The stubble crop from the previous year is retained in the soil as a mulch. This practice helps farmers to maintain soil organic matter which improves soil fertility, which in turn increases production. Additionally, minimum tillage of the land can preserve soil structure. Baker and Saxton (2007) also found that minimum soil tillage resulted in increased water infiltration and maintaining soil structure.

Hence, the advantage of practising conservation agriculture technology is not merely the increase in maize production, it also helps farmers to manage the land in a sustainable manner. According to Friedrich and Kienzle (2007), conservation agriculture emphasised using agriculture resources prudently in order to maximise profit without damage to the environment. Hence, CA provides an advantage to farmers in the surveyed areas, as they do not undertake multiple tillages of the land but rather use minimum till techniques.

Another component of CA is crop rotation or intercropping with other legumes. This can engage farmers to cultivate more than one crop in the same parcel or to cultivate different crops in different seasons. This can encourage farmers to produce both maize and other crops such as cassava. Cultivating maize intercropped with cassava affects overall maize crop yield. As a result, farmers can sell more crops to the market, as well as consume some themselves and give away some to their relatives and friends.

7.3.2 Effect on income

The effect of CA on income was another aspect investigated in this study. Net income from maize farming was derived from two factors, cost and revenue. Cost included all expenses incurred during the maize farming activities, while revenue reflects the quantity of maize output and the price of maize.

Farmers mostly sold maize in the local market. The average market price of maize per kilogram during the time of the survey was US$0.35. The Ministry of Forestry and

Fisheries reported that the maize price was US$0.35 per kilogram (MAFF, 2015b). This maize price is offered by the local traders in the local market.

As indicated in Table 7.4 the average value of the maize output of CA farms was $108.56 per hectare (33%) higher than that of non-CA farmers using the NNM technique. It was statistically significantly different at 99 per cent level of confidence. There was substantial difference between the two techniques, so CA enhanced maize revenue for farmers.

The higher revenue of CA farmers, along with lower costs, resulted in the average income of CA farms being $157 per hectare higher than that of non-CA farmers, as measured by the NNM method (Table 7.4). Minimum till cultivation reduces crop production costs including reducing tractor hire costs for ploughing the land. It The resulting net income was statistically significantly different at 99 per cent level of confidence for CA and non-CA farmers. This demonstrates a significant improvement in income for farmers who adopted the CA technology. This result is similar to that obtained using the KDM technique.

Lestrelin et al. (2012) also found adoption of CA increased farmers' income, similar to the results in this study. The study of Tambo and Mockshell (2018) also found the uptake of CA had significantly increased household incomes of these farmers than non-CA farmers. Similarly, Teklewold et al. (2013) found that the income of maize farmers was significantly increased by using CA.

In the study area, however, farmers faced difficulties in negotiating the actual maize price, as they did not have access to adequate information about crop prices. Further, there was a limited number of buyers for maize. Farmers simply depended on market transactions (supply and demand). The result was unstable maize prices, which affected farmers' incomes. To overcome the problem of maize price, the government has organised farmers into cooperative associations. They also attempted to link farmers to potential buyers in order to facilitate market transactions. For example, farmers are involved in cooperative such as maize breeding cooperatives facilitated by the government to help farmers in selling their maize products at a reasonable price.

Farmers who face shortage of maize seeds could get them from the breeding cooperatives.

Another issue in the area is that many farmers do not immediately take up the technique of using crop residues and organic matter to cover the soil because farmers need crop stubble to feed their animals. Also, after maize is harvested, animals are grazed freely on the farm. Consequently, there are competing priorities between using residues from crops to feed animals and using it as soil covering.

Because of these circumstances, the Timorese government has collaborated with a local NGO to introduce a local customary law to prevent free grazing of animals and uncontrolled fires in areas where the CA program is implemented (FAO, 2015). Farmers who have livestock also agreed to look for the other areas where they can use for feeding their livestock. This enabled them to implement the CA technology program.

7.3.3 Effects on labour use

In terms of labour utilisation, as shown in Table 7.4, the average labour used in CA farms was 7.08 hours per hectare (7%) less than that of non-CA farmers, but the difference was not significant at 5 per cent level, measured with the NNM technique. There was no substantial difference in average hours between the two sets of results. This indicates that CA farmers are more likely to spend fewer hours working in maize farming, although this is not significantly lower than the hours spent by farmers in conventional tillage.

A plausible explanation is that the CA farmers in the study areas have encountered problems with weed infestation. In the first instance, when applying the CA method, weeds invade the maize crop because the soil is not disturbed and crop residues are not removed from the soil. Most CA farmers had to manage weeds by removing them manually while only some farmers used herbicides to control the weeds.

Intensive mobilisation of labour occurs during the first stage of implementing CA technology, as weed infestation problems emerge to dominate crop production. At the initial stage, the soil is disturbed at a minimum level, which provokes more weeds because the land is not cultivated and crop residues remain in the soil. Hence, when farmers use hand weeding for control this needs more labour. Farmers have the option of tackling weed infestations through either weeding by hand or using herbicide or both. A similar study on weed invasion in farm in the early stage of CA was reported by Ngwira et al. (2013) to require more labour time to control weeds. A study in Zimbabwe also found that weed infestation problems appeared when conservation agriculture was first implemented. To face the weed problem, farmers pulled out the weeds by hand as well as applied herbicide (Mazvimazi and Twomlow, 2009). With subsequent crops grown with CA technology, weed infestations are reduced as soil cover can suppress weed growth.

7.4 Conclusions and implication

Increasing crop production in Timor-Leste is a crucial response to avert shortage of food for the population. Introduction of new agricultural technology is essential in elevating agricultural production. Conservation agriculture is a good technology as its components offer good agriculture practice in managing land.

Farmers in the surveyed areas have implemented conservation agriculture. This study examined the effects of CA adoption on yield, income and labour utilisation. Adopting conservation agriculture was found to increase crop production which can contribute positively to food availability. Although farmers faced some limitations in accessing agriculture inputs, CA still generated a positive impact on crop production. Farmers' incomes also increased because of the increased revenue and decreased expenses. Although not statistically significant, the study confirms that labour utilisation under CA technology also reduced. If the trend in other studies are to go by and weed problem diminishes through time, then further reduction in labour use can be expected. The reduction of labour utilisation is beneficial to farmers. It reduces production costs and farmers have more time to do other on-farm or off-farm activities. For women in particular in the surveyed areas, CA technology provides an advantage as they have more time to manage household activities such as fetching water, preparing food for the family and looking for other economic activities. For example, women can participate in home industry activities such as baking, food processing (e.g., banana chips, cassava chips) for selling to the market, which can further enhance farm-households' revenue.

Given these results, this study indicates that CA offers positive outcomes for farm households in Timor-Leste. Hence, CA technology should be replicated in other crop areas to improve crop production and improve soil management. It is however noteworthy to mention that while overall CA technology increases crop production and income and reduces labour requirements, it is harder to change farmers' mindset as they have been tilling their land for a long time. Hence, a collaboration between the government and farmers needs to be more proactive in order to promote and spread CA technology more rapidly. Training, access to agriculture inputs, credit, access to markets and access to information (e.g., market information, climate change-related risk information and other related agricultural information) are required. These are essential components to help and encourage farmers to adopt new agricultural technologies such as CA in an appropriate fashion. Hence, an essential aspect of the expansion of conservation agriculture technology would be to incorporate support elements in order to minimise constraints or problems in the future.

Chapter 8

Summary, Conclusion and Policy Implications

8.1 Introduction

Agriculture is an important sector to providing food and nutrients to the population of Timor-Leste. Maize is one of the main foods consumed by people in Timor-Leste, but most farmers use traditional methods, apply low inputs, and lack knowledge and skills. At the same time, they face climate change-related risks such as erratic rainfall, drought, soil erosion and landslides, which have adverse effects on agricultural production. To support farmers, the Timorese government has introduced conservation agriculture as an alternative land management strategy to adapt to climate-related risks. However, there is no in-depth study that have examined the impact of CA on maize production and productivity in the country. This study examined the adoption and impact of CA on maize farming households in Timor-Leste.

The objectives of this study were to:

1. Determine the climate change adaptation strategies of farmers in Timor-Leste
2. Determine the extent and intensity of adoption of farmers on CA in Timor-Leste
3. Determine factors influencing adoption of CA in Timor-Leste
4. Determine the impact of CA on maize farm households
5. Identify barriers faced by farmers in adopting CA and possible solutions to address these challenges

In this chapter, the summary, conclusion, and policy implications of the research are presented. Section 8.1 introduces the chapter, Section 8.2 outlines the summary of the thesis, Section 8.3 presents the key findings, while Section 8.4 explores the implications of the study and presents some policy recommendations. This is then followed by the conclusion of the thesis in Section 8.5. Finally, Section 8.6 presents the limitations of the study and areas for future research.

8.2 Summary of the thesis

Chapter 1 introduces the research thesis and outlines the importance of the study in the context of Timor-Leste. In this chapter, the issue of climate variability problems and its influence is likewise presented. The concept of what conservation agriculture is also explored and a short description of the implementation of CA in different parts of the world is provided.

Food crops, particularly maize, is important in Timor-Leste as the majority of the population consumes maize as a staple food. Maize is mostly grown as a single crop in non-irrigated and rainfed upland areas. Farmers often lack knowledge and skills, and lack of inputs and are best by climate related-risks such drought. These factors affect maize production and productivity. Addressing the climate change problem and the low productivity, the Timorese government through the Ministry of Agriculture and Fisheries in collaboration with FAO introduced CA to maize farmer initially in two selected areas (i.e., Manatuto and Manufahi) in Timor-Leste. The extent of adoption and the effect of CA in Timor-Leste is examined in this study. As this is the first analysis of this kind in the context of Timor-Leste, this study can add to the academic literature in this field and provide better information to assist the Timor-Leste government and other development practitioners and international organizations in the country in promoting CA in Timor-Leste.

Chapter 2 of this thesis presented an overview of Timor-Leste's agriculture sector. The development of agriculture production in different era was presented including that of the Portugal time, Indonesian era and the current agricultural situation in Timor-Leste. During the Portugal regime, agriculture was more focussed on sandalwood and coffee as well as involved in crop production such as rice and maize. Extensive agriculture production, plantations, livestock and fisheries then appeared in the Indonesian time which resulted in the growth of the gross domestic product, but later agricultural production declined due to political instability in Timor-Leste. During the independence era, farming systems was classified by variety domains such as lowland irrigated areas, upland rainfed areas, commercial crops, and livestock. Crop production of rice was 2.47 t/h and maize 1.53 t/h (MAFF, 2012). Farmers, however, experienced climate change-related risks such as drought and flooding. Thus, CA was introduced in Timor-Leste in 2013 (FAO 2015) as one of the alternative farming approaches to adapt to climate change. However, only few studies have so far been carried out on the adoption and effects of CA in Timor-Leste.

Chapter 3 described the conceptual framework and research approach in this study. This research was conducted in two municipalities (Manufahi and Manatuto) in Timor-Leste, chosen because CA was implemented first in these areas, and the predominant crops are rice and maize, the staple crops in Timor-Leste. Data were collected using quasi-experimental design. A total of 465 farmers were surveyed using random sampling. This is composed of 248 farmers from Manufahi and 217 farmers from Manatuto. The number of farmers surveyed practicing CA in Manufahi is 130 farmers while 118 farmers have not used CA. In Manatuto, 46 farmers used CA and 171 were non-CA farmers. This study used mixed-research approach (qualitative and quantitative). The qualitative method was used to explore the phenomenon and understand the problems and constraints of the CA program in Timor-Leste. Quantitative approaches such as descriptive statistics were used to examine the extent and intensity of CA adoption. T-test was used to compare the climate change adaptation strategies of CA and non-CA farmers. Factors influencing CA adoption and impacts of CA in terms of maize production, income and labour utilisation were analysed using logit regression and propensity score matching.

Results of the study were presented in four chapters consisting of Chapter 4, Chapter 5, Chapter 6 and Chapter 7 as described below.

Chapter 4 provided the results of the analysis of risk perceptions and adaptation strategies linked with natural risk hazards in maize production in Timor-Leste. This chapter was concentrated on perceptions of climate change-related risks in the two municipalities and the types of adaptation strategies by CA farmers and non-CA farmers.

Chapter 5 covered the analysis and results of the extent/ intensity of CA adoption in Timor-Leste. The implementation of CA components was analysed in this chapter. The key findings are summarised in the next section.

Chapter 6 presented the analysis and findings of the factors influencing CA adoption in maize production in Timor-Leste. Also, farmers' motivation for using CA and the decision to adopt CA are presented in this chapter. The key findings are summarised in the next section.

Chapter 7 focused on the analysis and results of the effect of CA on maize production, income, and labour. The key findings are summarised in Section 8.3 below.

Chapter 8 (this chapter) is this final chapter and summarises the thesis findings and provide the conclusions in relation to the objectives of the study. The limitations of the study and areas identified for future research are also presented at the end of the thesis.

8.3 Main findings of the study

In this section, the key findings of the study are presented.

8.3.1 What are the adaptation strategies used by maize smallholder farmers in response to climate change in Timor-Leste?

This study found that there are several types of adaptation strategies applied by farmers practicing CA and farmers that are not practicing CA to tackle climate change-related risks. CA farmers applied reduced tillage, zero tillage, crop residue as soil cover, early planting, intercropping, crop rotation, bed planting, laser land levelling, fertiliser management and crop/farm management as strategies to deal with climate variability. Meanwhile, non-CA farmers used increased seed rates, crop diversification, plot of farm, livestock, new seed varieties, substitute crops, and planted stress tolerant crops and pest/disease-tolerant varieties as important adaptation strategies to climate anomalies. These differences were statistically significant at 1 per cent level.

8.3.2 What is the extent/intensity of CA adoption?

Around 62.2 per cent of farmers had adopted different components of CA. The proportion of farmers who adopted two CA elements accounted for 15 per cent. CA components adopted included: permanent soil cover and intercropping; direct sowing or no-tillage and permanent soil cover; and zero tillage or minimum tillage and intercropping. About 12 per cent of farmers used one component including intercropping with other crops and permanent soil cover, while 10 per cent of farmers implemented all three components of CA - no-tillage or reduce tillage, permanent soil cover and intercropping.

Farmers who adopted CA mentioned that they used no-tillage or minimum soil disturbance to maintain soil nutrients, soil structure and reduce production costs. In contrast, farmers who did not adopt no-tillage stated that tilling the land can soften the soil and prevent weeds.

Farmers who practiced crop residue retention remarked that it enhanced soil nutrients, controlled soil moisture and reduced weed infestation. Some farmers did not apply permanent soil cover as they often cleared crop residues prior to planting crops for various reasons including lack of information related to the importance of applying crop residues as soil cover and leaving residues for livestock to graze.

In terms of intercropping with other crops, farmers reported that planting maize intercropped with cassava or legumes enhanced food production and income, and reduced weeds. Some of the farmers, on the other hand, did not use intercropping with other crops due to a shortage of legumes.

8.3.3 What factors influence adoption of CA?

The findings showed that net income, risk attitude of males, training on leaving crop residue/mulch and information about new farming practices from national NGOs, neighbours and friends were found to have positively and statistically highly significant effects on adoption at 1 per cent level of significance The risk attitude of females, land type, credit, training on minimum tillage and drought were found to positively and significantly affect CA adoption at 95 per cent level of confidence, while experience and entrepreneurial traits were found to positively and significantly affect adoption at 90 per cent level of confidence.

Age was found to negatively and statistically significantly influence CA adoption. This suggests that older farmers were less likely to practice CA in their farms. Farmers who had used existing farming techniques for a long time were reluctant to use a new technology as they were not familiar with the new farming method.

Farmers strongly agreed that factors motivating them to apply CA were drought mitigation, reduced labour time, higher yield expectation with CA and participating in training and observation of peers.

The very important criteria which induced farmers to decide to apply CA were labour saving, time saving/timely sowing of next crop, cost effectiveness/cost saving, enhanced yield/crop production/productivity, soil conservation health/management fertility, and lower irrigation/water requirement/saving.

8.3.4 What is the impact of applying CA technology?

The propensity score matching method was used to analyse the effect of CA to ensure the differences between CA farmers and non-CA farmers on maize production and productivity, income and farmers' workloads were due to the program intervention, not from other confounding elements. Matching design was applied to observe the similarities to minimise selection bias. The key findings are discussed below.

8.3.4.1 Impact of applying CA technology on maize production and productivity

The results showed that the average maize yield of CA farms was 296.65 kg per ha (28%) higher than the yield of non-CA farmers. The difference was statistically significant at 99 per cent level of confidence. This indicates that farmers that apply CA technique are more likely to obtain higher maize yields.

Conservation agriculture combines good techniques of land management such as no-tillage or reduce tillage, uses crop residue as soil cover and crop rotation or intercropping. Using these methods can lead to enhanced soil structure, soil nutrients and soil moisture, resulting in increased maize yield.

Crop residue retention as a soil cover can reduce soil evaporation, resulting in sufficient water to support plant growth, particularly for areas where water is lacking or there is a drought. It also helps reduce soil erosion, enhances soil organic matter, increases soil nutrients and consequently, increases maize yield.

Prior to using CA, farmers participated in training on how to apply CA and its requirements in order to understand the use of CA. Farmers also overcame weed problems that arose following implementation of CA as no soil disturbance initially allowed more weeds to emerge. Farmers controlled weeds by hand weeding and some farmers applied herbicide. A similar problem was also encountered by farmers in other countries. Mazvimazi and Twomlow (2009) found that farmers struggled to tackle weed problems when first applying CA. These farmers also used hand weeding and herbicides to control weed infestations.

8.3.4.2 Effect of applying CA on farmers' revenue and income

The findings indicated that the average value of maize output was $108.56 per ha (33%) higher than non-CA farmers and statistically significant at 99 per cent level of confidence. Farmers produce more maize from applying CA and while they are mainly subsistence farmers, they normally sell surpluses of the maize crop. Using CA therefore generates an opportunity for farmers to sell more maize to the market.

The average market price of maize at the time of the survey is about $0.35 per kilogram. Farmers receive the maize price from the market.

The average income of CA maize farmers was $157 per ha higher than non-CA farmers and statically significant at 99 per cent level. CA positively increases farmers' income, which can help them buy agriculture inputs and other household needs such as paying school fees for their children.

8.3.4.3 Impact of applying CA on farm labour utilisation

The study showed that the average labour utilisation in CA farms was 7.08 hours per ha (7%) less than non-CA farmers, although it was not statistically significant at the 95 per cent level.

Conservation agriculture requires less labour in land preparation, as it simply needs labour for bed planting and land levelling. There is no ploughing, digging and hoeing. Farmers can use simple tools such as a hoe to direct seeds into the basin. Some of the farmers use either hand jab planters or Li seeders or rolling injector planters on sloping or flat land with fixed planting spacing being set up in these planting tools. Also, farmers do not clear the land. The crop residues and legumes left over from the previous season act as weed cover and mulch, thereby reducing labour workload in terms of the land preparation. However, the disadvantage of using CA for the first time is that more weeds appear initially, which can negatively affect maize yields. This is due to no tillage or minimum tillage of the soil and not using herbicides correctly to control weeds. Consequently, farmers use extra labour and time to pull out the weeds.

In general, however, CA is suitable for farmers with a shortage of labour during the peak seasons due to land preparation and planting tasks as these tasks have to be undertaken promptly. Moreover, it appears that CA offers a better alternative solution to the farmers as it is less labour intensive in the long run. Also, it can reduce production cost as farmers spend less money to pay for labour.

8.3.5 What are the barriers faced by farmers using CA technology?

There are several factors that constrain farmers when using CA, such as lack of knowledge and skills related to CA, level of education, cultural factors, information availability, capital, cost of CA tools/machinery, cost of inputs, availability of inputs and availability of CA tools/machinery.

The most common reason cited by farmers in this study was lack of knowledge and skills in CA (29%), level of education (35%), cultural factors (31%), lack of information (24%), capital (23%) and inputs (16%). Farmers expect that these barriers can be resolved through the strategies discussed below.

8.4 Implications of the study and policy recommendations

This study found that the maize production, productivity, and income of CA farmers is greater than for non-CA farmers. Therefore, expanding CA technology to other areas of Timor-Leste should be followed up by the Ministry of Agriculture, Forestry and Fisheries. An annual reported by the government (FAO, 2015) recommended that CA be introduced to the other areas, but it is unclear how many crop areas are being covered by CA. The CA program can be replicated to other areas in the country. Increasing crop production will improve farmers' food security and reduce poverty, particularly for people living in rural spheres as agriculture is their main livelihood.

Another key finding of the study is that only 10 per cent of farmers applying CA are fully implementing all CA elements. The number of farmers that are only using two components of CA is 15 per cent while those using one CA component is only 12 per cent. This indicates that farmers are gradually adopting conservation agriculture. Farmers do not apply all the components of conservation agriculture at once. They first observe the benefits of conservation agriculture in enhancing crop production, increasing soil nutrients and resistance to drought as well as saving labour time prior to adopting all components of conservation agriculture. Hence, there is still scope to improve adoption in the areas where CA technology has already been introduced and especially in new areas. Consequently, it is important for the government to address the barriers restricting farmers to improve the implementation of CA in Timor-Leste. These potential areas for improvement are discussed in the next sections.

8.4.1 Improve knowledge and skills of farmers

Knowing about CA and its benefits are important to farmers to increase their ability to apply CA. Hence, when introducing CA to farmers it is important to ensure they understand the CA method, which will also engage more farmers to be interested in practicing CA. As CA is a package of technology, each element has its own requirements, which are necessary to get increased crop production. Farmers' education levels are also low. Hence, CA has to be introduced to farmers appropriately, so they understand the essence of CA rapidly.

Farmers are new to the CA techniques as they have used tillage for many years and they also clear the land of crop residues prior to cultivating crops. They often use residues to feed livestock during the fallow period. Changing these practices requires major cultural change so the messages need to be convincing.

8.4.2 Improve access to agricultural information

Farmers have limited access to information about new farming practices, agricultural inputs information, agriculture production and marketing information. Hence, dissemination of information to farmers that is appropriate and timely is required to respond to their farming needs. Farmers often get information through farmer to farmers' interaction. This is due to the farmers living in rural areas where it is difficult for extension workers to visit farmers to provide the information. Better and more target extension work in the field will ensure farmers receive relevant information.

8.4.3 Improve access to capital

Another factor constraining farmers to undertake their farming activity is capital. Farmers do not have sufficient cash to buy agricultural inputs and need to look for the credit for agricultural activities. Capital is a resource that can support farmers to take up new CA technology and the required inputs (such as herbicides) that need to go hand-in-hand with CA technologies.

8.4.4 Improve access to agricultural inputs

As alluded above, the availability of agricultural inputs is another aspect necessary for agriculture to be more productive. Farmers have difficulty accessing agricultural inputs such as seeds, fertilizers, chemicals and machinery at the right time and reasonable price. This is because these inputs are often lacking in farmers locations. Also, some farmers do not use agriculture inputs in their crop production. For example, weed infestation and insect pests are problems in crop farming. Farmers normally use hands and simply tools such as hoe to remove weeds. Those who wish to use herbicides and pesticides have difficulty purchasing them when needed. Farmers also struggled to obtain fertiliser and CA machines, as these inputs are mostly imported and have limited stocks. Farmers rely mostly on organic fertilizers and apply low levels of chemical fertilizer.

To increase crop yield, agriculture inputs need to be made available to farmers at the right time. Strategies are needed to address this issue. The government should look at policies that will enhance international agencies and private sector participation in agriculture input markets to improve input availability to farmers. Also, the government should remove barriers to entry by private sectors as improving private sector entry in input markets can ease the shortage of agricultural inputs.

8.5 Conclusion

Conservation agriculture, consisting of a package of technology that includes: no-tillage or reduced tillage, permanent soil cover with crop residues, and crop rotation and intercropping have been generally shown to support sustainable land management. Among its benefits are maintaining soil structure, enhancing soil moisture, increasing soil nutrients, and preventing soil erosion. Hence, this technology is suitable for farmers in Timor-Leste, as they face problems of soil degradation or soil infertility, drought, and soil erosion.

This study showed that implementation of conservation agriculture in Timor-Leste has impacted positively on maize production, productivity, income, and labour utilisation. Famers who use conservation agriculture obtained higher maize yields and higher income compared to those who did not practice conservation agriculture. Labour utilisation under conservation agriculture was slightly lower compared to conventional tillage agriculture, mainly due to lesser time for land preparation under CA. Consequently, farmers have more time to be involved in on and off-farm activities or leisure. Hence, applying conservation agriculture had generated benefits to the CA farmers in both municipalities (Manufahi and Manatuto) in Timor-Leste. Given its benefits, there is a case for it to be replicated to other areas across the country.

Several factors positively influence farmers to use conservation agriculture including experience, income, entrepreneurial traits, risk attitude of male, risk attitude of female, land type, credit, training on minimum tillage, training on leaving crop residue/mulch, drought and receives information about new farming practices from national NGOs, neighbours, and friends. The introduction of conservation agriculture to farmers in other areas needs to take account of these factors as they affect adoption and can be used by government for better planning and decision making on enabling factors when implementing conservation agriculture in Timor-Leste.

Farmers also encounter barriers in adoption of conservation agriculture. The constraint factors were lack of knowledge and skills related to CA, level of education, cultural factors, information availability, capital, cost of CA tools/machinery, cost of inputs, availability of inputs and availability of CA tools/machinery. These constraints can impede adoption of CA by farmers. The Timor-Leste government should resolve these issues, particularly enhance farmers’ knowledge and skills in CA to ensure farmers understand the benefits of using conservation agriculture. They should also ensure farmers can access credit for farming activities, can easily access relevant information (e.g. production and marketing), and that agricultural inputs are available to farmers locally at the right time.

Finally, conservation agriculture can enhance farmers' maize yields and income. It can improve food security and reduce poverty. There is a strong case for the Timorese government, particularly the Ministry of Agriculture, Forestry and Fisheries to focus on promotion of conservation agriculture and to expand to other municipalities across the country. To sustain the benefits of conservation agriculture, the Timorese government need to address the barriers mentioned above, then the country will be able to achieve better implementation of conservation agriculture to increase maize yield and also use CA as an adaptation strategy to tackle climate change in Timor-Leste.

8.6 Recommendation of the study and areas for future research

This study has several limitations. The study was carried out in two municipalities, Manufahi and Manatuto although other areas of the country also cultivate maize, which is a major food consumed by people in Timor-Leste. The reason for choosing Manufahi and Manatuto was because conservation agriculture had been introduced in those areas when the study was conducted. The sample was drawn from the same population, which was composed of conservation agriculture farmers and non-conservation agriculture farmers. On the other hand, the investigation of the impact of conservation agriculture might possibly expand to other areas across the country that have different agro-climate conditions and socio-cultural environments. Hence, future research could include analysis of CA in more municipalities, once CA has been trialled, to assess the wider impact of conservation agriculture.

Another limitation of this study is that it used cross-sectional data from farmers who practiced conservation agriculture and farmers who did not. This was because no baseline data was available. Hence, the findings of this study were only based on one single point in time and not before and after (although propensity score matching was used to control for bias). It is proposed that future research use time series analysis, preferably with baseline data.

Finally, data was gathered from adopters and non-adopters, but not dis-adopters. For future research, it is possible to incorporate data of dis-adopters to understand causes of why farmers do not continue to practice conservation agriculture. This will allow researchers to investigate deeper the benefits and issues of using conservation agriculture which can provide important information on how to promote conservation agriculture to smallholder farmers.

REFERENCES

Abdur Rashid Sarker, M., Alam, K., & Gow, J. (2013). Assessing the determinants of rice farmers' adaptation strategies to climate change in Bangladesh. *International Journal of Climate Change Strategies and Management, 5*(4), 382-403.

Abid, M., Scheffran, J., Schneider, U., & Ashfaq, M. (2015). Farmers' perceptions of and adaptation strategies to climate change and their determinants: the case of Punjab province, Pakistan. *Earth System Dynamics, 6*(1), 225.

Ajzen, I. (1985). From intentions to actions: A theory of planned behavior *Action control* (pp. 11-39). Berlin, Heidelberg: Springer.

Ajzen, I. (1991). The theory of planned behavior. *Organizational behavior and human decision processes, 50*(2), 179-211.

Ajzen, I., & Fishbein, M. (1975). *Belief, attitude, intention, and behavior : an introduction to theory and research.*: Reading, Mass. : Addison-Wesley Pub. Co.

Alesina, A., & Perotti, R. (1996). Income distribution, political instability, and investment. *European economic review, 40*(6), 1203-1228.

Arslan, A., McCarthy, N., Lipper, L., Asfaw, S., & Cattaneo, A. (2014). Adoption and intensity of adoption of conservation farming practices in Zambia. *Agriculture, ecosystems & environment, 187,* 72-86.

Agresti, A., & Kateri, M. (2011). Categorical data analysis: Springer.

Australian Bureau of Meteorology, & CSIRO. (2014). *Climate Variability, Extremesand Change in the Western Tropical Pacific: New Science and Updated Country Reports*. Retrieved from Melbourne, Australia.

Baker, & Saxton, K. E. (2007). The “what” and “why” of no-tillage farming. In C. J. Baker & K. E. Saxton (Eds.), *No-tillage seeding in conservation agriculture* (pp. 1-10). Rome, Italy: FAO.

Baker, C. J., Ritchie, W., & Saxton, K. E. (2007). The nature of risk in no-tillage. In C. J. Baker & K. E. Saxton (Eds.), *No-tillage seeding in conservation agriculture* (2 ed., pp. 21-33). Rome, Italy: FAO.

Baker, J. L. (2000). *Evaluating the impact of development projects on poverty: A handbook for practitioners*. Washington, D.C.: The World Bank.

Bandura, A. (1986). *Social foundations of thought and action : a social cognitive theory / Albert Bandura*. Englewood Cliffs, N.J.: Englewood Cliffs, N.J. : Prentice-Hall.

Barnett, J., Dessai, S., & Jones, R. (2003). Climate change in Timor Leste: science, impacts, policy and planning: briefing to government, civil society, and donors, República Democrática de Timor-Leste (pp. 40). Australia: University of Melbourne; CSIRO.

Barnett, J., Dessai, S., & Jones, R. N. (2007). Vulnerability to climate variability and change in East Timor. *AMBIO: A Journal of the Human Environment, 36*(5), 372-378.

Batterbury, S., P.J., Palmer, L. R., Reuter, T. R., Carvalho, D. A., Kehi, B., & Cullen, A. (2015). Land access and livelihoods in post-conflict Timor-Leste: no magic bullets. *International Journal of the Commons, 9*, 619–647.

Becerril, J., & Abdulai, A. (2010). The impact of improved maize varieties on poverty in Mexico: a propensity score-matching approach. *World Development, 38*(7), 1024-1035.

Bellotti, B., & Rochecouste, J. F. (2014). The development of Conservation Agriculture in Australia—Farmers as innovators. *International Soil and Water Conservation Research, 2*(1), 21-34.

Calegari, A., Derpsch, R., & Lorenzatti, S. (2008). *An international technical workshop investing in sustainable crop intensification: The case for imptoving soil health* (Vol. 6). Rome, Italy: FAO.

Caliendo, M., & Kopeinig, S. (2008). Some practical guidance for the implementation of propensity score matching. *Journal of economic surveys, 22*(1), 31-72.

Carmona, I., Griffith, D. M., Soriano, M.-A., Murillo, J. M., Madejón, E., & Gómez-Macpherson, H. (2015). What do farmers mean when they say they practice conservation agriculture? A comprehensive case study from southern Spain. *Agriculture, ecosystems & environment, 213*, 164-177.

Chandio, A. A., & Yuansheng, J. (2018). Determinants of Adoption of Improved Rice Varieties in Northern Sindh, Pakistan. *Rice Science, 25*(2), 103-110.

Chen, S., Chen, X., & Xu, J. (2016). Impacts of climate change on agriculture: evidence from China. *Journal of Environmental Economics and Management, 76*, 105-124.

Chen, Y., Liu, S., Li, H., Li, X., Song, C., Cruse, R., & Zhang, X. (2011). Effects of conservation tillage on corn and soybean yield in the humid continental climate region of Northeast China. *Soil and Tillage Research, 115*, 56-61.

Costa, H. (2003). *The evolution of agricultural policies in East Timor*. Paper presented at the ACIAR proceedings (pp. 45-56).

Creevey, L., & Woller, G. (2006). *Methodological issues in conducting impact assessments of private sector development programs*. Washington, DC: USAID.

Creswell, J. W. (2007). *Qualitative inquiry and research design: Choosing among five approaches*: Sage publications.

D'Souza, A., & Mishra, A. K. (2018). Adoption and abandonment of partial conservation technologies in developing economies: The case of South Asia. *Land Use Policy*, *70*, 212-223.

Davis, F. D., Bagozzi, R. P., & Warshaw, P. R. (1989). User acceptance of computer technology: a comparison of two theoretical models. *Management science, 35*(8), 982-1003.

Deichert, G., Barros, J., & Noltze, M. (2009). *Introducing the System of Rice Intensification in Timor Leste-Experiences and Prospects.* Paper presented at the 7th PAWEES Conference on Promising Practices for the Development of Sustainable Paddy Fields.

Derpsch, R., & Friedrich, T. (2009). *Development and current status of no-till adoption in the world.* Paper presented at the Proceedings on CD, 18th Triennial Conference of the International Soil Tillage Research Organisation (ISTRO).

Dolcemascolo, G. (2003). *Climate Risk and Agriculture in Timor Loro'Sae.* Paper presented at the Seminar on Climate Change and Severe Weather Events in Asia and the Caribbean, Barbados, July 24.

Donley, A. M. (2012). *Research Methods*. New York New York : Infobase Pub.

Egashira, K., Gusmao, M. N., & Kurosawa, K. (2006). The present and future land management in East Timor-From" slush and burn" to" slush and mulch". *Journal of the Faculty of Agriculture, Kyushu University, 51*(2), 367-372.

Erenstein, O., & Laxmi, V. (2008). Zero tillage impacts in India's rice–wheat systems: a review. *Soil and Tillage Research, 100*(1-2), 1-14.

Ervin, C. A., & Ervin, D. E. (1982). Factors affecting the use of soil conservation practices: hypotheses, evidence, and policy implications. *Land Economics, 58*(3), 277-292.

Espíritu-Olmos, R., & Sastre-Castillo, M. A. (2015). Personality traits versus work values: Comparing psychological theories on entrepreneurial intention. *Journal of Business Research*, *68*(7), 1595-1598.

FAO. (2011). *Save and Grow, a policymaker's guide to sustainable intensification of smallholder crop production*. Rome, Italy: FAO. Retrieved from www.fao.org/3/a-i2215e.

FAO. (2011). *Timor-Leste and FAO achievements and success stories*. Rome, Italy Retrieved from www.fao.org/3/a-at018e.

FAO. (2014a). *Conservation agriculture: The 3 principles*. Rome, Italy Retrieved from www.fao.org/resources/infographics/infographics-details/.../216754/.

FAO. (2014b). *Enhancing food and nutrition security and reducing disaster risk through the promotion of conservation agriculture*. Dili, Timor-Leste.

FAO. (2015). *Enhancing food and nutrition security and reducing disaster risk through the promotion of conservation agriculture*. Dili, Timor-Leste:

FAO. (2018). *Promoting conservation agriculture in Timor-Leste*. Bangkok, Thailand Retrieved from www.fao.org/publications/card/en/c/I8858EN

FAO/WFP. (2003). *FAO/WFP crop and food supply assessment mission to Timor-Leste*. Rome, Italy.

FAO/WFP. (2007). *FAO/WFP crop and food supply assessment mission to Timor-Leste*. Rome, Italy.

Friedrich, T., Derpsch, R., & Kassam, A. (2012). Overview of the global spread of conservation agriculture. *Field Actions Science Reports. The journal of field actions*(Special Issue 6).

Friedrich, T., & Kienzle, J. (2007). *Conservation agriculture: impact on farmers' livelihoods, labour, mechanization and equipment.* Paper presented at the Conservation Agriculture for Sustainable Land Management to Improve the Livelihood of People in Dry Areas. Proceedings of an international workshop (pp. 25-36).

Gebrehiwot, T., & van der Veen, A. (2013). Farm level adaptation to climate change: the case of farmer's in the Ethiopian Highlands. *Environmental management, 52*(1), 29-44.

Gebremariam, G., & Tesfaye, W. (2018). The heterogeneous effect of shocks on agricultural innovations adoption: Microeconometric evidence from rural Ethiopia. *Food policy, 74*, 154-161.

Ghimire, R., Wen-chi, H., & Shrestha, R. B. (2015). Factors affecting adoption of improved rice varieties among rural farm households in Central Nepal. *Rice Science, 22*(1), 35-43.

Gomez, N. (2015). Climate change and adaptation on selected crops in Southern Philippines. *International Journal of Climate Change Strategies and Management, 7*(3), 290-305.

Gonçalves, M. M. (1989). *Aspectos das Actividades Agrárias em Timor Oriental*. Evora, portugal.

Gornott, C., & Wechsung, F. (2016). Statistical regression models for assessing climate impacts on crop yields: A validation study for winter wheat and silage maize in Germany. *Agricultural and Forest Meteorology, 217*, 89-100.

GoTL. (2002). *National Development Plan*. Dili, Timor-Leste: United Nations Development Programme in Timor-Leste.

GoTL. (2008). *General budget of state 2008*. Dili, Timor-Leste.

GoTL. (2010). *Timor-Leste startegic development plan 2011-2030*. Dili, Timor-Leste.

GoTL. (2011a). *Population and housing census 2010; Population distribution by administrative areas*. Dili, Timor-Leste.

GoTL. (2011b). *Timor-Leste household income and expenditure survey 2011*. Dili, Timor-Leste.

GoTL. (2013). *Timor-Leste's initial national communication*. Dili, Timor-Leste: Timor-Leste's state secretariat for environment.

GoTL. (2015a). *State budget 2015*. Dili, Timor-Leste.

GoTL. (2015b). *Timor-Leste population and housing census*. Dili, Timor-Leste.

GoTL. (2017). *Analytical report on education*. Dili, Timor-Leste.

Griffin, J. M. (2003). Introduction: The many dimessions of the climate change issue. In J. M. Griffin (Ed.), *Global climate change: The science, economics and politics* (Vol. IV). Lincolnshire, UK.

Gujarati, D. (2011). *Econometrics by example*: Palgrave macmillan.

Habanyati, E. J., Nyanga, P. H., & Umar, B. B. (2018). Factors contributing to disadoption of conservation agriculture among smallholder farmers in Petauke, Zambia. *Kasetsart Journal of Social Sciences*.

Hansemark, O. C. (1998). The effects of an entrepreneurship programme on need for achievement and locus of control of reinforcement. *International Journal of Entrepreneurial Behavior & Research, 4*(1), 28-50.

Harper, J. K., Roth, G. W., Garalejić, B., & Škrbić, N. (2018). Programs to promote adoption of conservation tillage: A Serbian case study. *Land Use Policy, 78*, 295-302.

Harris, J. E., Gleason, P. M., Sheean, P. M., Boushey, C., Beto, J. A., & Bruemmer, B. (2009). An introduction to qualitative research for food and nutrition professionals. *Journal of the American Dietetic Association, 109*(1), 80-90.

Heckman, J. J., & Robb Jr, R. (1985). Alternative methods for evaluating the impact of interventions: An overview. *Journal of econometrics, 30*(1-2), 239-267.

Hobbs, P. R. (2007). Conservation agriculture: what is it and why is it important for future sustainable food production? *Journal Of Agricultural Science-Cambridge, 145*(2), 127.

Hu, F., Feng, F., Zhao, C., Chai, Q., Yu, A., Yin, W., & Gan, Y. (2017). Integration of wheat-maize intercropping with conservation practices reduces CO2 emissions and enhances water use in dry areas. *Soil and Tillage Research, 169*, 44-53.

Huang, M., Liang, T., Wang, L., & Zhou, C. (2015). Effects of no-tillage systems on soil physical properties and carbon sequestration under long-term wheat–maize double cropping system. *Catena, 128*, 195-202.

Huang, M., Zou, Y., Feng, Y., Cheng, Z., Mo, Y., Ibrahim, M., . . . Jiang, P. (2011). No-tillage and direct seeding for super hybrid rice production in rice–oilseed rape cropping system. *European journal of agronomy, 34*(4), 278-286.

Huanwen, G., Karabayev, M., & Il, K. K. (2008). *An international technical workshop investing in sustainable crop intensification: The case for imptoving soil health* (Vol. 6). Rome, Italy: FAO.

IPCC. (2014). *Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*. Geneva, Switzerland.

Islam, R., & Reeder, R. (2014). No-till and conservation agriculture in the United States: an example from the David Brandt farm, Carroll, Ohio. *International Soil and Water Conservation Research, 2*(1), 97-107.

Jain, R., & Ali, S. W. (2013). A review of facilitators, barriers and gateways to entrepreneurship: directions for future research. *South Asian Journal of Management, 20*(3), 122-163.

Jiri, O., Mafongoya, P. L., & Chivenge, P. (2017). Building climate change resilience through adaptation in smallholder farming systems in semi-arid Zimbabwe. *International Journal of Climate Change Strategies and Management, 9*(2), 151-165.

Johnson, R. B., & Onwuegbuzie, A. J. (2004). Mixed methods research: A research paradigm whose time has come. *Educational researcher, 33*(7), 14-26.

Joshi, B., Ji, W., & Joshi, N. B. (2017). Farm households' perception on climate change and adaptation practices: A case from mountain district of Nepal. *International Journal of Climate Change Strategies and Management, 9*(4), 433-445.

Kaish, S., & Gilad, B. (1991). Characteristics of opportunities search of entrepreneurs versus executives: Sources, interests, general alertness. *Journal of business venturing, 6*(1), 45-61.

Karabulut, A. T. (2016). Personality Traits on Entrepreneurial Intention. *Procedia-Social and Behavioral Sciences, 229*, 12-21.

Kassam, A., Friedrich, T., & Derpsch, R. (2010). *Conservation agriculture in the 21st century: A paradigm of sustainable agriculture.* Paper presented at the European Congress on Conservation Agriculture (Vol. 10, pp. 4-6).

Kassie, M., Shiferaw, B., & Muricho, G. (2011). Agricultural technology, crop income, and poverty alleviation in Uganda. *World Development, 39*(10), 1784-1795.

Keefer, G. D. (2000). *Report on Restoration of Meteorological Network-Timor Loro Sae*: United Nation Translation Administration in East Timor. 53 pratten St. Corinda 4075 Qld: Australia.

Keil, A., D'souza, A., & McDonald, A. (2015). Zero-tillage as a pathway for sustainable wheat intensification in the Eastern Indo-Gangetic Plains: does it work in farmers' fields? *Food Security, 7*(5), 983-1001.

Kessler, C. (2006). Decisive key-factors influencing farm households' soil and water conservation investments. *Applied Geography, 26*(1), 40-60.

Khanal, U., Wilson, C., Hoang, V.-N., & Lee, B. (2018). Farmers' adaptation to climate change, its determinants and impacts on rice yield in Nepal. *Ecological Economics, 144*, 139-147.

Khandker, S., B. Koolwal, G., & Samad, H. (2009). *Handbook on impact evaluation: quantitative methods and practices*: The World Bank.

Khonje, M., Manda, J., Alene, A. D., & Kassie, M. (2015). Analysis of adoption and impacts of improved maize varieties in eastern Zambia. *World Development, 66*, 695-706.

King, D. (2005). Climate change: the science and the policy. *Journal of Applied Ecology, 42*(5), 779-783.

Kumar, V., Jat, H. S., Sharma, P. C., Gathala, M. K., Malik, R. K., Kamboj, B. R., . . . Sharma, D. (2018). Can productivity and profitability be enhanced in intensively managed cereal systems while reducing the environmental footprint of production? Assessing sustainable intensification options in the breadbasket of India. *Agriculture, ecosystems & environment, 252*, 132-147.

Lalani, B., Dorward, P., Holloway, G., & Wauters, E. (2016). Smallholder farmers' motivations for using Conservation Agriculture and the roles of yield, labour and soil fertility in decision making. *Agricultural Systems, 146*, 80-90.

Laxmi, V., Erenstein, O., & Gupta, R. K. (2007). *Impact of zero tillage in India's rice-wheat systems*: CIMMYT.

Laxmi, V., & Mishra, V. (2007). Factors affecting the adoption of resource conservation technology: case of zero tillage in rice-wheat farming systems. *Indian Journal of Agricultural Economics, 62*(1), 126-136.

Lemke, R., VandenBygaart, A., Campbell, C., Lafond, G., & Grant, B. (2010). Crop residue removal and fertilizer N: effects on soil organic carbon in a long-term crop rotation experiment on a Udic Boroll. *Agriculture, ecosystems & environment*, *135*(1-2), 42-51.

Lestrelin, G., Quoc, H. T., Jullien, F., Rattanatray, B., Khamxaykhay, C., & Tivet, F. (2012). Conservation agriculture in Laos: Diffusion and determinants for adoption of direct seeding mulch-based cropping systems in smallholder agriculture. *Renewable Agriculture and Food Systems, 27*(1), 81-92.

Li Liu, D., Zeleke, K. T., Wang, B., Macadam, I., Scott, F., & Martin, R. J. (2017). Crop residue incorporation can mitigate negative climate change impacts on crop yield and improve water use efficiency in a semiarid environment. *European journal of agronomy, 85*, 51-68.

Liu, X., Herbert, S., Hashemi, A., Zhang, X., & Ding, G. (2006). Effects of agricultural management on soil organic matter and carbon transformation-a review. *Plant Soil and Environment, 52*(12), 531.

Long, S. J., Long, J. S., & Freese, J. (2006). *Regression models for categorical dependent variables using Stata*: Stata press.

Loria, N., & Bhardwaj, S. (2016). Farmers' Response and Adaptation Strategies to Climate Change in Low-Hills of Himachal Pradesh in India. *Nature Environment and Pollution Technology, 15*(3), 895.

Mace, M. J. (2010). International treaties. In S. H. Schneider, A. Rosencranz, M. D. Mastrandrea, & K. K. Duriseti (Eds.), *Climate change science and policy*. Washington, DC, USA: Island Press, 1718 Connecticut Ave. NW,Suite 300.

MAFF. (2004). *Policy and strategic framework*. Dili, Timor-Leste.

MAFF. (2006). *Rice overview.* Dili, Timor-Leste.

MAFF. (2012). *Ministry of Agriculture and Fisheries Strategic Plan 2014-2020*. Dili, Timor-Leste.

MAFF. (2013a). *Agriculture sector development medium term operational plan 2014 - 2018*. Dili, Timor-Leste.

MAFF. (2013b). Manufahi municapality. Dili, Timor-Leste.

MAFF. (2014a). *Data record on potential, planted area and production of maize, by year of 2014*. Dili, Timor-Leste.

MAFF. (2014b). *Data record on potential, planted area and production of rice, by year of 2014*. Dili, Timor-Leste.

MAFF. (2015a). *Food Security Bulletin of Timor-Leste*. Retrieved from Dili Timor-Lesre:

MAFF. (2015b). *Maize production*. Dili, Timor-Leste.

Mafongoya, P., Rusinamhodzi, L., Siziba, S., Thierfelder, C., Mvumi, B. M., Nhau, B., . . . Chivenge, P. (2016). Maize productivity and profitability in conservation agriculture systems across agro-ecological regions in Zimbabwe:

a review of knowledge and practice. *Agriculture, ecosystems & environment, 220*, 211-225.

Maredia, M. K. (2009). *Improving the proof: Evolution of and emerging trends in impact assessment methods and approaches in agricultural development* (Vol. 929): Intl Food Policy Res Inst.

Mariano, M. J., Villano, R., & Fleming, E. (2012). Factors influencing farmers' adoption of modern rice technologies and good management practices in the Philippines. *Agricultural Systems, 110,* 41-53.

Marra, M., Pannell, D. J., & Ghadim, A. A. (2003). The economics of risk, uncertainty and learning in the adoption of new agricultural technologies: where are we on the learning curve? *Agricultural Systems, 75*(2-3), 215-234.

Mase, A. S., Gramig, B. M., & Prokopy, L. S. (2017). Climate change beliefs, risk perceptions, and adaptation behavior among Midwestern US crop farmers. *Climate Risk Management, 15,* 8-17.

Mashingaidze, N., Madakadze, C., Twomlow, S., Nyamangara, J., & Hove, L. (2012). Crop yield and weed growth under conservation agriculture in semi-arid Zimbabwe. *Soil and Tillage Research, 124,* 102-110.

Mazvimavi, K. (2010). Socio-Economic Analysis of Conservation Agriculture in Southern Africa. FAO.

Mazvimavi, K., & Twomlow, S. (2009). Socioeconomic and institutional factors influencing adoption of conservation farming by vulnerable households in Zimbabwe. *Agricultural Systems, 101*(1-2), 20-29.

McNamara, K. T., Wetzstein, M. E., & Douce, G. K. (1991). Factors affecting peanut producer adoption of integrated pest management. *Review of agricultural economics, 13*(1), 129-139.

Meneses, D. N. d. C. (2008). *Timor: de colónia a país nos fins do século xx. Um sistema educativo em re-estruturação. (um estudo documental).* Universidade Portucalense Infante D. Henrique, Porto, Portugal.

Metzner, J. K. (1977). *Man and environment in East Timor; A geological analysis of the Baucau – Viqueque area as a possible basis for regional planning*. Canberra, Australia.

Mueller, S. L., & Thomas, A. S. (2001). Culture and entrepreneurial potential: A nine country study of locus of control and innovativeness. *Journal of business venturing, 16*(1), 51-75.

Nawaz, A., Farooq, M., Lal, R., & Rehman, A. (2017). Comparison of conventional and conservation rice-wheat systems in Punjab, Pakistan. *Soil and Tillage Research, 169*, 35-43.

Ngwira, A. R., Aune, J. B., & Mkwinda, S. (2012). On-farm evaluation of yield and economic benefit of short term maize legume intercropping systems under conservation agriculture in Malawi. *Field Crops Research, 132*, 149-157.

Ngwira, A. R., Thierfelder, C., & Lambert, D. M. (2013). Conservation agriculture systems for Malawian smallholder farmers: long-term effects on crop productivity, profitability and soil quality. *Renewable Agriculture and Food Systems, 28*(4), 350-363.

Noltze, M., Schwarze, S., & Qaim, M. (2013). Impacts of natural resource management technologies on agricultural yield and household income: The system of rice intensification in Timor Leste. *Ecological Economics, 85*, 59-68.

North, G. R. (2003). Climate change over the next century In J. M. Griffin (Ed.), *Global climate change: The science, economics and politics* (Vol. IV). Lincolnshire, UK.

Ntshangase, N. L., Muroyiwa, B., & Sibanda, M. (2018). Farmers' Perceptions and Factors Influencing the Adoption of No-Till Conservation Agriculture by Small-Scale Farmers in Zashuke, KwaZulu-Natal Province. *Sustainability, 10*(2), 555.

Okoba, B., & Mariki, W. (2008). *An international technical workshop investing in sustainable crop intensification: The case for imptoving soil health* (Vol. 6). Rome, Italy: FAO.

Oxfam. (2004). *Overview of the rice sector in Timor-Leste.* Dili, Timor-Leste.

Pannell, D. J., Llewellyn, R. S., & Corbeels, M. (2014). The farm-level economics of conservation agriculture for resource-poor farmers. *Agriculture, ecosystems & environment, 187*, 52-64.

Pannell, D. J., Marshall, G. R., Barr, N., Curtis, A., Vanclay, F., & Wilkinson, R. (2006). Understanding and promoting adoption of conservation practices by rural landholders. *Australian journal of experimental agriculture, 46*(11), 1407-1424.

Parihar, C., Jat, S., Singh, A., Kumar, B., Pradhan, S., Pooniya, V., . . . Jat, R. (2016). Conservation agriculture in irrigated intensive maize-based systems of north-western India: Effects on crop yields, water productivity and economic profitability. *Field Crops Research, 193*, 104-116.

Paudel, B., Radovich, T. J., Chan-Halbrendt, C., Crow, S., Tamang, B., Halbrendt, J., & Thapa, K. (2014). Effect of conservation agriculture on maize-based farming system in the mid-hills of Nepal. *Procedia Engineering, 78*, 327-336.

Pedersen, J., & Arneberg, M. (1999). *Social and economic conditions in East Timor*. Retrieved from New York, USA:

Powlson, D. S., Stirling, C. M., Thierfelder, C., White, R. P., & Jat, M. (2016). Does conservation agriculture deliver climate change mitigation through soil carbon sequestration in tropical agro-ecosystems? *Agriculture, ecosystems & environment, 220*, 164-174.

Reicosky, D. C. (2001). Effects of conservation tillage on soil organic carbon dynamics: field experiments in the US corn belt. *Sustaining the global farm. Purdue University, West Lafayette*, 481-485.

Reicosky, D. C., & Saxton, K. E. (2007). The benefits of no-tillage. In C. J. Baker & K. E. Saxton (Eds.), *No-tillage seeding in conservation agriculture* (Vol. 2, pp. 11-20). Nosworthy Way Wallingford, Oxfordshire OX10 8DE, UK.

Rietveld, T., & van Hout, R. (2017). The paired t test and beyond: Recommendations for testing the central tendencies of two paired samples in research on speech, language and hearing pathology. *Journal of communication disorders, 69*, 44-57.

Rio, N. (1999). *The status of the East Timor agricultural sector 1999*. Columbia University, International Conflict Resolution Program. New York, USA.: Columbia University.

Rogers, E. M. (1995). *Diffusion of Innovations* (Fourth edition ed.). New York, USA.

Rogers, E. M. (2002). Diffusion of preventive innovations. *Addictive behaviors, 27*(6), 989-993.

Rogers, E. M., & Shoemaker, F. F. (1971). *Communication of Innovations; A Cross-Cultural Approach*. New York, USA.

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

Rusinamhodzi, L., Corbeels, M., Van Wijk, M. T., Rufino, M. C., Nyamangara, J., & Giller, K. E. (2011). A meta-analysis of long-term effects of conservation agriculture on maize grain yield under rain-fed conditions. *Agronomy for sustainable development, 31*(4), 657.

Saldanha, J. M., & Costa, H. (1999). Economic Viability of East Timor Revisited: Outlook for the 21st Century. *East Timor Study Group (ETSG) Working Paper, 1*, 5-9.

Sattler, C., & Nagel, U. J. (2010). Factors affecting farmers' acceptance of conservation measures—a case study from north-eastern Germany. *Land Use Policy, 27*(1), 70-77.

Saunders, M., Lewis, P., & Thornhill, A. (2016). *Research methods for business students* (Seventh edition ed.). Edinburg Gate Harlow Essex CM202JE, England, UK.

Scheider, S. H., Rosencranz, A., Mastrandrea, M. D., & Kuntz-Duriseti, K. (2010). *Climate change science and policy*. Washington, DC, USA: Island Press, 1718 Connecticut Ave. NW,Suite 300.

Schlesinger, W. H. (2003). The carbon cycle: Human perturbations and potential management options. In J. M. Griffin (Ed.), *Global climate change: The science, economics and politics* (Vol. IV). Lincolnshire, UK.: Cheltenham, UK Northampton, MA, USA.

Schneider, S. H., & Mastrandrea, M. D. (2010). Climate change science overview. In S. H. Schneider, A. Rosencranz, M. D. Mastrandrea, & K. K. Duriseti (Eds.), *Climate change science and policy*. Washington, DC, USA: Island Press, 1718 Connecticut Ave. NW,Suite 300.

Sheikh, A., Rehman, T., & Yates, C. (2003). Logit models for identifying the factors that influence the uptake of new 'no-tillage'technologies by farmers in the rice–wheat and the cotton–wheat farming systems of Pakistan's Punjab. *Agricultural Systems, 75*(1), 79-95.

Shepherd, C. J. (2009). Participation, authority, and distributive equity in East Timorese development. *East Asian Science, Technology and Society, 3*(2-3), 315-342.

Sheppard, B. H., Hartwick, J., & Warshaw, P. R. (1988). The theory of reasoned action: A meta-analysis of past research with recommendations for modifications and future research. *Journal of consumer research, 15*(3), 325-343.

Sherlock, S. (1996). Political economy of the East Timor conflict. *Asian Survey, 36*(9), 835-851.

Sheskin, D. J. (2003). *Handbook of parametric and nonparametric statistical procedures* (Third edition ed.): CHAPMAN & HALL/CRC.

Silva, H. L. (1952). *Timor e a cultura do café*. Evora, Portugal.

Sithole, N. J., Magwaza, L. S., & Mafongoya, P. L. (2016). Conservation agriculture and its impact on soil quality and maize yield: A South African perspective. *Soil and Tillage Research, 162*, 55-67.

Sivakumar, M. V. K., & Hansen, J. (2007). *Climate Prediction and Agriculture : Advances and Challenges / edited by Mannava V. K. Sivakumar, James Hansen*. Springer. Berlin, Heidelberg.

Smith, W. G. C. (1992). *Planters and small holders in Portuguese Timor in the nineteenth and twentieth centuries*. London, UK.

Sun, L., Wang, S., Zhang, Y., Li, J., Wang, X., Wang, R., . . . Wang, Q. (2018). Conservation agriculture based on crop rotation and tillage in the semi-arid Loess Plateau, China: Effects on crop yield and soil water use. *Agriculture, ecosystems & environment, 251*, 67-77.

Tambo, J. A., & Abdoulaye, T. (2013). Smallholder farmers' perceptions of and adaptations to climate change in the Nigerian savanna. *Regional Environmental Change, 13*(2), 375-388.

Tarhini, A., Arachchilage, N., Masa, apos, deh, R., apos, . . . Abbasi, M. (2015). A Critical Review of Theories and Models of Technology Adoption and Acceptance in Information System Research. *International Journal of Technology Diffusion (IJTD), 6*(4), 58-77.

Tashakkori, A., Teddlie, C., & Johnson, B. (2015). Mixed Methods. In J. D. Wright (Ed.), *International Encyclopedia of the Social & Behavioral Sciences (Second Edition)* (pp. 618-623). Oxford: Elsevier.

Teklewold, H., Kassie, M., Shiferaw, B., & Köhlin, G. (2013). Cropping system diversification, conservation tillage and modern seed adoption in Ethiopia: Impacts on household income, agrochemical use and demand for labor. *Ecological Economics*, *93*, 85-93.

Thierfelder, C., Cheesman, S., & Rusinamhodzi, L. (2012). A comparative analysis of conservation agriculture systems: Benefits and challenges of rotations and intercropping in Zimbabwe. *Field Crops Research, 137*, 237-250.

Thierfelder, C., Rusinamhodzi, L., Ngwira, A. R., Mupangwa, W., Nyagumbo, I., Kassie, G. T., & Cairns, J. E. (2015). Conservation agriculture in Southern Africa: Advances in knowledge. *Renewable Agriculture and Food Systems, 30*(4), 328-348.

Thierfelder, C., Rusinamhodzi, L., Setimela, P., Walker, F., & Eash, N. S. (2016). Conservation agriculture and drought-tolerant germplasm: Reaping the benefits of climate-smart agriculture technologies in central Mozambique. *Renewable Agriculture and Food Systems, 31*(5), 414-428.

Thomas, G., Titmarsh, G., Freebairn, D., & Radford, B. (2007). No-tillage and conservation farming practices in grain growing areas of Queensland–a review of 40 years of development. *Animal Production Science, 47*(8), 887-898.

Trinh, T. Q., Rañola, R. F., Camacho, L. D., & Simelton, E. (2018). Determinants of farmers' adaptation to climate change in agricultural production in the central region of Vietnam. *Land Use Policy, 70*, 224-231.

Tun Oo, A., Van Huylenbroeck, G., & Speelman, S. (2017). Determining factors for the application of climate change adaptation strategies among farmers in Magwe District, dry zone region of Myanmar. *International Journal of Climate Change Strategies and Management, 9*(1), 36-55.

Turmel, M.-S., Speratti, A., Baudron, F., Verhulst, N., & Govaerts, B. (2015). Crop residue management and soil health: A systems analysis. *Agricultural Systems, 134*, 6-16.

U.S. Environmental Protection Agency. (2014). *Climate change indicators in the United States*. Retrieved from: www.epa.gov/climatechange/indicators.

UNDP. (2002a). *Handbook on monitoring and evaluating for results*. New York.

UNDP. (2002b). *Ukun rasik a'an the way ahead*. Dili, Timor-Leste.

UNDP. (2003). *Poverty in a new nation: Analysis for action*. Dili, Timor-Leste.

UNDP. (2006). *The path out of poverty*. Dili, Timor-Leste.

UNDP. (2009). *Initial national communication under the UN framework convention on climate change for Timor-Leste*. Dili, Timor-Leste.

UNDP. (2011). *Managing natural resources for human development.* Dili, Timor-Leste.

UNDP. (2015). *Climate vulnerability and capacity assessment: A baseline report*. Dili, Timor-Leste.

Urdín, R. F. (2016). *Food security in Timor-Leste through crop production.* Paper presented at the Proceedings of TimorAg2016, an international conference held in Dili, Timor-Leste.

Van, S. T., Boyd, W., Slavich, P., & Van, T. M. (2015). Perception of Climate Change and Farmers' Adaptation: A Case Study of Poor and Non-Poor Farmers in Northern Central Coast of Vietnam. *Journal of Basic & Applied Sciences, 11*, 323.

Verhulst, N., Govaerts, B., Verachtert, E., Castellanos-Navarrete, A., Mezzalama, M., Wall, P., . . . Sayre, K. D. (2010). Conservation agriculture, improving soil quality for sustainable production systems. *Advances in soil science: food security and soil quality, 1799267585*, 137-208.

Vezzani, F. M., Anderson, C., Meenken, E., Gillespie, R., Peterson, M., & Beare, M. H. (2018). The importance of plants to development and maintenance of soil structure, microbial communities and ecosystem functions. *Soil and Tillage Research, 175*, 139-149.

Wei, T., Cherry, T. L., Glomrød, S., & Zhang, T. (2014). Climate change impacts on crop yield: Evidence from China. *Science of the Total Environment, 499,* 133 - 140.

WFP. (2005). *Food insecurity and vulnerability analysis Timor - Leste*. Dili, Timor – Leste: WFP.

World Bank. (2003). *Timor-Leste poverty assessment*. Retrieved from Dili, Timor-Leste.

World Bank. (2006). *Conducting quality impact evaluations under budget, time and data constraints*. Washingtonm, D.C.: World Bank.

World Bank. (2008). *Reducing the risk of disasters and climate variability in the pacifi islands: Timor-Leste country assessment*. Retrieved from Washington, D.C., New York.

World Bank. (2011). *Timor-Leste country program evaluation 2000 – 2010.* Washington, D.C. : World Bank Group.

World Bank. (2011). *Timor-Leste expanding earn-term agricultural exports*. Retrieved from Dili, Timor-Leste.

World Bank. (2013). *Timor-Leste - Country partnership strategy for the period FY2013-2017* Retrieved from Washington, DC.

World Bank. (2015). *Democratic Republic of Timor-Leste public expenditure review: Infractructure*. Retrieved from Dili, Timor-Leste.

World Bank. (2016). *Poverty in Timor-Leste 2014*. Washington, D. C.

World Bank. (2018). *Timor-Leste economic report (March 2018)*. Retrieved from Washington, D.C.

Wu, H., Ding, S., Pandey, S., & Tao, D. (2010). Assessing the Impact of Agricultural Technology Adoption on Farmers' Well-being Using Propensity-Score Matching Analysis in Rural China. *Asian Economic Journal, 24*(2), 141-160.

Yang, C., Huang, G., Chai, Q., & Luo, Z. (2011). Water use and yield of wheat/maize intercropping under alternate irrigation in the oasis field of northwest China. Field Crops Research, 124(3), 426-432.

Yorobe, J. M., & Quicoy, C. B. (2006). Economic impact of Bt corn in the Philippines. *Philippine Agricultural Scientist, 89*(3), 258.

Zhao, H., & Seibert, S. E. (2006). The Big Five personality dimensions and entrepreneurial status: A meta-analytical review. *Journal of applied psychology, 91*(2), 259.

Zheng, C., Jiang, Y., Chen, C., Sun, Y., Feng, J., Deng, A., . . . Zhang, W. (2014). The impacts of conservation agriculture on crop yield in China depend on specific practices, crops and cropping regions. *The Crop Journal, 2*(5), 289-296.

Zheng, S., Xu, P., & Wang, Z. (2012). Farmers' adoption of new plant varieties under variety property right protection: Evidence from rural China. *China Agricultural Economic Review, 4*(1), 124-140.

Appendix 1: Survey questionnaire

Introduction

I am Marcolino Estevão Fernandes E Brito a postgraduate student of School of Management, Faculty of Business and Law, Curtin Business School, Curtin University, Perth, Western Australia.

The purpose of my presence here is to ask your assistance for completing the questionnaire as requirement of completing the study. The title of the study is about Adoption and Impact of Conservation Agriculture on Maize Farming Households in Timor-Leste. Data collection through interviews used questionnaire. The identification of the respondents will be kept confidentially. You will be identified personally in this study.

Thank you

QUESTIONNAIRE

Questionnaire no. ___________________

Interviewer: _______________________________________ Date: - ________________

Area: village _____________ sub-village ___________________

Administrative ___________________ Municipality______________________

Type of farmer: _____ CA _______Non-CA Disadopter ________

A. General Information

1. Name of farmer: ____

2. Gender: ☐ Male ☐ Female 3. Age ____________________

4. Highest educational attainment? ____________________

5. How long have you been farming? _____ yrs

6. Age of spouse: ____________________

7. Gender of spouse: [ ] Male [ ] Female

8. Highest educational attainment of spouse? ……...........................

9. No of years farming of spouse?

10. Main occupation of spouse: …………....

11. Number of household members (including farmer): …………....

12. Number of dependent household members: Below 18 yrs ……….... Above 65 yrs

13. What are the sources of income of the family? (Fill in the table)

Sources of income	**Who among the family has this income?** *(1= Husband; 2=Wife; 3=Son; 4=Daughter; 5= others (specify)*	**Income earned per month**	
		Average income / month	**Total no of month/s per year**
01 Maize farming			
02 Farming other crops____________			
03 Vegetable Gardening			
04 Small store			
05 Paid employment			
06 Services (laundry, haircut, labor, etc.)			
07 Rentals (land, house, rooms, agricultural equipment*)*			
08 Subsidy from other family members			
09 Remittances from abroad			
10 Poultry raising			
11 Hog/ pig raising			
12 Cattle raising			
13 Other livestock (goats, cattles)			
14 Eatery/ restaurant			
15.Fruit trees or other perennial crops			
16 Others ______________________			

14. How many livestock do you have?

Livestock	Quantity
Buffalo	
Cattle	
Horse	
Pig	
Goat	
Others	

15. What are the expenses of household on average per month?

Items	Cash expense (USD/mo)	Total no of month/s per year	In Kind (estimated value in USD/mo)	Total no of month/s per year
Food				
House/lot rental fee				
Schooling (tuition/ allowance/ books, uniform, etc.)				
Electricity & water				
Medicines/ health care				
Fuel/ wood				
Clothing				
Grocery items				
99 Others, _________				

B. Farm characteristics

16. What is the size, type of land, tenure status and crops planted for each parcel? (Fill in the table)

Parcel No.	What is the approximate size of each parcel? (ha)	What is the land type (1 = lowland irrigated; 2 = lowland rainfed; 3 = upland rainfed; 4 = upland irrigated)	Tenure status (1 = owned ; 2 = leased ; 3 = rented; 4 = share tenant; 5 = others)	Irrigation type 1. No irrigation 2. Pump irrigation 3.Hand sprinkler 4. Gravity 5. Sprinkler 6. Drip 6. Others, please	Crops Planted	
					What are the Usual crops planted?	What are the Crops planted at present?
1						
2						
3						
4						

C. Maize production and marketing

Cropping season 2016 (The following questions are for your maize production last year 2016)

17. How much land area did you use for maize production in 2016?_____ hectares?
18. What varieties of maize did you use?___________________________________

☐Sele ☐Noi Mutin ☐Others (pls. specify) _________________________

19. Why did you choose these varieties? _________________________________

20. What inputs did you use and how much did you use for maize production in your maize production in 2016? (Fill in table)

Type	**Amount**			**Unit**	**Price/ unit**	**Total Value**
	Owned	**Purchased**	**Hired**			
Granular Fertiliser						
Complete						
Phosphate						
Potassium						
Liquid Fertilizer						
Organic Fertilizer						
Manure						
Lime						
Herbicide						
Nematicide						
Insecticide						
Fungicide						
Seeds (specify variety) ____________						
Water (irrigation)						
Oil						
Petrol (Gasoline, diesel)						
Specify Equipment:						
Sacks						
Others (pls specify)						

Note: For commercial products such as fertilizer, lime, herbicide, seeds, specify name and brand.

21. Labor utilisation: Who did the actual work during your maize cropping season in 2016?*

	Family						Hired						Others (Exchange labour)						Cost of Wages for Hired labor			
	Man Hrs	Man Days	Woman Hrs	Woman Days	Children Hrs	Children Days	Man Hrs	Man Days	Woman Hrs	Woman Days	Children Hrs	Children Days	Man Hrs	Man Days	Woman Hrs	Woman Days	Children Hrs	Children Days	Cash payment		In-kind	
																			Wage/ day	Total Cost	Description	Total value of in-kind payment
Land Preparation																						
Planting																						
Fertilising																						
Weeding																						
Pesticide application																						
Harvesting																						
Packing																						
Transporting																						
Marketing																						
Others																						

Note: Children are those who are less than 18 years old.

22. Conventional tools and Machinery Utilisation for maize production cropping season in 2016 (Fill in table)

Type of machinery	Tools and machineries					
	Owned		Hired			
	Hrs	Days	Hrs	Days	Price/day	Value
Hand sprayer						
Long-handled sickles						
Manual rolling injector seeder						
Crowbar						
Manual Jab planter						
Lee seeder						
Ripper attached to two-wheel tractor						
Tractor						
Others						

23. Total maize production and marketing from cropping season in 2016 (by kg /ha)

Parcel	Harvested area (ha)	Total Output harvested (sacks of 50kg/ sack)	Consumed by family (sack)	Gifts/ Given away (sack)	Sold				
					Quantity sold (sack)	Price /unit ($/sack	Total Value ($)	Where sold? 1. Traders who came to the farm 2.Wholesalers at village level 3.Wholesalers at sub-district market 4.Wholesalers at District market 5. Local cooperative 6. NGO 7. Others …..	Who determined the price? 1. Me (farmer) 2. Buyer 3. Both (negotiated)
1									
2									
3									
4									

24. If you do not sell your maize output, please rate the reason for not selling in the following table based on their importance
5= Very important, 4 = Important, 3 = Moderately important, 2 = Slightly important, 1 = Not at all important

	Rating
I don’t have surplus to sell	
I can’t access market	
Lack of knowledge on markets	
Not enough profit margin (i.e., inputs are too expensive & output prices are too low)	
Output prices are too low	
The nearest market is too far	
Poor road access	
Cost of transport	
Others (pls. specify) ______________________	

25. Please rate in order of importance, what would enable you to produce surplus to sell.
5= Very important, 4 = Important, 3 = Moderately important, 2 = Slightly important, 1 = Not at all important

	Rating
Fertiliser availability	
Affordable cost of fertilisers	
Herbicide availability	
Affordable cost of herbicides	
Availability of seeds	
Better quality of seed	
Affordable cost of seeds fertilisers	
Availability of credit	
Labour availability	
Availability of irrigation	
Market accessibility	
Higher output prices	
Others (pls. specify) ________________	

26. If you sell your harvest, what are the main problems/constraints that you face?
    5= Very important, 4 = Important, 3 = Moderately important, 2 = Slightly important, 1 = Not at all important

	Rating
Cost of inputs too high	
Cost of transport too high	
Selling price low	
Price fluctuating	
Limited demand	
Others	

27. What kind of climate-related risks occur in your place?
    ……1. Drought
    ……2. Flooding
    ……3. Soil erosion
    ……4. Land slides
    ……4. Others (pls specify) ____

28. What kind of problems/ issues have recently affected your maize production in the last 5 years?
    5 = Strongly agree 4= Agree, 3 = Moderately agree, 2 = Slightly agree, 1 = Not agree at all

	Rating
Reduce crop production and productivity	
Longer dry period and drought	
More frequent extreme rains	
Increase loss of nutrients into waterways	
Higher incidence of crop disease	
Others (pls. specify) ________________	

29. How important are the following adaptation strategies to overcome natural risk hazard in your maize production?
5= Very important, 4 = Important, 3 = Moderately important, 2 = Slightly important, 1 = Not at all important

	Rating
Adaptation of new seed variety	
Plant stress tolerant crops	
Plant stress tolerant varieties	
Plant pest/disease tolerant varieties	
Plant early	
Diversify crops, plot, livestock	
Substitute crops	
Increase seed rate	
Use other chemical inputs	
Intercropping	
Crop rotation	
Reduce tillage	
Use crop residue as soil cover	
Reduce fertilizer use	
Use manure	
Laser land levelling	
Bed planting	
ZT maize	
Jab planter	
Rotavator	
Leaf color chart	
Site specific nutrient management	
Crop rotation	
Residue management	
Contouring	
Terracing	
Others (specify).	

D. Impact and components of Conservation Agriculture (CA)

30. Have you ever practiced Conservation Agriculture (CA) techniques? ☐ Yes ☐ No (Go to Q40)

31. When did you start using CA?

32 What CA method/ technique do you use?

CA method	What CA method and components do you use (please tick all that apply)	Reason for using or not using
General:		
No tillage and minimum soil disturbance		
Permanent soil cover with residues		
Intercropping with legume		
Detailed components:		
Removing weed or organic matter using rolling climber		
Mulching (i.e., any organic material such as decaying leaves, bark, or compost) for 3-4 wks		
Direct seeding of maize		
Using planting distance of 75cm x 35 cm (or recommended distance)		
Applying liquid organic fertiliser		
Manual Weeding		
Using organic liquid herbicides		
Intercropping with legume		
- Velvet bean		
- Winged bean		
- Cowpeas		
- Pigeon peas		
- Other (pls specify) __________		

Other (please specify) ______________		

33. Has CA method increased your maize production? ☐ Yes ☐ No

34. What is the impact of conservation agriculture in your maize production?

5= Very important, 4 = Important, 3 = Moderately important, 2 = Slightly important, 1 = Not at all important

Impact	(Rating)	
	Men	Women
Cost effective/cost saving		
Cropping patterns/mixed production		
Decayed weeds become fertiliser		
Decrease cost/low tillage cost		
Decreased labor use/less drudgery /easy labor		
Early seeding/maturity/harvesting		
Eco-friendly		
Improved plant growth		
Improved soil health condition		
Increased profit		
Increased yield/ better production/at par production		
Less irrigation		
Less seed cost/less seed use		
Less stalk logging/less water logging/reduced plant damage		
Reduced crop turn overtime		
Reduction of women workload		
Time saving/ timely planting/timely seeding		
Timely crop establishment		
Water saving		

E. Behavioural aspects

35. How did you first know about CA? ________________________

36. When did you first use (try) CA in your farm? _______________

37. What motivated you to apply conservation agriculture in your maize production?

5 = Strongly agree 4= Agree, 3 = Moderately agree, 2 = Slightly agree, 1 = Not agree at all

	Rating
Drought mitigation	
Higher yield	
Participates in training and observation of peers	
Reduce labour time	
More time for off farm work	
Save water	
Save input costs	
To adopt to climate change	
To improve maize production and productivity	
To increase income	
To safeguard income for the future	
To sell surplus to market	
To work with other members of the family	
Others (pls. specify) _______________	

38. After your first trial of using CA, where you happy about it?

☐ Yes Why? ____ (Go to 39)

____

☐ No Why not? ____

____

Did you then decide to continue with CA or not?

☐ Yes Why? ____

____

☐ No (Go to Q40)

39. After your first trial of using CA, what made you decide to adopt it?

5= Very important, 4 = Important, 3 = Moderately important, 2 = Slightly important, 1 = Not at all important

	Rating
Reduced cost/cost saving	
Decayed weeds become fertiliser	
Decreased labor use	
Improved plant growth	
Improved soil health condition	

Less irrigation	
Increased yield	
Others (pls. specify) _______________	

40. What decision criteria did you use in deciding to adopt or not adopt CA?
5= Very important, 4 = Important, 3 = Moderately important, 2 = Slightly important, 1 = Not at all important

		Rating
Labour saving		
Cost effectiveness/cost saving/advantage		
Enhance yield/crop production/productivity		
Time saving/timely sowing of next crop		
Less irrigation/water requirement/saving		
Weed control/herbicide use/availability		
Easy management/operational use		
Land levelling/good field/soil condition		
Machine availability		
Soil conservation/health/management fertility		
Early maturity/cropping frequency/timelines		
Other (pls specify) __________________________		

41. What are the issues/ problems/ constraints you have encountered in using CA?
5= Very important, 4 = Important, 3 = Moderately important, 2 = Slightly important, 1 = Not at all important

	Rating
More weed/weed control/weed problem	
Poor germination/reduced germination	
Lack of suitable herbicides/difficult herbicides application	
Limited operators/limited skills of operators and mechanic	
Increased insect/pest/diseases	
More compact soil/undulated land/clogging of soil	
machine not user friendly	
Other (pls specify) __________________________	

42. Do you intend to continue using CA in the future?
Yes Why? ____
No Why not? ____

F. RISK ATTITUDES

43. Are you concerned about risks in your maize production?

☐ Yes Why? ____
____

☐ No Why not? ____
____

44. What risks do you encounter/ experience in your maize production?
5 = Strongly agree 4= Agree, 3 = Moderately agree, 2 = Slightly agree, 1 = Not agree at all

	Description of risk	Rating
Yield risks		
Income risks		
Farmer health risk		
Farmer family condition		
Climate risks		
Flooding		
Drought		
Soil erosion		
Land slide		
Market risk		
Price risk		
Return risk		
Institution risk		
Government policy change risk		
Trader agreement risk		
Others		

45. What is the preference in overcome risk in your maize production?
5 = Strongly agree 4= Agree, 3 = Moderately agree, 2 = Slightly agree, 1 = Not agree at all

	Rating
When selling my maize product, I prefer financial certainty to financial uncertainty	
With respect to the conduct of business, in general, I prefer certainty to uncertainty	
I am willing to take higher financial risks in order to realize higher average returns	
I like taking financial risks	
I like playing it safe	
With respect to the conduct of business, I am risk averse	

46. In general, to what extent do you take risk? Please choose on the scale below

Male Female

- fully willing to take risk
- more willing to take risk
- indifferent
- less willing to take risk
- unwilling to take risk

- fully willing to take risk
- more willing to take risk
- indifferent
- less willing to take risk
- unwilling to take risk

G. Entrepreneurial traits

47. How confident are you to be able to modify events in an environment (Individual locus of control)?
 5 = Strongly agree 4= Agree, 3 = Moderately agree, 2 = Slightly agree, 1 = Not agree at all

	Rating
Diligence and hard work usually lead to success	
If I do not succeed on task, I tend to give up	
I do not really believe in luck	
I feel in control of my life	
Others (pls. specify) _______________	

48. Do you intend to carry out tasks (need for achievement)?
 5 = Strongly agree 4= Agree, 3 = Moderately agree, 2 = Slightly agree, 1 = Not agree at all

	Rating
I will do very well in fairly difficult tasks relating to maize production	
I will try hard to work better in my maize production	
I will more responsibility to work in my maize production	
I will try to perform better maize production than my neighbour	
Others (pls. specify) ________________	

49. Are you concerned about risk (risk propensity/tolerance)?
 5 = Strongly agree 4= Agree, 3 = Moderately agree, 2 = Slightly agree, 1 = Not agree at all

	Rating
One should not adopt a technology if there is a risk it might fail	
Risk of failure is a major concern for me	
Others (pls. specify) _________________	

50. Are you alert to try a new agricultural technology?

5 = Strongly agree 4= Agree, 3 = Moderately agree, 2 = Slightly agree, 1 = Not agree at all

	Rating
I often go to look for new information about maize farming to apply into my own maize production	
I think about new method of maize production in my free time	
I think about new method of maize production even during my holidays to start my own maize farming	
I Think about new business ideas in related to maize production in my free time to start my own business	
Others (pls. specify) ________________	

51. What is your creativity in your farm business?
5 = Strongly agree 4= Agree, 3 = Moderately agree, 2 = Slightly agree, 1 = Not agree at all

	Rating
I have innovative ideas	
If something cannot be done, I find a way	
I often find more than one solution to a problem	
Others (pls. specify) ______________	

H. External environment

52. Where do you get your inputs (i.e. fertiliser, pesticide and herbicide) for your maize production? (Tick all relevant answers)

Provided free by the government	
NOGs	
Buy in shop	
Others (pls specify) ______________________	

53. How did you react to the CA technology when you first heard about it? Reason

	Reason
I innovated/ started the technology	
Adopt quickly - first to adopt the technology	
Amongst the earliest adopters	
I waited wait till others have adopted	
I was last to adopt	
Refuse to use CA. If so, why?	

54. What factors constrain you in the adoption of CA method?
    5 = Strongly agree 4= Agree, 3 = Moderately agree, 2 = Slightly agree, 1 = Not agree at all

	Rating
Cultural factors	
Capital	
Level of education	
Information availability	
Costs of inputs	
Availability of inputs	
Cost of CA tools/ machinery	
Availability of CA tools/ machinery	
Cost of irrigation	
Availability of irrigation	
Knowledge/ skills about CA	
Others (pls specify): ________________________________	

55. How do you normally obtain information about new technology, climate change information and farming practices (tick all that applies)?
    5 = Strongly agree 4= Agree, 3 = Moderately agree, 2 = Slightly agree, 1 = Not agree at all

	Information: 1). MAFP,2). Church, 3). National NGOs, 4). International agencies, 5). Neighbours, 6). Extension agent from MAFF, 7). Relatives, 8). Group meeting organised by XXX, 9). Friends, 10). Field days, 11). Demonstration fields by MAFF, 12). Mass media, 13). Others (pls specify) ______________________	Rating
New technology		
Climate change information		
Farming production		
Others (pls specify) ___________		

56. What kind of mass media do you use to get information about new technology and farming practices (tick all that applies)?

☐ Radio ☐ TV ☐ STL ☐Timor Post ☐ Leaflet ☐ Internet
☐ Smart phone ☐ Standard mobile phone ☐others ________________

57. Where do you get your agricultural technology?
1. Supported by the government 2. Supported by NGOs 3. Purchased by themselves (Price: …………..) 4. Rent (Price …………) 5. Association/farmer group 6. Others ____________

CA technologies	Source of the technology
Hand sprayer	
Long-handled sickles	
Manual rolling injector seeder	
Crowbar	
Manual Jab planter	
Lee seeder	
Ripper attached to two-wheel tractor	
Other (pls specify)	

58. Did you or any of your household member borrow money? ☐Yes ☐No

59. What is your source of credit? Why do you get it from this source? What did you use it for?

	Reason for source	Purpose of loan
Government		
Private financing		
Neighbour		
Friends		
NGOs		
Others		

60. Social capital

Does any member of the household currently belong to any group? (Code 1=Yes 0=No)						
Me mb er	Type of group the household member registered:	Three most important group functions:			Year joined	Benefits of being a member
	Codes A	**Codes B**			**YYY Y**	

Codes A 1. Input supply/farmer coops/union, 2. Crop/seed producer and marketing group/coops, 3. Local administration, 4. Farmers' Association, 5. Women's Association, 6. Youth Association, 7. Saving and credit group, 8. Water User's Association, 99. Other, specify…

61. Access to extension services

Issue	Have you ever received training	Have you ever received information	What is the main information source for [issue]?
	1- Yes , 0- No	1- Yes, 0- No	**Code A**
1. New varieties of maize			
2. New varieties of legumes			
3. Field pest and disease control			
4. Soil and water management			
5. Crop rotation			
6. Minimum tillage			
7. Leaving crop residue in the			
8. Adaptation to climate change			
9. Improved crop storage methods			
10. Storage pests			
11. Output markets and prices			
12. Input markets and prices			
13. Collective action/farmer			
14. Livestock production			
15. Tree planting			
16. Others (specify)			

Codes A 1. Government extension service, 2. Farmer Coop or groups, 3. Neighbour farmers, 4. Seed traders/Agrovets,
5. Relative farmers NGOs, 6. Other private trader, 7. Private Company, 8. Research center, 9. School, 10. Radio/TV, 11. Newspaper, 12= Mobile phone, 13- Others (specify

Codes B 1. Produce marketing, 2. Input access/marketing, 3. Seed production, 4. Farmer research group, 5.Savings &credit, 6.Tree planting and nurseries, 7.Soil & water conservation, 8. Other, specify………

62. What is the conditions of the infrastructure (i.e. road, market place and others) here? 5 = excellent 4 = good 3= neither good nor bad 2 = bad 1 = very bad

	Rating
Road conditions	
Market place facility	
School facility	
Health facility	
Drinking water supply	
Others (pls. specify) ________________	

63. Food Security

Taking into consideration **ALL** your food sources (own food production + food purchase + help from different sources, how would you define your family's food consumption last year? *Codes A:1=Food shortage throughout the year 2= Occasional food shortage, 3= No food short- age but no surplus , 4= Food surplus.*	
In the last 12 months, did you at any time not have enough food (0 = no; 1 =yes)	

If Yes to 2 above, which months did you not have enough food to meet your family needs last year? Circle appropriate

Jan	Feb	March	April	May	June	July	August	Sep	Oct	Nov	Dec
1	2	3	4	5	6	7	8	9	10	11	12

64. What are the three most important factors that constrain your maize production and how do you think these problems can be overcome?

What are the three most important factors that constrain your rice production?	**How do you think these problems can be overcome?**

~Thank you ~