



MSc Thesis

Adaptation Strategies of Smallholder Farmers using Climate-Smart Agriculture: The Case of Rejosari Village, Indonesia


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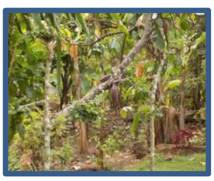

2020-2021



Abstract

Warming temperatures due to climate change have resulted in an increasing trend of extreme events that disrupt the agricultural sector, which affects weather and soil fertility. Both of these components have important roles in farming activities which affect agricultural yields. This situation endangers farmers who are poor and become smallholder farmers, and heavily rely on rainfall irrigation systems. Therefore, planning proper adaptation strategies through Climate-Smart Agriculture (CSA) can increase the yields and alleviate farmers' problems due to climate impacts.

Smallholder farmers in Rejosari village, Indonesia, implement rainfed agriculture. Currently, they experience drought, reduced crop quality, and pest and disease outbreaks. The changing climate makes these problems worse. In this regard, farmers implement adaptation strategies through CSA practices such as soil management, utilization of decomposed manure, and agroforestry and intercropping systems.

This study aims to examine CSA practices to improve the climate change adaptation strategies and climate resilience of smallholder farmers in Rejosari village. For this purpose, data were collected and analysed through field observation, interviews, and document reviews on the perceived impacts of climate change, farmers' characteristics, strategies, and decision-making processes. Finally, CSA practices chosen by the farmers were assessed in order to discover their benefits and the improvements needed.

The results reveal that smallholder farmers in Rejosari village implement beneficial CSA practices to adapt to climate change. They tend to choose adaptation strategies that bring economic benefits rather than long-term effects on natural resources. Thus, governments should give more attention and priority to improve the awareness and lessen the vulnerabilities of smallholder farmers in the village to address the impacts of climate change.

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List of Abbreviations

APIK	*Adaptasi Perubahan Iklim dan Ketangguhan* (Climate Change Adaptation and Resilience)
AUTP	*Asuransi Usaha Tani Padi* (Rice Crops Insurance Programme)
BMKG	*Badan Meteorologi, Klimatologi, dan Geofisika* (Meteorology, Climatology, and Geophysics Agency, Malang Climatology Station)
BPS	*Badan Pusat Statistik* (BPS-Statistics Indonesia)
CSA	Climate-Smart Agriculture
DLH	*Dinas Lingkungan Hidup* (Environmental Agency)
DTPHP	*Dinas Tanaman Pangan, Hortikultura dan Perkebunan* (Food Crops, Horticulture and Plantation Service of Malang district)
FAO	*Food and Agriculture Organization of the United Nations*
IPCC	*Intergovernmental Panel on Climate Change*
ITS	*Institut Teknologi Sepuluh Nopember* (Sepuluh Nopember Institute of Technology
PPN/BAPPENAS	*Perencanaan Pembangunan Nasional Republik Indonesia/Badan Perencanaan Pembangunan Nasional* (National Planning Board)
UB	*Universitas Brawijaya* (Brawijaya University)
UMM	*Universitas Muhammadiyah Malang* (University of Muhammadiyah Malang)
UNFCCC	United Nations Framework Convention on Climate Change
USAID	United States Agency for International Development
PG	*Pabrik Gula* (Sugar Factory)
PUSDA	*Pekerjaan Umum dan Sumber Daya Air* (Water Resources Department Malang District)

Acknowledgments

The completion of this thesis could not have been possible without motivation and support from plenty of people. I take this opportunity to thank and show appreciation to the people who have been a part of that. Foremost, I would like to express my warmest thanks to Dr. Gül Özerol as my first supervisor. Thank you for your invaluable insight, kindness, patience, motivation, and immense knowledge throughout the thesis period. I am so grateful for your supervision. I am also thankful to Dr. Kris Lulofs as my second supervisor. Thank you very much for your insightful feedback and your guidance. My sincere gratitude also goes to Prof. Dr. Johan Iskandar as my supervisor at Padjadjaran University. Thank you for the brilliant thoughts.

I would like to thank Bappenas for awarding me the scholarship to study at Padjadjaran University and University of Twente. I would also like to thank the director of MEEM programme, Prof. Dr. Michiel Heldeweg, and also coordinators of programme, Rinske Koster and Hilde van Meerendonk-Obinna for the great support since the beginning process of applying to this programme. I am sincerely thankful to all my lecturers at Padjadjaran University and University of Twente for providing me invaluable guidance and knowledge that were very helpful to improve my understanding in writing this thesis. A big thanks also to all my friends in MEEM programme who made my journey in The Netherlands became more meaningful. Lastly, I would like to express my deepest gratitude to my husband, my mother, and my kids for their continuous support and prayer throughout my study.

1. Introduction

Climate change has significant effects on environmental, agricultural, and socio-economic sectors (IPCC, 2018; UNFCCC, 2007). The challenges of climate change jeopardize water availability for irrigation systems, degrading soil fertility, and increasing the risks of pests and diseases for crop growth (Shahzad et al., 2021). Critical problems regarding agricultural activities are caused by their dependency on weather and land for growing food, feed, and fodder (Abera & Tesema, 2019).

The trend of hydro-meteorological disasters in Indonesia related to changing climate, such as floods, landslides, and droughts, has increased between 2015 and 2019. Drought, which created water shortage, occurs more often in extremely dry climates and reduces agricultural productivity that significantly affects the economic development within the country (Kementerian PPN/BAPPENAS, 2019). In addition, agriculture plays significant roles, such as a source of food for the people and the main source of income from time to time, making agriculture more flexible for managing workforces who are less able to compete in other sectors (Kusumaningrum, 2019). Moreover, this increases the gross domestic product for the country by supporting the difficulties faced in the economic system during the Covid-19 pandemic (BPS, 2020).

Smallholder farmers in developing countries are among the most vulnerable groups toward climate change due to their limited skills and capabilities (Cacho et al., 2020). In Indonesia, the smallholder farmers are distinguished based on their land size, which is less than 0,5 hectare. They practice subsistence agriculture, growing crops to meet their daily consumption rather than commercial agriculture (Susilowati & Maulana 2012; Saputra, 2018; Assan, 2019; BPS, 2018; Soekartawi, 1984). In Uganda, smallholder farmers are defined as those who mainly use their products for their needs and a limited surplus for the market (Atube et al., 2021). In Asia, they generally have low initial capital and access to resources (Devendra & Thomas, 2002). Moreover, in Central America and Madagascar, these farmers suffer from food insecurity (Harvey et al., 2014; Harvey et al., 2018). Thus, developing adaptation strategies to address climate change impacts is crucial for smallholder farmers, who highly depend on agriculture for their livelihood (Atube et al., 2021).

Climate-smart agriculture (CSA) is a proper adaptation strategy for farmers to deal with climate change impacts. CSA improves agricultural production and conserves natural resources through land and water management (Olawuyi, 2020). For instance, land management enhances the soil's organic content to improve the land capacity and hold more water, which positively impact crop growth. In addition, water management through tree planting maintains the groundwater level in the soil. Other techniques that improve farmers' capability to address drought with less financial cost, such as implementing rainwater harvesting and cultivating drought-resistant crops, are also considered as CSA practices (Neufeldt et al., 2013).

Recent studies focusing on smallholder farmers practices on CSA and discussing policy and investment options for food security (Cacho et al., 2020), indigenous practices by rice growers (Shanabhoga, 2020), participation in collective action for conservation agriculture (Olawuyi, 2020), comparison of CSA and traditional systems on cotton farming (Jamil et al., 2021), and the effectiveness of policy to solve pre-existing and emerging agricultural challenges (Mbuli et al., 2021). Based on the results of these studies, it can be argued that CSA practices are beneficial for smallholder farmers to lessen their vulnerabilities to climate change and improve their economic conditions (Berhanu et al., 2021). At the same time, to support CSA practices by farmers, it requires transformations in governance and utilization of natural resources (Neufeldt et al., 2013).

1.1. Problem Definition

Rejosari village is located in the southern part of Malang. Its boundaries are Wonokerto village in the north, Bantur village in the south, Pringgodani village in the west, and Sumberejo village in the east. This village is located around 600 meters above sea level, containing karst and less surface water, and dominated by drylands (USAID APIK, 2017). The area of this village, as shown in Figure 1, is approximately 1332 hectares. Based on the 2018 population data, there are 2828 families in the village. They are farmers, traders, and private employees, comprised of 75%, 20%, 5% respectively. The farmers are implementing rainfall based agricultural systems that become more vulnerable because of their erratic and unreliable nature (PMM UMM, 2020).

This problem is worsened by climate change. Climate change contributes to the drought that becomes more frequent in every dry season. Subsequently, the farmers also experience reduced crops' quality, and pest outbreaks. These impacts threaten crop's growth and health, affecting agricultural products. There are 50 households of farmers that are poor and become smallholder farmers who are highly dependent on agriculture. They use the product to satisfy their daily needs and the remains is sold as a source of family income.

Figure 1. Rejosari Village, Malang District, East Java Province, Indonesia
(Source: Kemendagri, 2018)

To overcome this condition, the affected farmers have adopted some adaptation strategies, such as tree planting, agroforestry system, soil management, and planting crops resistant to drought. They use fertilizer from decomposed manure of their livestock to improve the soil fertility and maintain the crop's growth. They also sell the processed food from agroforestry products to other regions and other countries. They create connections and good communication with local governments and also universities. Besides networking, they gain technical supports that help to improve their small businesses (DLH Provinsi Jawa Timur, 2018).

However, the conditions of smallholder farmers with minimal land area, individual farming systems, and inadequate facilities and infrastructure can worsen their climate vulnerability. There is little empirical insight on the application and results of different CSA practices. Therefore, research on how smallholder farmers can identify and adopt CSA practices as an adaptation strategy is needed. The present research provides empirical knowledge regarding farmers' adaptation strategies, which combine multiple CSA practices to improve their environmental and economic conditions. Moreover, this research uses indicators to assess the CSA practices of farmers in order to improve their climate resilience.

1.2. Research Objective

The thesis aims to understand and improve the climate change adaptation strategies of smallholder farmers in Indonesia by examining CSA practices. The study focuses on smallholder farmers in the Rejosari village located in a highland area in the southern part of Malang district, East Java province. It assesses strategies and decision-making processes of smallholder farmers in developing their environment and livelihood through CSA.

1.3. Research Questions

To achieve the research objective, the main research question is formulated as follows:

How do smallholder farmers in Indonesia implement CSA to adapt to the adverse impacts of climate change?

To be able to answer the main research question, the following sub-questions are formulated:

1) What are the impacts of climate change in Rejosari village?
2) What adaptation strategies do the farmers adopt to tackle those impacts?
3) How do smallholder farmers make their decisions with regards to CSA practices?
4) How to improve current CSA practices to increase its climate resilience?

1.4. Thesis Outline

The thesis is structured as follows: current chapter explains the research background, objectives and measures to reach the goals. Chapter 2 presents the theoretical background on the main concepts. Chapter 3 explains the research design. Chapter 4 presents the results from document analysis, field observations, and interviews. Chapter 5 provides a discussion of the current findings. Finally, chapter 6 presents the conclusions and recommendations.

2. Theoretical Background

In this chapter, the scientific and grey literature about the impacts of climate change on agriculture; climate change adaptation in agriculture; CSA; smallholder farmers; and climate adaptation strategies of farmers are reviewed. The review builds a theoretical framework and limits the research on CSA practices of smallholder farmers.

2.1. Impacts of Climate Change on Agriculture

Climate change impacts, such as prolonged dry spells, droughts, floods, flash floods, landslides, and other extreme events greatly affect crops cultivation. These impacts reduce the food yields by decreasing water supplies, reducing soil fertility, and degrading the natural resources (FAO & Ministry of Agriculture Livestock and Fisheries, 2018).

In the rainfed agricultural system, the change in rainfall patterns affects the planting periods. Mistake in planting time prediction contributes to having lower profits because crops receive inadequate water. Farmers grow crops in the rainy season to have sufficient irrigation for germinating the seeds. In addition, rainfall pattern also relates to cropping pattern. Farmers need to plant different crops when less water is available for maintaining productivity (Kuwornu et al., 2013).

The climate variability affects the growth of the crops and increases disease and pest outbreaks in the field. Climate factors affect diseases in term of their life cycle, infectious power, transmission, and reproduction of pathogen. Temperature and humidity directly affect the pests' life cycle. Insect populations will rise along with temperatures. Generally, small insects, such as fleas, become a problem in the dry seasons because they are not exposed to rainwater (Susanti et al., 2018; Aqil et al., 2013; Wiyono, 2007; Herlina & Prasetyorini, 2020).

2.2. Climate Change Adaptation in Agriculture

Climate change negatively impacts the ecosystems and natural resources through warmer temperatures (FAO, 2017b). This causes problems such as soil degradation, pest outbreaks, and groundwater level reduction which will disrupt the agricultural system. It is because agricultural system highly depends on natural system processes (FAO, 2010). Climate change also affects food production, which is crucial for human beings. These impacts urge humans to adopt specific measures to address the damages created and possible future risks.

Climate change adaptation is an important measure to tackle damages caused by the changing climate by adjusting nature utilization and human systems to moderates harm and exploits beneficial opportunities (Obayelu et al., 2014). According to Turasih & Kolopaking (2016), adaptation should be integrated into institutional planning to get more merits. The successful implementation of a country's adaptation strategies needs government involvement at national, regional, and local levels through different projects, programmes, policies or strategies to enhance adaptive capacity and strengthen institutions which regard to reducing climate change impacts (FAO, 2017b).

Adaptation strategies in agriculture enable farmers to alleviate the risks of damages and losses in food production (FAO, 2017b). These measures are carried out by harnessing the opportunities available due to the changing climate by modifying farming techniques and developing alternative approaches (World Bank, 2011; Ramamasy & Baas, 2007). Farmers have their adaptive capacity when they are capable of adjusting to the changing climate conditions.

2.3. Climate-Smart Agriculture

The concept of climate-smart agriculture (CSA) was introduced in 2010 by the Food and Agriculture Organization (FAO) of the United Nations to face climate change in the agricultural sector (FAO, 2010). It is an integrated approach to farming to address the problems of climate change in the farming system (Ramamasy & Baas, 2007). It can help improve crop yields for enhancing food security by using environmentally friendly techniques (FAO, 2010; World Bank, 2011; Ho & Shimada, 2019).

Transformation in agricultural systems is crucial and urgent to be implemented in areas that mainly rely on rainfed agriculture and face the changing climate (Belay et al, 2017). The conservation of agricultural system avoids further destruction of soil structure, improves the organic content in the soil and retains more water to maximize the crop yield, prevent soil erosion and downstream flooding (Olawuyi, 2020). Moreover, these environmental benefits help to strengthen the economic sector to face poverty (FAO, 2010).

Agroforestry system is one of the CSA practices that combine agricultural crop production including trees, forestry plants, and animal husbandry in the same unit of land in accordance with the culture of the local population for public welfare (Suryani & Dariah, 2012). Planting trees improve the organic matter in the soil. As a result, soil fertility and soil moisture increase as well (FAO, 2010). Moreover, the presence of forests lessens the rate of small to moderate rain flows. The water that falls to the ground is more controlled and does not erode the soil (Asdak, 2010).

Paraserianthes (Paraserianthes falcataria) and teak *(Tectona grandis)* are general components in an agroforestry system. Both increase the infiltration rate, decrease the possibility of landslide, and have high economic value several years. They can be harvested after several years. Commonly, they are mixed with pineapple, coffee, cloves, cocoa, chili, and porang *(Amorphophallus muelleri*), which can be harvested in a shorter time (Sari et al., 2018; Aminah, et al., 2015).

Besides agroforestry, farmers are likely to have an intercropping system in their lands which is considered as a CSA technique as well. It is profitable because they grow two or more different plants simultaneously in the same area. This system increases diversity, assures ecological balance, more utilization of natural resources, enhancement and sustainability in agricultural production (Maitra et al., 2019).

Another CSA practice is soil management which is a beneficial strategy to maintain crop growth. This technique develops soil performance by managing its fertility and health by using compost and manure. Both improve the nutrient content that is needed by the crops. As shown in Table 1, different animal species have different nutrient contents. This is an affordable method available for poor farmers. In addition, growing trees and shrubs improve soil cover and protect it from landslides because the trees maintain the soil moisture while retaining more water (FAO & Ministry of Agriculture Livestock and Fisheries, 2018).

Table 1. Nutrient Content of Manure from Different Livestock Species

Animal species	***Nitrogen (N) - %***	***Phosphorus (P) - %***	***Potassium (K) - %***
Rabbit	2,4	1,4	0,6
Chicken	1,1	0,8	0,5
Sheep	0,7	0,3	0,6
Horse	0,7	0,3	0,6
Steer	0,7	0,3	0,4
Dairy cow	0,25	0,15	0,25

Source: FAO & Ministry of Agriculture Livestock and Fisheries, 2018

Transforming the traditional agricultural techniques, which prioritize productivity and show less concern on environmental degradation, into CSA, which enhances food security by conserving natural resources, requires improving the synergies and reducing the trade-offs between agricultural productivity and natural resources management. In this regard, developing the infrastructure and capacity for the farmers through financial investment, such as by collaborating with private sectors, plays a significant role (FAO, 2010).

The ability to prepare for climate disturbance, recovering from shocks and distress, and grow from destructive experiences is defined as climate resilience (World Bank, 2021; Obrist et al., 2010; Djalante & Thomalla, 2011). Climate resilience through CSA practices can be developed by utilizing ecosystem services. For instance, farmers implement agroforestry that combines trees and shrubs in forests and gardens. On one side, this technique gives direct benefits to them, such as improving their income and diversifying food productivity. On the other side, it provides merits to the environment, such as preventing erosion, increasing the infiltration rate and biodiversity, and balancing the ecosystem (FAO, 2010). These advantages enable farmers to be more flexible to cope with nuisances in their surrounding areas due to climate change.

Several indicators for assessing the benefits of CSA practices are formulated as follows (FAO, 2017a; Kpadonou et al., 2017):

1. Improvement of agricultural productivity;
2. Improvement of resilient crops to climate variability;
3. Improvement of soil fertility;
4. Improvement of income from crop diversification;
5. Improvement of water and soil conservation;
6. Improvement of irrigation system for drought prevention;
7. Improvement of forest area that applies CSA practices
8. Improvement of farmers' awareness of environmental protection

This research uses the eight indicators above to ensure that the adopted CSA practices have positively impacts on the farmers. These merits are chosen because they are appropriate with the implemented CSA in Rejosari village. In addition, several benefits can be obtained from synergies of techniques, such as soil management and the use of organic fertilizers, which improve soil fertility and agricultural productivity.

2.4. Smallholder Farmers

Smallholder farmers usually have limited financial and technical capacity to adapt to climate change (FAO, 2010; Tazeze et al., 2012). In addition, smallholder farmers are less dynamic and implementing empowerment programmes for them is often less successful. It is because they do not participate in the programmes since information and agricultural innovations are poorly understood, not applied by farmers, and ignore local knowledge (Aminah et al., 2015). Smallholder farmers in Indonesia cultivate their crops in farming lands less than 0.5 hectares and practice subsistence agriculture to meet their daily consumption needs rather than commercial agriculture (Susilowati & Maulana 2012; Saputra, 2018; Assan, 2019; BPS, 2018; Soekartawi, 1984).

Definition of smallholder farmers can vary from one region to another. In Uganda, smallholder farmers are defined as those who cultivate land less than one hectare in a cropping season. This type of farmer collaborates with their family to work on cultivating their field using simple techniques of farming. They own a few heads of cattle and use the agricultural production to satisfy the family's needs while also selling the limited surplus to the market (Atube et al., 2021). They rely on their farms' production to provide their food and generate income (Vignola et al., 2015). Meanwhile, smallholders in Asia are generally resource-poor farmers who apply rain-fed agriculture. These farmers have farming lands ranging from 0,5 to 4,3 hectares, small initial capital, limited access to resources, low financial effectiveness, and differentiated agribusiness and resource use. They also implement conservative techniques (Devendra & Thomas, 2002). Whereas in Central America and Madagascar, these farmers are poor and suffer from food insecurity with smallholder farming systems (Harvey et al., 2014; Harvey et al., 2018).

Due to the limited capability of smallholder farmers, support from the government, donors, and practitioners is paramount to help them addressing negative impacts and becoming more resilient to the changing climate. Access to climate information and technical practices, tailored policies, and programmes related to climate adaptation is urgently needed to improve socio-economic and biophysical conditions and reduce climate-related problems faced by smallholders (Kuwornu et al., 2013; Harvey et al., 2018).

Agricultural insurance is an important tool for assisting smallholder farmers in mitigating farming risks. A good understanding regarding obvious benefits and their effectiveness needs to be adequately shared to make it acceptable for farmers (Harvey et al., 2014). The Indonesian government protects the farmers who own 2 hectares of agricultural land or less by giving agricultural insurance to improve farmers' welfare (Republic of Indonesia, 2013). This insurance is provided by central and local governments and is dedicated to rice farmers who are in danger of crop damage caused by floods, drought, and pest attacks.

The Governor of East Java Province has issued a policy concerning the improvement of agricultural productivity which is part of the Governor's "*Nawa Bhakti*" (nine services) programme. Part of that programme is "Jatim Agro", a policy focusing on agriculture in East Java. The Governor is eager to increase the capacity, competitiveness, and welfare by giving insurance for rice growers, called "AUTP" (Dinas Pertanian dan Ketahanan Pangan, 2019). It is vital to protect rice because it is the staple food in Indonesia. Business in the rice farming sector is full of uncertainty due to the consequences of climate change that is detrimental to farmers (Ministry of Agriculture, 2021).

Furthermore, the country conduct subsidy programmes through a provision of fertilizer to alleviate poverty (Falatehan et al., 2021). Hence, poor farmers can access fertilizer needed for their farming business at an affordable price, improving efficiency and production at the farm level (Nasrin et al., 2018; Kholis & Setiaji, 2020). The allocation of subsidized fertilizers in Indonesia is regulated by the Minister of Agriculture Regulation Number 49 of 2020. There are five types of subsidized fertilizers such as organic fertilizers and four inorganic fertilizers, namely urea, SP-36, NPK, and ZA. These fertilizers are given to farmers who are members of farmer groups, registered in the Group Needs Definitive Plan (RDKK) system, have an identity card, and fill out a subsidy redemption form (Ministry of Agriculture, 2020).

2.5. Climate Adaptation Strategies of Farmers

Climate adaptation can address the long-term impacts of the changing climate. CSA practices, such as soil management, tree planting, agroforestry and intercropping system, and balanced use of organic and organic pesticides are applied by smallholder farmers to improve productivity and moderate the negative impacts. These practices enhance crops' health as well as crop yields. Soil-related farming activities increase the soil's nutrients, positively affecting crop growth (Kuwornu et al., 2013).

The household heads' characteristics are important to determine proper strategies for farmers. These strategies should be adjusted to how farmers respond to the existing climatic and environmental conditions. The age and education of the farmers influence the conservation techniques applied on the farm (Obayelu et al., 2014; Tazeze et al., 2012). The old and low-educated farmers tend to choose traditional strategies learned from their predecessors. The younger farmers, who have higher education levels, prefer the new techniques that are profitable and easier to apply.

Furthermore, socio-economic factors influence farmers' decisions for adopting particular strategies. For instance, farmers who have wider land are able to adopt more strategies and have more opportunities to improve their income (Belay et al., 2017). In addition, farmers' cohesion is a key factor related to the social and cultural dimensions (Adger et al., 2013). Similar experiences in dealing with the local phenomena (Turasih & M Kolopaking, 2016) contribute to the efforts of improving their prosperity and quality of life (Adger et al., 2013).

3. Research Design

This chapter explains all steps needed to reach the research objective by developing conceptual design through research framework, and the methodology which consist of research strategy, data collection, data analysis, and research ethics.

3.1. Research Framework

The research framework is a schematic illustration of the whole research processes using a step-by-step approach created by Verschuren & Doorewaard (2010).

<u>Step 1. Research objective characterization:</u> As_stated in section 1.2, the objective of this thesis is to understand and improve the climate change adaptation strategies of smallholder farmers in Indonesia by focusing on CSA practices.

<u>Step 2. Research object definition:</u> The objects of the research are smallholder farmers in Rejosari Village and their CSA practices. These CSA practices help farmers lessen the disturbances of the climate change in the village and improve their income and social conditions.

<u>Step 3. Research perspective development:</u> This research focuses on the current CSA practices of smallholder farmers. Qualitative research was conducted through field observation and interviews with households and stakeholders to understand farmers' adaptation strategies and decision-making processes regarding CSA practices. It is supported by a quantitative data regarding the farmers' characteristics such as age, education level, land size, and crop type in the choice of CSA practices.

<u>Step 4. The sources of the research perspective</u>**:** Relevant publications from the scientific and grey literature were reviewed. Scientific literature was accessed via Scopus, Google Scholar, and ScienceDirect, focusing on climate change adaptation, climate-smart agriculture, smallholder farmers, and climate resilience. The grey literature includes governmental documents and reports on the climate challenges and impacts in the region, weather forecasts, agricultural systems, and other relevant information about the Rejosari village.

<u>Step 5. A schematic of the research framework:</u> A schematic representation has been made to visualize the whole research processes, as shown in Figure 2.

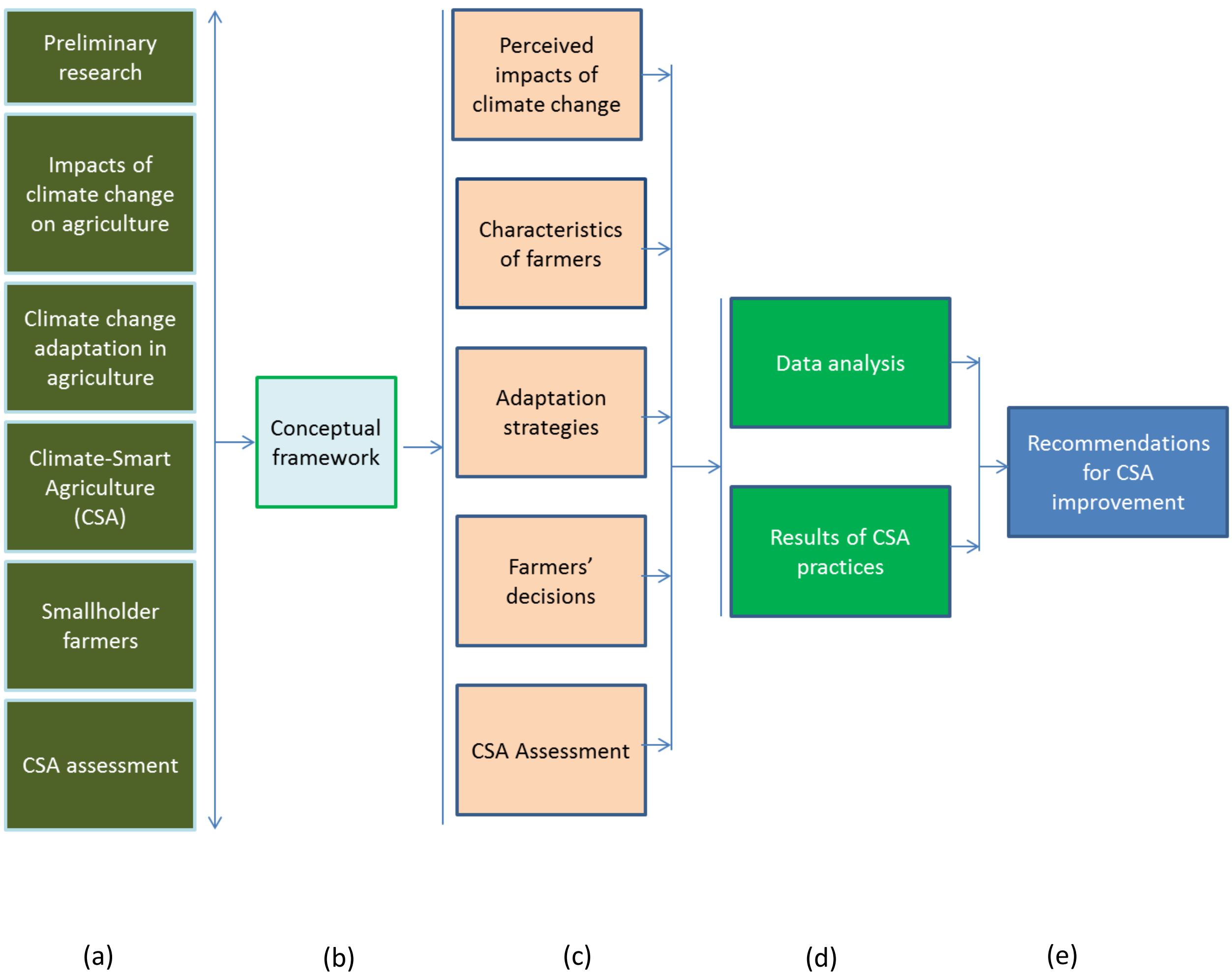

Figure 2. Research Framework

Step 6. Formulate the research framework

Following the steps in Figure 2, the research framework is formulated as follows:

(a) Conduct preliminary research and review the relevant literature.

(b) Develop the conceptual framework of the research based on the preliminary research and theoretical background.

(c) Collect data using desk research, field observations, and interviews with farmers to understand the perceived impacts of climate change, their adaptation strategies and how they make decisions to choose CSA practices, and assess them to know their benefits.

(d) Confront the results of CSA practices of the farmers and data analysis.

(e) Provide recommendations for improving the CSA practices of smallholder farmers to adapt to climate change.

Step 7. Check the research framework for possible revisions

After data were collected, revisions to the research framework were made. All farmers in Rejosari village own the land that they farm. Thus, land ownership was not analysed in the research.

3.2. Research Strategy

This research focuses on one case study in a particular area using two research units, smallholder farmers and stakeholders that are involved in CSA practises for adapting to climate change. This research uses qualitative methods to describe farmers' strategies and their decision-making processes through field observations, interviews, and desk research; and also quantitative data regarding farmer characteristics that affect the farmers' decisions on CSA practices.

It began with a theoretical framework addressing climate change impacts on smallholder farmers in a region that is vulnerable to drought. In order to obtain the necessary data, field observation and interviews were conducted. Based on the collected data, households' characteristics, strategies, and decision-making processes were analysed.

3.2.1. Research Unit

The units of this research are individuals; namely the smallholder farmers in the Rejosari village, and representatives from the governmental organizations at national, provincial and district levels, a non-ministry government institution and a donor organization.

3.2.2. Selection of Research Unit

Different selection criteria were applied to select the two research units. The farmers were selected based on their age, education, crop type, land size, and participation in the farmers' group, whereas the representatives of governments were selected based on the working group for adaptation strategies in East Java province developed by the Head of Regional Development Planning Agency (Bappeda) of East Java province. The lists of informants from the smallholder farmers and stakeholders in this research are shown in Table 2 and Table 3 respectively.

Table 2. List of Informants from Smallholder Farmers

No.	***Name***
1	Jais (Chief of farmer's group)
2	Suraji
3	Painun
4	Sukiman
5	Gino
6	Kasminten
7	Siatun
8	Poniyah
9	Mini
10	Sakriono Untung
11	Rahmawati
12	Sanawi
13	Sunardi
14	Bambang Hariyono
15	Suliyanto
16	Adi Supriyanto
17	Triswanto
18	Sri Yuliani
19	Hariono
20	Yudik Cahyono

The adaptation of climate change in central government is related to the Ministry of Environment and Forestry (MoEF). In the province, climate change impacts in agriculture are handled by Bappeda, Agricultural Agency, Technical Implementation Unit of Crops Protection, Plantation Agency, Forestry Agency and Environmental Agency (DLH). Lastly, at district level, this issue is managed by Food Crops, Horticulture and Plantation Service (DTPHP), Water Resources Department (PUSDA), and Environmental Board (DLH). Other stakeholders that join the working group are a non-ministry government institution namely Meteorological, Climatological, and Geophysical Agency (BMKG) in Malang station, and a donor, namely United States Agency for International Development on Climate Change Adaptation and Resilience programme (USAID APIK) of East Java province.

Table 3. List of Informants from Stakeholders

No.	***Name***	***Institution***	***Position***
1	Tri Widayati	Directorate of Climate Change Adaptation, Ministry of Environment and Forestry (MoEF)	Deputy Director for Man-made Ecology Adaptation
2	M. Yusqi E. F.	Regional Development Planning Agency (Bappeda), East Java Province	Technical Staff at Department of Economics and Natural Resources (Policy for agricultural sector)
3	Anita Megawati	Regional Development Planning Agency (Bappeda), East Java Province	Technical Staff at Department of Economics and Natural Resources (Policy for Climate Change)
4	Edy Purwanto Tertius	Agricultural Agency, East Java Province	Section Head of Fertilizers and Pre-harvest Tools for Food and Horticulture Crops
5	Irma Kisworini	Plantation Agency, East Java Province	Technical Staff of Pest and Disease Control Department
6	Cicilia Nova R.	Technical implementation unit for food crop and horticulture protection, East Java Province	Pest controller
7	Prasetyo	Technical Implementation Unit of Crops Protection, Plantation Agency, East Java Province	Pest controller for rice and horticulture crops in Malang Raya (Malang district, Malang city, Batu city)
8	Joko Subowo	Technical Implementation Unit of Crops Protection, Plantation Agency, East Java Province	Extension officer for pest control in 4 Sub-districts (Bantur, Pagak, Donomulyo, Kalipare)
9	Elmi Sumiyarsono	Environmental Agency (DLH), East Java Province	Technical Staff
10	Anugro Purwidyatmoko	Forestry Agency, East Java Province	Technical Staff
11	Aptu Andy Kurniawan	Public Works for Water Resources (PUSDA), Malang District	Section Head of Water Resources Development
12	Slamet Budi Samsul	Food Crops, Horticulture and Plantation Agency (DTPHP), Malang District	Head of Food Crops Department
13	Anis Sulistyowati	Environmental Agency (DLH), Malang district	Section Head of Environmental Preservation
14	Ahmad Luthfi	Meteorological, Climatological, and Geophysical Agency (BMKG), Malang Station	Senior Forecaster
15	Yofianus Toni Sakera	USAID	Provincial Project Coordinator

3.2.3. Research Boundaries

This research has boundaries to make sure that it can be completed on time and within available resources. The following boundaries were used in this research:

a) The research location was Rejosari village, Malang district, East Java Province, Indonesia.

b) The main research unit was farmer households, while the secondary research unit, consisted of governmental organizations or other actors supporting the CSA practices, was selected based on the information obtained from the farmers.
c) A total of 20 farmer households and 15 stakeholder representatives were selected for field observation and interviews.

3.3. Data Collection

This research uses both primary and secondary data. The primary data were collected from field observation and interviews, while the secondary data were obtained from desk research. The field observations involved direct, non-participant observations. In this regard, the researcher took notes and documented the processes and observed participants without actively participating in the research unit regarding daily CSA practices. Moreover, in-depth, semi-structured interviews with open-ended questions were conducted to gain reliable and comparable qualitative data regarding their vulnerabilities, strategies, and other aspects affecting the selection of the strategies through CSA.

Field observations and interviews with farmers were conducted over five days in May 2021. The steps for conducting the field observations are as follows:

1. Give a clear introduction about the researcher identity, research objectives, activities. Documentation in the form of notes, pictures, videos, and audio recordings about farmers' adaptation strategies through CSA is also taken.
2. Inform the participants for consent and ask them to fill the consent form for voluntary participation in the research without the intervention of any element of force, fraud, and deceit.
3. Ask permission from household heads to start observing their activities and family members regarding CSA practices. In the field observation, there were discussions about agricultural management within the family, perceived vulnerabilities of climate change, strategies and decision-making processes, farmers' cohesion, and government involvement. During the observation, participants might feel inconvenient, afraid of making mistakes in conducting their everyday activities, or worried about the confidentiality of gathered information. In this regard, participants were assured that this observation is only for study purposes and improves the community's resilience to climate change through good approach and communication.

4. To avoid problems during field observation, such as invasion of privacy and problems related to trust and deceit, making friends and maintaining openness with the participants is extremely important.
5. Finally, providing participants with information collected about themselves that has been uncovered in the research to respect and gratitude for their contributions.

Furthermore, the representatives from governments at national, provincial and district levels, and other stakeholders were interviewed to know the extent of which government policies support adaptation strategies implemented by smallholder farmers in vulnerable areas. Subsequently, in-depth, semi-structured interviews were held for 50-60 minutes for each informant, both farmers and the stakeholder representatives.

During the interviews, questions regarding CSA practices and the government's support of climate change were asked to the farmers and stakeholders. To understand how farmers' characteristics influenced decision-making process, those characteristics are explored including farmers' age, education level, crop type, and land size, as shown in Appendix 2. The interviews also explored weather conditions and climate change information, the perceived impact of climate change, and strategies to address the problems were explored. To understand farmers' decision-making processes, the relationships of farmers and government were studied. Furthermore, to discover the government's role in this issue, questions regarding the government's policy, goals, and projects on CSA practices of smallholder farmers, depicted in Appendix 3, were asked to the relevant stakeholders.

The secondary data were obtained using desk research through scientific articles from Scopus, Google Scholar, ScienceDirect, and also grey literature from government reports, such as policies, reports about disasters, weather and climate in Rejosari village, and CSA-related programmes at the national, provincial, and district levels. The research material and collection methods are described in Table 4.

Table 4. Research Material and Collection Methods

No	***Sub-question***	***Required information to answer sub-question***	***Data Source***	***Collection methods***
1	What are the impacts of climate change in Rejosari village?	Impacts of climate change faced by smallholder farmers	Primary data	• Field observations at the household level • Interviews with farmers
			Secondary data • Hydrological data • Geomorphological data	Desk research of documents from the climatology station in Malang District, and the government reports in Malang District and East Java Province
2	What adaptation strategies do the farmers adopt to tackle those impacts?	Strategies based on farmers' characteristics	Primary data	• Field observations at the household level • Interviews with farmers
			Secondary data	Desk research of documents about the village, and relevant records and reports.
3	How do smallholder farmers make their decisions with regards to CSA practices?	Farmers' skills to implement CSA	Primary data	• Field observations at household level • Interviews with farmers
		Cohesion among the farmers	Primary data	• Field observations at household level • Interviews with farmers
		Decision-making processes	Primary data	• Field observations at household level • Interviews with farmers
4	How to improve current CSA practices to increase its climate resilience?	Assessing current CSA practices using eight indicators	Primary data	• Interviews with farmers
			Secondary data	Desk research using: • the scientific literature • the grey literature

3.4. Data Analysis

After necessary data were collected, the next step was analysing the data. This research uses qualitative and quantitative content analysis as data analysis method to get in-depth insights for understanding the CSA practices.

3.4.1. Methods of Data Analysis

The data were collected from the informants until it was saturated or there was no new information obtained. Each type of data collected for answering each sub-question was analysed based on criteria displayed in Table 5.

Table 5. Data Analysis Methods

No	*Sub-question*	*Required information to answer sub-question*	*Method of Analysis*
1	What are the impacts of climate change in Rejosari village?	Impacts of climate change faced by smallholder farmers	Qualitative: analysing the impacts of each extreme event
2	What adaptation strategies do the farmers adopt to tackle those impacts?	Strategies based on farmers' characteristics	Qualitative and quantitative: analysing farmers' strategies based on characteristics of the households heads: age, education level, land size, crop types
3	How do smallholder farmers make their decisions with regards to CSA practices?	Farmers' skills to implement CSA	Qualitative: analysing technical skills of the farmers
		Cohesion among the farmers	Qualitative: analysing how the farmers build their communication, networking, membership in organizations, and access to climate information
		Decision-making processes	Qualitative: analysing stakeholders that influence the farmers in the decision making processes of CSA implementation
4	How to improve current CSA practices to improve its climate resilience?	Assessment of current CSA practices using climate resilience indicators	Qualitative: analysing current CSA practices using indicators regarding their benefits after adopting climate-smart agriculture practices.

3.4.2. Validation of Data Analysis

Data were validated using data source triangulation to ensure their validity through the convergence of information from different sources. Triangulation of data was conducted by comparing data from different farmers and stakeholder representatives during interviews, and comparing the data obtained from field observation and desk research (Carter et al., 2014)

3.5. Ethical Considerations

This research is designed to create new knowledge about adaptation strategies implemented by poor farmers in a drought-prone area in Indonesia through CSA practices. Farmers and representatives from relevant stakeholders are the main informants. In-depth insights were gained by observing and interviewing farmer households and interviewing the representatives from stakeholders. As shown in Appendix 1, an informed consent form was set up before conducting the interviews to ensure that the data collection was carried out without coercion to the informants in participating in this research. The form includes ethical considerations such as interviewees' privacy and confidentiality. Moreover, the data obtained from the interviews were used solely for the completion of the thesis.

4. Results

This chapter describes the research results based on field observations and interviews with 20 Rejosari smallholder farmers, 15 representatives of governments at national, provincial, and district levels, and document analysis regarding CSA practices of smallholder farmers in the village. All farmers report that they have perceived changes in local climate detected from the changing pattern of rainy seasons. The main perceived impacts are drought, reduced quality of crops, and disease and pest outbreaks. They overcome these by managing soil before the planting period, utilizing decomposed manure to enhance crop growth, planting trees, and implementing agroforestry and intercropping systems to boost their productivity. Those strategies are influenced by the characteristics of household heads', the interactions among farmers, and the support from the government.

4.1. Impacts of Climate Change

In Rejosari village, three significant impacts of climate change, namely drought, low quality of crops, and disease and pest outbreaks, are experienced by smallholder farmers. The following describes these impacts.

4.1.1. Drought

Based on the field observation, farmers in Rejosari village implement rainfed agriculture. It means they rely on rainwater to grow crops on their agricultural land, which included fields and yards. In regards to rainfed agriculture, the farmers recognize that the climate is changing based on the pattern of the rainy season. Consequently, they plant all crops at the same time to avoid zero rainfall that occurs in particular months. As depicted in Figure 3, precipitation levels drop in the dry seasons from April to October. The lowest rate of rainfall occurs in August.

The rainy season is determined by the amount of rainfall equal to or more than 50 millimeters in 10 consecutive days. To avoid mistakes in defining the rainy season, farmers can manually carry out the rainfall measurements. The correct planting time helps crops receive optimum water (Stakeholder interview 14).

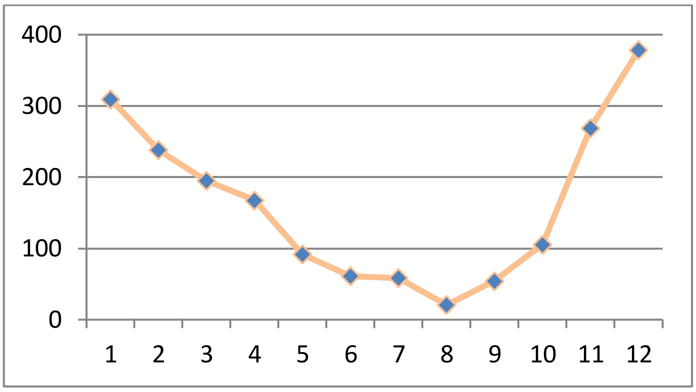

Figure 3. Average Monthly Rainfall in Bantur Sub-district (2010-2019)
(Source: BMKG, 2021)

However, none of the farmers implement this method. They plant crops after the first raindrops so that the plants can get ample water. Actually, it can be a false rain or heavy rainfall for 3-4 days and subsequently, it do not rain for two to three weeks. Farmers make their decision to plant at that time because they believe that the rainy season has arrived. As a result, their plants are wilt and possible to die because of no water (Stakeholder interviews 1, 14, 15; Saubani, 2017).

As shown in Table 6, the rainfall tends to drop to zero in every dry season between April and October (Stakeholder interview 11). Because of this, the agricultural lands cannot be adequately irrigated. Climate change worsens this condition since the duration of the dry season becomes longer than before (Farmer interview 1, Stakeholder interview 14). In 2021, the rainfall had stopped in the second week of March and affected the crops' growth. Some crops did not receive rainwater as expected (Farmer interview 10).

Table 6. Monthly Rainfall in Bantur Sub-district

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2010	245	294	195	336	325	158	125	50	253	202	437	207
2011	141	148	135	175	108	17	0	0	0	0	215	235
2012	456	214	490	74	124	0	0	0	0	71	158	355
2013	288	20	170	27	122	224	336	56	0	0	116	604
2014	302	178	23	130	19	0	0	0	0	0	215	435
2015	177	283	59	252	28	0	0	0	0	0	0	266
2016	266	593	85	180	157	215	104	38	232	547	878	553
2017	524	226	381	297	5	0	21	62	50	235	472	483
2018	505	254	64	0	28	0	0	0	11	0	110	465
2019	191	171	349	206	0	0	0	0	0	0	90	182

Source: BMKG, 2021

4.1.2. Reduced Quality of Crops

Smallholder farmers explain that some crops cannot grow appropriately without sufficient irrigation (Farmer interviews 3, 6, 7, 10, 11). Growing conditions that are too dry decrease the crop's health significantly. For instance, sugarcane grows shorter and thinner due to insufficient water (Farmer interview 10). As a result, sugarcane production decreases around 25-50% (Farmer interview 19). As Hariono, a 33 year-old-farmer, explained: "*For 0,25 hectares of sugarcane, it should produce around two trucks of sugarcane, but due to less rainfall, currently, it is only one truck.*" Another farmer experienced lowered groundnut yields due to the dry soil (Farmer interview 18). The filling of the groundnut pods cannot be optimal when the groundnut experiences drought in the generative period (Pratiwi, 2013).

As explained in the previous section, the rainfall durations have become shorter than they should be. One of the farmers, who grows horticultural crops such as chili, eggplants, and long beans, explains that his crops are drying due to no rainfall in March and he cannot sell the products because of their low quality. As depicted in Figure 4, the chili plants cannot grow well due to inadequate irrigation (Farmer interview 3).

Figure 4. Dry Chili in the Intercropping System (chili, ginger, and banana)
(Source: Field data)

4.1.3. Disease and Pest Outbreaks

Changing climate causes an increased trend of disease and pest outbreaks. The diseases come from fungi, bacteria, viruses. In addition, pests are related to mice, insects, such as brown planthoppers, fruit flies, and grasshoppers. In 2015-2017, Rejosari village experienced high rainfall, and many crops suffered from disease outbreaks. Furthermore, pest outbreaks occurred more often in dry seasons. The eggs of the pests hatched more quickly in warmer temperatures (Stakeholder interview 8).

Pests from one field can move to another when the crops in the previous field have been harvested and more crops are available in another field. In this regard, when the pest outbreak occurs, all farmers should conduct simultaneous pest control. Usually, this measure is assisted by Agricultural extension officers (Stakeholder interview 8, 11).

Farmers used organic materials to avoid pests and diseases. They prepare them using soursop leaves mixed with wastewater from rice, a technique which they had learned from the agriculture extension officers (Farmer interviews 1 and 3). Nevertheless, it takes some time to kill the pests and diseases. Hence, the majority of the farmers still use inorganic pesticides to kill the disease and pest outbreaks while also using the organic ones to maintain the crops health. Chili plants are the most vulnerable crops to fungi. The chili farmers, who face disease outbreaks, are unwilling to use organic materials to overcome this matter. It is because chili has a high price in the market. Thus, chili farmers prefer to use inorganic pesticides because of their immediate effect (Farmer interviews 12, 15; Stakeholder interview 8).

4.2. Characteristics of Farmers

Adaptation strategies of each smallholder farmer depend on the characteristics of the household head, namely age, education, land size, and crop types. Each of the characteristics is explained as follows. The overview of farmers' characteristics can be found in Appendix 4.

4.2.1. Age

With regards to age, there are two types of farmers, old and young. Those who are between 24 and 44 years are categorized as young farmers, and those who are 45 years old or older are classified as old farmers (BPS, 2018). In the whole village, most of the farmers are old (Stakeholder interview 11). It is supported by the observation result that stated 80% of the informants are old, and 20% of them are young farmers (Field observation).

The old farmers in the village tend to use traditional knowledge. Their farming techniques are based on their experiences and knowledge from their ancestors. For instance, the old farmers have learned that it is more profitable to have live stocks to support their agricultural system. They can satisfy the needs for organic fertilizer to manage the land. It has lower costs due to less inorganic fertilizer used, which is beneficial to conserve the land (Field observation). The old farmers were more familiar with predicting the following seasons to define the planting periods. They observed the birds, the soil condition, and other physical changes of the environment to predict the weather for the coming weeks. However, they cannot use this traditional knowledge anymore because the result is not longer accurate. The predicted weather often does not match with the actual condition (Farmer interviews 1,3,5).

There are few young people in the village that work as farmers. Most of them prefer to work as laborers. They leave the village to earn more money in the city by working in construction or factory workers. In addition, they raise their capital for lands and live stocks to support the farming activities that they will do. When they have gathered enough money, they return to the village and cultivate the land. The young farmers are eager to learn the traditional farming systems and new knowledge shared by the governmental organizations. They are willing to do any technique which is profitable and need less money. In decision-making processes, the young farmers are influenced by inputs from their family members. They have low confidence in deciding farming activities due to less experience (Field observation, and Farmer interviews 10, 17, 19, 20).

4.2.2. Education Level

As shown in Figure 5, the interviewed smallholder farmers in Rejosari village are graduated from elementary school, junior, and senior high school with a total of 45%, 20%, 35%, respectively. The farmers in the whole village are mostly elementary and junior high school graduates (Stakeholder interview 8). Farmers with an elementary school education have less enthusiasm to innovate. However, they can still adapt to environmental changes, such as reducing the use of inorganic fertilizer and planting crops resistant to drought like *porang* by imitating the success of other farmers (Field observation, Farmer interviews 8, 9).

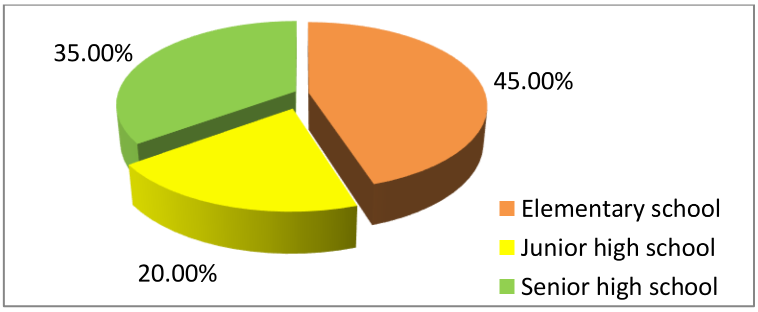

Figure 5. Education Level

(Source: Field data)

Farmers who graduate from junior and senior high school are more active in joining the farmers' organization. They communicate and discuss with others to cope with their agricultural problems. In addition, they are open to innovation and calculate every step they want to take. For instance, one of the junior high school graduate farmers intends to change the crop type from sugarcane to *porang* because of its profitability. He considers the farming techniques, seed's cost, maintenance system, and selling price of *porang* compared to sugarcane. Another is a farmer who graduated from senior high school who plants chili before the rain falls. He uses freshwater from the water seller to irrigate his yard. He has predicted that he will harvest the chili when its price is high. Therefore, he can cover the irrigation cost from his profits (Field observation and Farmer interviews 12, 13, 15).

4.2.3. Land Size

Each smallholder farmer in Rejosari village has two types of land, namely field and yard. On the one hand, the field is more extensive and located away from their homes. Farmers grow crops such as rice, sugar cane, and corn in their fields as their primary source of income. On the other hand, the yard is smaller and is located close to the house. They grow chili, banana, eggplant, papaya in their yards for daily consumption, and the remains are sold in the market (Field observation). Generally, both lands are family inheritances (Farmer Interview 1). Farmers increase their land by buying it with the money they earn while working as laborers.

The range of total land in the yards and fields of the informants is between 0,125 and 2 hectares, while the mean size is 0,63 hectares. As depicted in Figure 6, 45% of the informants (9 farmers) have a land size less than 0,5 hectares, the other 30% (6 farmers) have more than or equal to 0,5 hectares, and the remaining 25% (5 farmers) have more than or equal to 1 hectare.

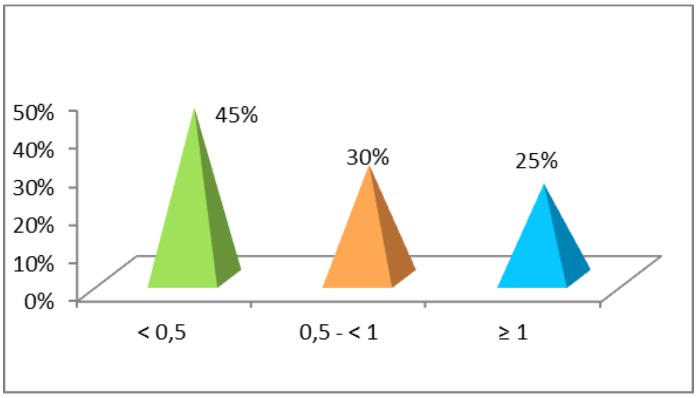

Figure 6. Distribution of the Total Land Size
(Source: Field data)

In addition, the distribution of the field size in the village is shown in Figure 7. 65% of them (13 farmers) own fields less than 0,5 hectares, other 25 % or five farmers own more than or equal to five hectares, and 10 % remaining or two farmers have more than or equal to one hectare. The median of the field from 20 farmers is 0,36 hectares, while median of the field from each smallholder farmer in the whole village is 0,3 hectares (Farmer interview 1; Stakeholder interview 8 and 11).

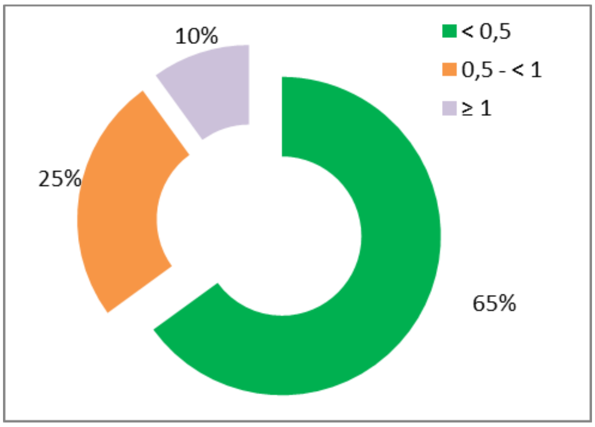

Figure 7. Distribution of Field Size

(Source: Field data)

The bigger the field, the more eager the farmers are to find solutions and innovations to improve the quality of their agricultural products instead of surrendering to existing conditions or finding another source of livelihood. Farmers with more extensive lands are willing to cultivate the crops well (Farmer interviews 1, 3, 12, 14). They adopt more adaptation strategies and tend to show higher effort to gain profit. For instance, a farmer has developed an irrigation system for irrigating horticultural crops such as long beans and cucumbers in the field by constructing a piping system from a nearby river. He knew that it needed a lot of money, but he was confident that the profit outweighs the cost (Farmer interview 12).

In contrast, farmers who have smaller lands and mostly plant sugarcane are not too ambitious to improve their farming conditions. They are more likely to find another job while waiting for the harvest to improve their income (Farmer interview 10, 19). As Sakriono Untung, a 51 year-old-sugarcane farmer, states: *"Current earnings are not sufficient to meet my family's needs. While waiting for the harvest and there is no activity in my fields, I work as a laborer in other fields to earn more money."*

4.2.4. Crop Types

Farmers in Rejosari village grow many kinds of crops in their lands by implementing agroforestry and intercropping system. They diversify their crops to maintain their income from agricultural products. The main crops planted in the fields are sugarcane, rice, maize, peanuts, cassava, and *porang*. Moreover, the type of crops grown in the yard is categorized as horticultural crops such as chili, eggplants, long beans, banana, papaya, jack fruit, mango, orange, ginger, lemongrass, turmeric; and plantation crops such as coconut, cocoa, and coffee (Field observation).

Based on interviews, 17 out of 20 farmers grow sugarcane. Many farmers choose this crop because it is easier to maintain. This crop needs more water in the vegetative growth than in generative growth[1]. Hence, they plant the crop when rain falls, and it requires less water afterward. They eliminate pests by cutting one clump of infected sugarcane to avoid their dispersion. Moreover, the farmers utilize the leaves for the fodder. Planting sugarcane is also favorable because farmers, who have joined the group managed by a sugar factory, need no capital for fertilizing the crops. They receive a loan from the factory in the form of fertilizers. However, this type of crop gives a one-time profit in a year. Therefore, while waiting for the harvest, farmers who have excellent physical conditions work as laborers in other fields to add their income.

Other crops grown in the village are horticultural crops, such as maize, fruits, herbs and spices, and vegetables. Farmers plant these crops because they can get profit in a shorter time. They harvest these crops 3-4 times a year. Nevertheless, growing horticultural crops are more complicated since they are vulnerable to warmer temperature and they need more water. To address these, farmers use pesticides more frequently and apply additional irrigation when they plant them in dry seasons (Field observation, Farmer interview 3, 12, 15).

Moreover, based on the interviews, there is only one farmer who grows rainfed rice. This crop needs more water than other crops. As shown in Figure 8, the old farmer plants this type of crop. She thought it would be profitable as long as it was grown during rainy seasons. It is the staple food in the Indonesian diet. She hopes it always has a reasonable price in the market. This year, she had planted rice four times because the rain continued to fall. Usually, she only plants this crop three times a year. Rice crops which are planted in the fourth

[1] Vegetative growth is an increase in the volume, number, shape and size of leaves, stems and roots, while generative growth begins with the initial formation of flowers until the fruit is ripe (Solikin, 2013).

planting period receive less water and it makes their grains grow less. She was not willing to change her crop. She thought she would need bigger effort if she had to plant different crops such as buying different seeds, preparing other fertilizers, and providing pesticides (Farmer interview 6).

Figure 8. Rice Surrounded by Bamboos and Coconut Trees in the Field
(Source: Field data)

Furthermore, some crops are grown by farmers for particular purposes. To avoid landslides, farmers plant bamboos, teak (*T. grandis*), and *paraserianthes (P. falcataria*) on slope areas (Field observation). Bamboo is a non-timber forest product that could survive in all weather, both in hot and cold regions, in the lowlands, cliffs, and mountains, and can be used for several purposes such as food, and construction material to substitute wood (Arsad, 2015). It is used as a conservation plant because it has strong roots that protect the hydrological system as a binder of soil and water (Widnyana, 2012). Other trees are teak and *paraserianthes*. These woody trees can hold the soil, increase soil fertility, and improve the farmers' income (Sari et al., 2018).

In addition, farmers plant cassava, ginger, turmeric, *porang* in their fields that are resistant to dry conditions. These crops do not need a lot of water for irrigation in their generative growth (Farmer interview 3). Furthermore, *porang (A. muelleri)* has the highest economic value of all root crops planted in the village. It can be processed for several kinds of food such as ice cream, flour, and noodle. Currently, smallholder farmers in Rejosari village are like to plant this type of crop mixed with woody trees in the field (Farmer interview 1, 14).

4.3. Strategies of Farmers

As the area receives less precipitation, especially in the dry season, the farmers in the Rejosari village need strategies to improve their agricultural production. Below are CSA strategies applied by smallholder farmers.

4.3.1. Soil Management

Soil contains various organisms that have significant roles in maintaining soil health for ascertaining soil's vital services. The organisms break down organic matter as food for growing plants. Healthy soil provides basic services to support plant growth and contribute to the needs for nutrient, water, carbon, and gas cycles (FAO, 2013).

Smallholder farmers in Rejosari village have implemented soil management. They explain that it is essential to do before planting the crops (Field observation). They had learned these techniques from their ancestors and from their experiences. These techniques improve the soil's organic content which will affect water infiltration. Thus, more water can be stored in the ground (Stakeholder interview 4).

The farmers conduct soil management by using hand tractors. They utilize organic fertilizers from decomposed manure on the soil to fertilize it before planting the crops that is held in the rainy season (Farmer interview 1, 20). They believe it improve crop health. Hence, sugarcane and other crops can grow more prominent (Farmer interview 16, l0). Furthermore, using organic fertilizer from decomposed manure of their own livestock is affordable (Farmer interview 16).

Soil management reduces compacted soil due to excessive use of inorganic fertilizers. It helps to regenerate the land and maintain crop health (Stakeholder interview 11). Time management is essential to conduct soil management as soon as possible after harvesting and before the rainy seasons. Otherwise, the soil is not adequately managed and not ready to be planted when the rain comes (Farmers interview 1 and 16).

4.3.2. Utilizing Decomposed Manure as Organic Fertilizer

Organic fertilizer plays a vital role in farming. It can loosen the soil structure and makes the crops grow healthier because the roots can grow deeper. This fertilizer is made from decomposed manure or fresh manure that covers the land mixed with dead leaves (Stakeholder interview 4, Farmer interviews 7 and 16).

The cows and goats produce manure, which can be used as organic fertilizer for crops. It creates a synergy between livestock and land management since they positively impact each other. On one side, crops' leaves can be used as fodder for the livestock, and on another side, farmers get nutrients from the livestock manure (Farmer interview 3, 16, 19, 20).

This strategy reduces the use of inorganic fertilizer that is subsidized by the national government. The inorganic fertilizer is applied by farmers when crops are in fruiting periods. In this regard, farmers depend on inorganic fertilizer provided by the government. They can not afford to buy it in the public market (Farmer interview 2, 5, 12). The farmers believe that using organic fertilizer only is insufficient for ensuring healthy growth of crops because particular nutrients, obtained from the inorganic ones, are essential to produce high yields (Field observation; Farmer interview 1, 10, 16, 19).

4.3.3. Tree Planting

Smallholder farmers realize that they live on drylands. Therefore, they need to improve the environment by planting trees. Besides cooling the air, many trees are also helpful for protecting the soil from landslides and increasing groundwater. They grow them on the side of the road, on their yards, and on their fields mixed with other plants (Field observation).

Tree planting is conducted annually in Rejosari village. MoEF and Forestry Agency of East Java Province provide woody trees, such as teak, *paraserianthes*, and fruits such as avocado, soursop, mango, and longan to increase the land cover and promote agroforestry system. The farmers get the trees for free by sending a letter to them and informing the number of seeds needed in the village (Stakeholder interview 10).

In addition, smallholder farmers in the village also plant trees in slope areas to protect the soil from landslides. These trees have positive impacts on water conservation. During observation, the researcher found a spring located in the field, around which planted with various kinds of trees. A farmer reported that it was a new spring, as seen in Figure 9, appeared in 2019 (Farmer interview 1, field observation).

Figure 9. The New Spring that Appeared in 2019

(Source: Field data)

4.3.4. Agroforestry and Intercropping Systems

All farmers in Rejosari village implement agroforestry and intercropping to improve their income. Agroforestry systems can be found in the yards and fields of the farmers. As depicted in Figure 10, they plant woody plants, fruits, and plantation crops on the same land. Furthermore, intercropping is implemented in the field by planting chili, long beans, cassava, and *porang* (Farmer interviews 18, 11, 20).

Figure 10. Agroforestry System (teak, *paraserianthes,* clove, coffee)

(Source: Field data)

As mentioned earlier, agroforestry is beneficial for the environment and also for farmers' economies. This system increases biodiversity and water conservation, restores critical land, and prevents landslides. The farmers can utilize the products for themselves and/or sell them in the public market. Promoting agroforestry system engages the community to manage the forest ecosystem and to use the available resources properly (Stakeholder interview 10).

Intercropping system or a polyculture pattern of horticultural crops (FAO & Ministry of Agriculture Livestock and Fisheries, 2018) is applied by all smallholder farmers in the village. It is favorable because farmers generate the products and generate income 3-4 times a year from several types of crops in a single area. Good crop maintenance and water management are crucial to producing high-quality crops (Farmer interview 3).

Intercropping system increases the chances for harvest in difficult seasons. For instance, as depicted in Figure 11, one of the farmers planted long beans and cassava in the same field. It was beneficial for him because he could harvest the long beans after three months of planting. He produced the cassava in 3-5 months afterward (Farmer interview 12).

Figure 11. Intercropping System (long beans and cassava)
(Source: Field data)

4.3.5. Governmental Support

Through insurance and subsidies, the Indonesian government protects farmers that own 2 hectares or less land from unpredictable events due to climate change which endanger their farming systems. This support enables the farmers to minimise agriculture risks and avoid crop failure (Republic of Indonesia, 2013). The insurance, namely a rice crop insurance programme (AUTP), is available for rice growers. It protects farmers from decreasing income due to losses and facilitates them to continue farming after a bad crop year (Ministry of

Agriculture, 2021). In addition, the government subsidizes AUTP premium for the farmers. It should be Rp. 180.000,00 but they could pay it at Rp. 40.000,00 per month. Unfortunately, none of the smallholder farmers who grow rice in Rejosari village join the insurance programme. They cannot afford the subsidized premium. Another reason is their small land size, which make joining AUTP not profitable for them and will add to their burden of life instead (Stakeholder interviews 2, 8; Farmer interview 1).

Furthermore, the Ministry of Agriculture and the Agricultural Agency of East Java province support farmers, who own 2 hectares or less land, with five types of fertilizer subsidies. First is an organic fertilizer that increases soil nutrition for land preparation. Second is urea fertilizer or $CO(NH_2)_2$ as nutrition for soil and crops vegetative growth to create more leaves and increase the stems. It is a preferable fertilizer for farmers in the village because it is suitable for all types of plants such as maize, groundnuts, and chili. The third is "SP-36" or superphosphate fertilizer, to support crops in their fruiting periods. This fertilizer improves seed quality, stimulates plant division, accelerates fruit ripening, strengthens plant stems, and enlarges cell tissue. Fourth is "ZA", a basic fertilizer to enhance the plant's immune system that increases crops' ability to defend themselves from pests, diseases, and drought. It is suitable for sugarcane because it does not have a sugar-lowering effect. Finally is "NPK", which containing nitrogen, phosphate, potassium, magnesium, and calcium. NPK maintains roots to grow more robust, more abundant, and longer to absorb nutrients in the soil more easily. NPK fertilizer is used to prevent plant stunting (Stakeholder interviews 4, 5, 8; Farmer interview 18; Kumparan, 2019; Petrokimia Gresik, 2019; Dinas Pertanian dan Ketahanan Pangan Kabupaten Sragen, 2018).

Smallholders in the village rely on fertilizer subsidies from the government because of their affordable prices. The price of the fertilizer increases twofold in the market. Nevertheless, the distribution of the subsidized fertilizers is sometimes late, which causes the farmers to not be able to fertilize the crops properly. This year, there was late delivery of the subsidized fertilizer. It forced some farmers to buy in the public market, but some did not purchase the fertilizer due to the high price (Farmer interviews 1, 2, 5, 12, 16, 19, 20). Ironically, the farmers preferred to use inorganic fertilizers than the organic ones to improve the yields. They think that inorganic fertilizers are more efficacious than organic fertilizers. They are more concerned with getting abundant and fast yields in a short time rather than the long-term effect of inorganic fertilizer which is harmless on the natural resources (Stakeholder interview 4, 5, 6, 7, 8).

4.4. Farmers' Decisions Regarding CSA Practices

The decision of smallholder farmers to implement CSA is related to their skills, cohesion among farmers, and their networking.

4.4.1. Farmers' Skills to Implement CSA

The governments of Malang district and East Java province are concerned about improving the environmental condition and smallholder farmers in Rejosari village, to address climate change impacts. In the district level, it is related to DTPHP, PUSDA, and DLH. Moreover, in the provincial level, this issue corresponds to Technical Implementation Unit of Crops Protection and Plantation agency of East Java province and Plantation agency through their extension officers. They have trained smallholder farmers in Rejosari village regarding farming practices that help maintain farmers' productivity and address climate change impacts (Farmer interview 1, 3, 15).

Agricultural extension officers from DTPHP of Malang district, Technical Implementation Unit of Crops Protection and Plantation agency of East Java province support and provide training for farmers in Rejosari village regarding crops' cultivation towards climate change. They also monitor and train farmers to address disease and pest outbreaks. The extension officers also improve the farmers' skill to use environmentally friendly materials on cultivating the land and protecting the crops from diseases and pests (Stakeholder interview 7, 11).

PUSDA is a governmental institution that focuses on managing water supply and water demand for the irrigation system. It is protecting water resources that are utilized for irrigation in the Malang district. This institution engages and trains the farmers in Rejosari village to construct infiltration wells to retain water and prevent landslides, and plant trees to protect irrigation canal borders. 90% of the irrigation system in Malang district comes from water springs. Therefore particular trees and areas near the spring are protected by law (Stakeholder interview 12).

DLH officers in Malang district and East Java province have trained farmers in this village to protect the natural springs and conduct environmental conservation in critical lands by planting trees. Mostly they use particular trees (such as *Ficus benjamina*) to retain more water in the soil and improve water levels (Stakeholder interview 9 and 13). The farmers are also trained to have a rainwater system for their agricultural system. Traditional methods to retain rainwater have been implemented, such as making catch pits in the fields and yards. A pond is available in the village to support the agricultural system nearby (Farmer interview 1).

4.4.2. Farmers' Cohesion and Network

Smallholder farmers in Rejosari village have close connections and good communication with each other. They share many activities through local traditions that allow them for frequent communication, and improve their cohesion. They also discuss farming activities every time they meet in the field (Farmer interview 3, 20).

There is a Muslim tradition to meet every Thursday evening to pray together. In this meeting, they sometimes share crucial information regarding agriculture. They also organize common activities to clean up the village every Sunday (Farmer interviews 1, 5, 8, 11, 20). Moreover, they have an annual ceremony when harvesting the sugarcane as a gratitude to God. During this ceremony, they pray together to have a great harvest and always work safely (Farmer interviews 3, 5, 19). Furthermore, every year, they celebrate the independence day of the country and the Islamic new year by praying and eating together.

The communication among the farmers is more intense due to the availability of farmers' groups. There are two types of farmer groups in the village, groups of food crops farmers, consisted of those who grow rice and horticultural crops (maize, long beans, chili, groundnut, etc), and groups of sugarcane farmers. The food crops farmers groups are founded for food crops cultivation, distribution of subsidized fertilizers, and disease and pest controls. It is supported by agricultural extension officers from the province and the district. This group holds regular meetings with three agricultural extension officers to train food crops farmers regarding how to increase productivity and maintain crop growth and health. These meetings also aim to support farmers to tackle disease and pest outbreaks. They also talk about how to address climate impact in the farming system.

The sugarcane farmers' group deal with the distribution of fertilizers and sales of sugarcane (Farmer interview 16, 17). It is managed by the sugar cane company, namely PG Krebet. The factory provides a loan to sugarcane farmers in the form of fertilizer. At the harvest time, the factory will buy farmers' products, and subsequently, farmers pay the loan from their profits.

Farmers who join these groups tend to keep up with the latest information regarding seeds, subsidized fertilizers, and pest outbreaks. As a result, they accept new new programmes from agricultural extension officers more easily (Farmer interview 1). Participating in a farmers' group makes sharing information more manageable and expanding networking with other farmers in different regions beneficial for their businesses. By joining groups, they have more opportunities to participate in trainings or workshops held by the government or other institutions to improve their practical skills, such as *porang* cultivation and making processed foods. However, not all farmers want to join the groups because they think it is less beneficial. Joining activities in the group are seen as less useful and a waste of time (Field observation).

Currently, Rejosari village is the biggest *porang* producer in Malang district (ITS News, 2021). It was started by an active farmer who likes to improve and grow this new crop that is resilient in dry seasons. This success has influenced others to adopt the same strategy. As a result, they can earn additional income through planting *porang* (Stakeholder interview 8, 11). This village is often used as a place for student internships from several universities in East Java, such as Brawijaya University (UB), Sepuluh Nopember Institute of Technology (ITS), and the University of Muhammadiyah Malang (UMM) to study about *porang* cultivation. Moreover, other farmers from different regions and provinces also come there for the same purpose. As shown in Figure 12, networking makes it easier for farmers to receive technical assistance from other parties to improve their small business of making processed foods from *porang* (Farmer interview 1).

Figure 12. Support from Internship Students of ITS: a Dryer for *Porang* Noodles (Source: ITS News, 2021)

4.4.3. Decision-Making Processes

The interviewed smallholder farmers in Rejosari village make crucial decisions in agriculture in term of defining the planting time, changing crop types, and implementing a new farming practice or innovation. Defining the planting periods is related to the prediction of rainy seasons. The farmers plant all kinds of crops during this season. They are not implementing crop rotation[2] because of the possibility of zero rainfall occurring in the dry season which will endanger the crop's growth. In this regard, climate information provided by BMKG is crucial. This institution regularly shares weather forecasts with the extension agencies. Unfortunately, not all farmers receive this climate information. The extension officers share this information with the farmers in face-to-face meetings instead of using the easier online system. It is because most of the farmers are old and less familiar with the technology. Thus, the extension personnels share climate information using a direct meeting with the head of the farmer's group. Consequently, they cannot reach all farmers in the whole village (Stakeholder interviews 8, 11, 14, 15; Farmer interviews 1, 16, 17).

Furthermore, farmers discuss problems they face with each other, such as disease and pest outbreaks or choosing specific crops, pesticides, fertilizers, and new farming techniques. They share information regarding the weaknesses and the strengths of the solutions. It is helpful to spread the information and knowledge among farmers to solve particular problems. However, the decision of one farmer, who cultivates the field by himself, is influenced by his characteristics, especially the land size that reflects his financial condition. In addition, a farmer, who work together with other family members to manage the agricultural system, also takes into account his family inputs to decide any changes or development in their agricultural system (Stakeholder interview 5).

Both young and old smallholder farmers are willing to implement new agricultural practices or innovations which have proven successful. They are worried about experiencing losses and crop failure. In this regard, having a demonstration plot is quite essential. Yet, it needs a farmer who is willing to implement the innovation and a party that can cover the risks of possible losses (Field observation).

4.5. CSA Assessment

CSA can be helpful to particular areas for addressing the negative impacts of climate change. However, it is also possible to cause maladaptation when it does not lessen the farmers' climate vulnerabilities. Therefore, assessing CSA practices implemented by the smallholder farmers is essential in the Rejosari village to improve their climate resilience. Building climate resilience involves adapting and recovering from climate-induced stresses

[2] crop rotation means cultivation of various types of crops in turns in one year (Rondhi et al., 2018; Thirdyawati et al., 2013)

through learning processes, gaining knowledge and experience, enhancing flexibility to create solutions (Obrist et al., 2010; Djalante & Thomalla, 2011). In this research, eight indicators are used to evaluate CSA practices. The following is the assessment based on field observations and interviews.

1. **Improvement of agricultural productivity**: The productivity of smallholder farmers' agricultural system improve due to the implementation of agroforestry and intercropping system. They harvest various kinds of crops in one land. Moreover, soil management using organic fertilizer from decomposed manure which affects the soil fertility influences the development of the products by making them bigger and healthier (Farmer interview 10).
2. **Improvement of resilient crops to climate variability**: Famers grow root crops which are resistant to dry conditions, such as ginger, cassava, turmeric, and *porang*. *Porang* has become popular lately, and many farmers plant it because the number of successful *porang*'s farmers is increasing. The agricultural extension officers support them by providing training on how to cultivate it properly. Moreover, ginger and cassava are common crops in Rejosari village because they are able to grow with less water (Field observation and farmer interview 3, 12).
3. **Improvement of soil fertility**: Farmers perceive improvement of soil fertility through better plant growth due to the implementation of soil management and the use of decomposed manure. All informants explain that both strategies are essential in growing crops (Field observation). The increase in soil fertility is also a result of planting trees that protects the soil cover from landslides and increases the organic content of the fallen leaves (Stakeholder interview 12).
4. **Improvement of income from crop diversification**: Agricultural diversification is an effort to diversify farming to alleviate crop losses or failures because of problems in the cultivation of one type of plant (Herlinawati, 2013). Diversification of crops can be observed by implementing agroforestry and intercropping system that are prevalent in the village. These systems bring more income and profit to the farmers by harvesting many crops in one land. Furthermore, the systems control pests and diseases, and enhance the biodiversity in the farming lands (Farmer interview 3).
5. **Improvement of water and soil conservation**: Implementing tree planting and agroforestry systems improve the water content and soil fertility that affect the availability of the springs. The representative of DTPHP stated that water flow of springs located in

the lower areas was affected by the particular tress covered in the higher catchment areas. A spring was found by one of the farmers in 2019 around farming land that applies agroforestry. Only one of the 15 springs is used for irrigation because the remaining springs had too low water flow. The farmers hold annual tree planting in both in the fields and the yards. Thus, the size of these areas will be improved year by year. In addition, there is a government's regulation which protects some trees located in areas near the springs and the irrigation system. PUSDA monitors these areas and particular trees, namely banyan trees (*Ficus benjamina*), to ensure their availability for protecting the springs, and retaining more water (Farmer interview 1, Stakeholder interview 11, 12).

6. **Improvement of irrigation system for drought prevention**: Because Rejosari village is located in the drylands and karst soil, the smallholder farmers implemented the rainfed agriculture system. The farmers develop rainwater harvesting to retain more rainwater for the crops by making a pond, and catch pits. There is no additional irrigation system in the field (Farmer interview 1). To keep crops growing well in the yard, some farmers use the freshwater which is supplied by the local government, and freshwater bought from water sellers, depicted in Figure 13. Based on field observation and interviews, since the end of 2020, residents in Rejosari Village receive freshwater supply from Malang district. Besides fulfilling drinking water needs, this water source is also used for irrigation in several people's yards. Yet, other farmers still rely on rainwater because they cannot afford the monthly payment for this water source. The farmers want to improve the agricultural products in the yard since the products are used for daily needs and sold in the public market to add their income.

Figure 13. Freshwater Supply from the Government (left); Water Tank for Yard Irrigation (right)

(Source: Field data)

7. **Improvement of forest area that applies CSA practices**: The significant improvement of forestry areas can be observed through the progress of the agroforestry system implemented by the farmers in their fields which reduces the size of critical lands. Support from the Forestry Agency of East Java Province and the national government through various types of trees increases farmers' enthusiasm to plant trees, especially those which have economic value.
8. **Improvement of farmers' awareness of environmental protection**: The farmers in Rejosari village are aware that protecting the environment from agricultural practices is vital for the sustainability of their farming. They use organic fertilizer from manure to manage the soil. They also use organic pesticides to maintain the crops' health. However, using inorganic pesticides is preferable to face pest outbreaks and protect high-economic crops such as chili which is quite prone to diseases. They also still depend on the use of inorganic fertilizer for improving generative growth of the crops.

5. Discussion

As described in the previous chapter, smallholder farmers in Rejosari village are prone to drought, have low quality of crops, and face pest and disease outbreaks because of climate change. They plant trees and implement agroforestry system for water conservation. The farmers manage the soil and utilize decomposed manure before planting periods as strategy to improve the crop quality. In addition, they also implement intercropping systems to gain higher income. Overall, CSA practices by smallholder farmers have positive impacts on the environment and also on their productivity. The constraints are mainly due to their limited capital which make them implement few CSA techniques that mentioned above. The following discussion outlines the areas identified as needing improvements.

1. Technology improvement to access climate information

There is no clear solution for predicting the planting periods. The changing seasons and unpredictable weather create a high risk of loss in the agricultural system. Access to climate information plays a significant role in this situation. BMKG provides the data, and it is proven accurate. However, the limited number of human resources from extensions officers becomes the main problem because currently, it is shared manually.

Giving updated information regarding climate through the board of information available for the farmers in an open area located in the village office can be a solution to predict the planting periods. This information links to the BMKG. Sharing the information using technology improvement might create an easier and better way. As a result, farmers can diminish the possibility of loss due to failure in defining planting seasons.

2. Irrigation system

The low rainfall in dry seasons makes the smallholder farmers more vulnerable. Additional irrigation systems should be available and accessible to increase the productivity during the prolonged periods of drought. The characteristic of the soil, which is composed of limestone, sandstone and volcanic rocks, makes it difficult to drill wells (Stakeholder interview 11, 12). Therefore, providing piping systems from other villages with water resources can help provide better irrigation systems to alleviate the possibility of crop failure in Rejosari village.

3. The correlation of plant transpiration and drought

The transpiration from trees' canopy is related to access to the groundwater. The tree species which has a high rate of transpiration consumes a tremendous amount of water. Hence, conducting tree planting needs to consider the character of the tree in order to get the appropriate benefits. Some trees slow down the movement of water, helping plants minimize water loss in dry seasons. In contrast, other plants transport high amounts of water vapour into the air, with larger openings in the leaves, and as a result, they bring worse drought, particularly on dry land with low rainfall (Anderegg et al., 2019; Asdak, 2010; Georgia Pacific, 1999; Leuning et al., 1991).

As described earlier, teak is a common woody tree which is a component in the agroforestry system planted by the farmers in the slope areas. Indonesia's tropical conditions support the growth of teak. This tree is suitable for areas in which the annual dry season around 3-6 months, the annual rainfall is on average 1250-1300 mm, and the annual average temperature of 22-26°C (Saputra & Mustafidah, 2016). It is appropriate to be planted in Rejosari village because between 2010-2019 this village experienced around 5-6 months dry seasons per year, total amount of rainfall around 1100-2000 mm/year, and temperature of 25-26°C (BMKG, 2021). Moreover, it fits drylands like Rejosari because teak sheds its leaves in the dry seasons to lower the transpiraton rate and to survive the drought (Luo et al., 2016). It also provides water conservation, protects the microclimates, and improves biodiversity (Pramono et al., 2011).

Beside teak, *paraserianthes* is favourable in the village due to its high economic value. However, this tree requires specific environment to grow optimally, such as temperature between 22-29 °C, rainfall of around 2000–3500 mm/year, and wet condition because it tends to do more transpiration (Krisnawati et al., 2011). In addition, farmers need to consider *paraserianthes*' root distribution and depth when combining it with seasonal plants on their lands. It is because there will be competition among the plants in absorbing water and nutrients in the upper soil layer, particularly between 20 - 80 cm from the stem (Hairiah et al., 2004). Hence, planting *paraserianthes* in Rejosari village is less suitable.

Understanding how trees respond to drought is crucial to predict the future climate. However, it is important to note that this feedbacks may vary in different places with different environmental conditions (Luo et al., 2016; Anderegg et al., 2019).

4. Subsidies and insurance for smallholder farmers

Rice farmers in Rejosari village are not willing to join AUTP, an insurance programme for rice crops. The farmers still cannot afford the insurance premium, although the government has subsidized them. The benefits of AUTP are not significant for them compared to the effort to pay monthly premiums. The size of their agricultural land is relatively small, so the compensation is not much (Farmer interview 1; Stakeholder interview

2, 6,7,8). A good explanation regarding the benefits of joining AUTP is essential for farmers' adequate understanding and for engaging them to participate in the programme. Meanwhile, another consideration should be made for more affordable insurance premiums.

In addition, eight of the interviewed farmers grow chili. As mentioned earlier, this crop is vulnerable to diseases that commonly emerge in rainy seasons. The farmers are less interested in using organic pesticides to combat the diseases. They use the inorganic ones because these kill the diseases quickly. Therefore, farmers do not face greater losses. Proposing insurance for chili farmers is beneficial because chili has a high economic value. It protects the smallholder farmers from worse risks due to agricultural damage and ensures the availability of production costs in the next planting season (Field observation).

Moreover, government should be more concerned regarding the subsidies allocation for supporting fertilizers to smallholder farmers. Problems with administration affect delays in distribution processes (Stakeholder interview 4). The price of unsubsidized fertilizers is two times higher. Hence, they are not affordable for farmers. As a result, farmers cannot apply the fertilizer properly at the planting time during rainy seasons, and it affects their products (Farmer interview 1, 20).

5. Demonstration plot programmes

The smallholder farmers have limited financial capital. Therefore, they are not interested in innovations or new programmes that have not been proven successful. Creating demonstration plots and financial support can engage them to improve the agricultural system through adaptation strategies recommended by the government. Nevertheless, for areas that become less prioritize by the government, this solution is difficult to apply. Collaboration with other stakeholders, such as private sectors through CSR, may solve the problem. Expanding the networking and actively communicate with farmers in other regions and universities is also possible to gain technical and capital support.

6. Regular use of organic fertilizer and organic pesticide

Changing farmers' mindset and improve their awareness to cultivate the farms using environmentally friendly ways takes a certain amount of time. Thus, it should be conducted regularly and continuously. Engaging farmers in environmental conservation using organic fertilizer and pesticides, new techniques modified with their traditional knowledge can be more acceptable because they are used to do the same activities. It also improves the creativity of smallholder farmers and lessens their dependency on extension officers to address farming problems.

Appreciation to farmers who apply environmentally friendly agriculture through crop failure protection and technical assistance is crucial to transform their old techniques. Gradually, they will get used to the new practices and prove the advantages such as fertile soil, cheaper farming costs, and less dependent on subsidized fertilizers. The success of one farmer will be imitated by other farmers.

7. Capacity building of agricultural extension officers

There are three extension officers who support the smallholder farmers in Rejosari village. They are agricultural extension for counselling from DTPHP of Malang district, extension for managing pests and diseases of food crops from Agricultural Agency of East Java province, and extension officer for managing pests and diseases of plantation crops from Plantation Agency of East Java Province. These officers should understand well about crop growth and health that may vary as the environment changes. Having competent extension officers who understand well the proper farming techniques in accordance with changes in the biophysical environment is extremely important. In addition, sharing the climate information to predict the planting period need particular skill to deliver information correctly. Therefore, sustainable capacity building for them is crucial and will be beneficial because it dramatically affects the quality of knowledge conveyed to smallholder farmers.

8. Home industry and market protection

Low quality of products reduces the farmers' profit. For instance, the case of chili plant that cannot grow properly due to dry soil. Creating a home industry to produce chili processed foods with a higher economic value can boost the farmers' profit. It also creates employment in the village. The local government can facilitate the farmers and create a new market for the affected farmers.

Further support is needed from the local government to protect the market through certain policies and subsidies for food quality and standardization. When this new product is accepted by the community and ready to compete with other products in the public market, it can be a source of new income for the smallholder farmers and the government.

6. Conclusions and Recommendations

This chapter answers each sub-research question and the main research question, presents future research directions based on the research limitations, and provides recommendations for governmental organizations.

6.1. Conclusions

This research had four sub-questions. The answers to each question are described as follows:

SQ 1: What are the impacts of climate change in Rejosari village?

The result and analysis reveal that smallholder farmers perceive changes in local climate based on changing patterns of rainy seasons. It had significant impacts which threaten smallholder farmers who highly depend on subsistence agriculture in the drylands. They rely on rainwater to grow their crops. Thus, precipitation changing caused several events such as drought, reduced crop quality, and disease and pest outbreaks perceived by the smallholder farmers in Rejosari village which reduced their product and income.

SQ 2: What adaptation strategies do the farmers adopt to tackle those impacts?

The farmers apply multiple CSA practices to address the negative effects of climate change. They implement soil management, utilize decomposed manure, conduct tree planting, agroforestry, and intercropping systems. Those practices bring significant impacts on the improvement of the products as well as their income. Since one strategy can synergize with others, farmers can get greater benefits when they apply more strategies to address climate change impacts. Moreover, farming activities of smallholder farmers highly depend on the government and the private company support through subsidized fertilizers, especially the inorganic ones. It is because inorganic fertilizers' effect on plants is faster. Thus, farmers can avoid losses.

SQ 3: How do smallholder farmers make their decisions with regards to CSA practices?

The characteristics of the head of farm households, such as age, education level, land size, and crop type, influence their decision to choose particular adaptation strategies. Young farmers consider the inputs from family members and the cost of applying new techniques ensuring that these were profitable for them. In comparison, old farmers prefer conservative farming by applying their experiences and knowledge passed down from their ancestors.

Farmers with junior and senior high school education tend to be more capable of finding solutions to address their problems than those with elementary school education. Farmers who have bigger fields adopt more adaptation strategies and tend to have higher effort to gain profit. They also plant multiple types of crops such as maize and vegetables in their field. Others, who own smaller lands and usually plant sugarcane, are not too ambitious to improve their farming conditions and were likely to find another job to improve their income.

Cooperation between farmers is well established. These farmers exchange ideas in dealing with various agricultural problems. Their capabilities of crop cultivation are developed by joining coaching and counseling from governments in enhancing their production and reducing environmental damage due to climate change. The success of one farmer influence and become an example for others in order to get similar benefits. Moreover, farmers in Rejosari village were visited by other farmers in different regions and also universities to learn about *porang* cultivation, as one of the typical root plants in the village of Rejosari resistant to drought. This networking is beneficial for the farmers to escalate their businesses in marketing processed food from *porang*.

SQ 4: How to improve current CSA practices to increase its climate resilience?

All practices applied by the farmers give merits to their productivity, soil fertility, and water conservation. Smallholder farmers can improve their resiliency when they apply more CSA practices with active supports from the government and other stakeholders to make them more open to adopting new adaptation strategies to address the impacts of climate change. However, these practices are currently limited, especially in disseminating climate information to predict the proper timing for planting, improving irrigation system in the dry seasons, selecting proper trees species in tree planting programme to prevent worse drought, and developing farmer's awareness regarding the use of organic material to fertilize the soil and kill pests and diseases. If these problems are solved, farmers will have a better planting pattern which enables them to improve their productivity. This will also allow them to increase the quality of agricultural products without worsening the environmental conditions affected by climate change. In this regard, farmers become resilient because they can adapt to and recover from climate stresses.

Based on the answers to the sub-questions, the main research question is answered: **How do smallholder farmers in Indonesia implement CSA to adapt to the adverse impacts of climate change?** Overall, smallholder farmers in Rejosari village implement CSA to adapt to the adverse impacts of climate change based on their experience, knowledge from their ancestors, and trainings from government. In addition, the strong farmers' relationship enable them to support each other to address agricultural problems. It is beneficial to share new information and experiences to tackle the impacts of climate change, and marketing farming products to improve their income. Their poor condition makes them reluctant for innovation to adapt to climate change on their agricultural land due to worries about yields reduction. As a result, farmers tend to choose adaptation strategies that create more benefits on their economic condition rather than long-term effects on natural resources. Therefore, transforming the current techniques into better CSA practices is essential and urgent in Rejosari village through government policies favouring smallholder farmers and drought problems due to climate change.

This study brings new knowledge regarding how to improve the adaptation strategy of climate change of smallholder farmers who have strong social capital with low financial condition. Their poor condition makes them need the support of other stakeholders to assist them in addressing the challenges of climate change. Nevertheless, this study is limited by the small number of farmers observed while working in the fields. Observing farmer activities while working requires their willingness and should not interfere with their routine activities. In addition, the term climate change is not very familiar to some farmers. It was overcome by asking easy-to-understand questions in the interviews, such as changes in the weather experienced by the farmers. Moreover, during the research, farmers were waiting for harvest time. Thus, no significant activities were conducted in the field. Furthermore, in May 2021, some plants could not be observed because they have been harvested (such as maize), and others were in dormant periods (such as *porang*). Lastly, this study only provides a short discussion about extension officers that strongly assist the farming activities of smallholder farmers. Their connection should be explored more because their communication, relation, collaboration are affecting the successful farming practices in the fields.

Based on the limitations of this study, future research should consider the appropriate time of field observations. Research on adaptation strategies in the agricultural sector requires the right time to observe more CSA activities in the fields without intervening with farmers. For instance, field observation should be conducted during the growing periods at rainy seasons, and all cultivated plants are planted simultaneously. CSA practices are widely practised in that period, and various obstacles encountered can be learned more deeply. In addition, future research should investigate more about the role of extension workers when studying smallholder farming systems. This is essential because their significant role and access to the provision of facilities and infrastructure enable them to reach smallholder farmers and disseminate crucial information to address climate change.

6.2. Recommendations

CSA is a proper adaptation strategy for smallholder farmers to cope with climate change impacts. It enhances agricultural productivity as well as environmental quality using affordable costs. To improve current CSA practices as climate adaptation strategies for smallholder farmers, four recommendations are made for governmental organizations at the national, provincial, and district levels to raise farmers' awareness as well as improving their social and economic conditions.

Firstly, the national, provincial, and district governments should give more attention and priority to the impacts of climate change on smallholder farmers by promoting and encouraging the framers to conduct proper CSA practices. Governmental organizations should develop policy measures that focus more on improving the knowledge and welfare of smallholder farmers in drylands and the extension officers who support them towards climate change. Such measures will boost farmers' independence to deal with the changing climate. Modifying adaptation strategies considering the vulnerabilities of the village, farmers' local knowledge and demonstration plots to enhance farmer participation in government programmes. Good communication and clear explanations are essential for climate insurance available for crops with high economic values to develop an adequate understanding for improving farmers' participation.

Secondly, disseminating climate information that supports farming activities is an urgent need. It affects the determination of the planting period that affecting the crop growth. Therefore, collaboration among government agencies at the district level involving Bappeda, DTPHP, PUSDA, DLH, and BMKG should be developed to increase funding, facilitation, and technical assistants for accessing climate information. The dissemination of climate information avoids maladaptation to climate change since farmers can predict the following seasons. When they are aware of the climate information, they will have a better cropping pattern system.

Thirdly, changing the mindset of the farmers is essential by promoting the use of organic material for fertilizers and pesticides to cultivate the lands. It can lessen the dependency on the fertilizers subsidized by the government and make their farming system more sustainable. The worries about losses due to new programmes can be addressed through awareness and capacity building, reasonable explanations using proven benefits. In addition, promoting tree planting and environmentally friendly farming practices is beneficial to all farmers to improve soil fertility, retain more water, protect the springs and restore the critical lands in supporting their agricultural systems.

Finally, support from the district government through policies and technology to improve their farmers' business may help farmers improve their capital and be more independent. Developing local food products can be an alternative to increasing the economic conditions of smallholder farmers in Rejosari village by processing crop products with low quality.

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Appendix 1. Informed Consent Form for Individual Interviews

for thesis studies in MSc MEEM, University of Twente

Adaptation Strategies of Smallholder Farmers using Climate-Smart Agriculture (CSA): The case of Rejosari village, Indonesia

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I declare to be informed about the nature, method and purpose of the investigation. I voluntarily agree to take part in this study. I keep the right to terminate my participation in this study without giving a reason at any time.

My responses may be used solely for the purposes of this study. In its publications, they may *(please tick one of the options):*

◯ be cited with my name or function revealed

◯ be cited anonymously, thus without identifying context

◯ only used as information source

During the course of the interview I keep the right to restrict the use of (some of) my answers further than indicated above.

Name participant:

…..……………………………………………………………………………………………

Date: …………………..…………… Signature participant: ………………………………….

I declare to fully adhere to the above.

Name researcher:

…………………………………………………………………………………………..……

Date: ………………………………..…… Signature researcher: ………………...……………….

Appendix 2. Interview Guide for Farmers

Adaptation Strategies of Smallholder Farmers using Climate Smart Agriculture: The case of Rejosari village, Indonesia

<u>A. Personal details</u>

Name	:	………………………………………
Gender	:	Male / Female
Birth year	:	………………………………………
Education	:	Elementary school / Junior high school / High school / Higher education
Origin	:	Natives / immigrants……………….. (City)
Length of stay in the village	:	since year …..

<u>B. Questions</u>

1. Farmers' characteristics

- What kind of crops are you cultivating in your field?
- Is the land used for farming owned by yourself or rented?
    - How large is it?
- How do you manage your agricultural system?
    - What is the division of responsibilities among your family members?
    - Do you irrigate the crops? If yes, which method do you use?
- Does the income from agricultural activities fulfill your family needs?
    - If not, do you have other sources of income?

2. Weather conditions and climate change [3]

- What are the weather conditions in surrounding area and in your field?
- How do you recognise the changing of the weather and the climate in your village and in your field?

[3] I asked about both weather and climate, because some farmers understand climate and some of them do not. They know that the seasons are changing and the temperature is getting warmer. But "climate" is not a familiar word for most of the farmers.

- How do the current weather conditions and climate influence your farming activities?
- What are the most significant impacts of changing weather and climate on your agricultural system?

3. Climate change adaptation strategies implemented by the farmers

- What kind of Climate-smart Agriculture (CSA) practices (e.g. agroforestry, using compost and organic pesticides, rainwater harvesting, soil management to improve the organic content, etc) do you implement to overcome disruptions of your agricultural system due to weather and climate change?
- How do you identify the proper CSA practices to increase crop yields and avoid failed harvests?
- To what extent has your agricultural productivity changed after implementing climate-smart farming practices?
- How are the changes in productive resilience to climate variability in your field?
- What are the benefits resulting from the climate-smart agricultural practices that you have implemented so far?
    - How is the improvement of soil fertility in your farm?
    - How is the diversification of your livelihood sources?
    - How is the improvement in the irrigation system in dealing with drought in your farming location? Could you explain more about them?
    - Could you explain about the improvement of water and soil conservation activities in your farming location, such as planting trees, prohibiting logging of illegal trees, cultivating using organic fertilizers, etc.?
    - How is the improvement of agricultural land that applies climate-smart agricultural technologies?
    - How is the improvement of forest area which implements climate-smart farming practices?

4. Decision-making processes and support from the government

- What do you take into account when choosing the farming practices that are most appropriate to address the environmental problems faced in your field?
    - Do the actions or projects of governments or other organizations affect your choice of particular practices? If yes, could you explain how?

    - Do other farmers affect your choice? If yes, could you explain how?
- What types of support do you receive from the government or other organizations to protect your agricultural system and improve its productivity?
    - What organizations provide support in agricultural practices, such as field cultivation, soil management, irrigation, etc.?
    - Do they share information on particular techniques or new technologies?
        - If yes, on what topic, using which method, and how often?
    - Have you ever attended any training related to farming from the government or other organizations?
        - If yes, when and on what topic? Was it useful?
    - To what extent do they help you to solve the problems regarding weather and climate change?

5. Farmers' relationships with regards to climate change adaptation

- Could you explain the relationships between farmers in this village regarding practices to overcome climate change impacts?
    - How does the traditional culture influence the agricultural system among farmers to address climate change?
    - Are there certain common beliefs or values that strengthen the relationship between the farmers in the village? (to know the perception)
- How do you collaborate with other farmers in the village to deal with the negative impacts of climate change?
    - Do the farmers collectively carry out any agricultural improvement activities? If yes, which activities and on which impacts?
    - Are there any rules to collectively improve the agricultural practices? If yes, what are they, and how are they implemented?
- How do you exchange information and knowledge with other farmers regarding new farming practices that are profitable and economical for your agricultural systems?

Appendix 3. Interview Guide for Stakeholders

Adaptation Strategies of Smallholder Farmers using Climate Smart Agriculture:
The case of Rejosari village, Indonesia

A. Personal Details

Name : ………………………………………
Institution : ………………………………………
Position : ………………………………………

B. Questions

1. Government's policy to address climate change

- What are the major problems related to agriculture and climate change? Do you observe any negative impacts of climate change on agriculture?
- Do you have any goals or objective about climate change adaptation in agriculture? If yes, what are they? Do you have any strategies or action plans that you can share with me?
- What is the government's policy that concern about smallholder farmers' vulnerabilities to climate change?
- Which policy instruments do the government implement related to climate change adaptation by smallholder farmers?
    - Legal instruments, such as laws and regulations
    - Economic instruments, such as subsidises
    - Communication instruments, such as trainings and information campaigns

2. Government's programmes and projects on CSA practices to improve climate change adaptation by farmers

- What is the role of the government in improving climate change adaptation activities with the CSA?
- What programmes or projects does the government implement currently regarding Climate-smart Agriculture practices (e.g. agroforestry, using compost and organic pesticides, rainwater harvesting, soil management to improve the organic content, etc.) to support farmers in addressing climate change?

- The subsidized fertilizer from the government is extremely important for smallholder farmers. How do you manage to provide them continually?
- How does the government support the farmers to obtain climate-related information that is important for the management of their agricultural systems?
  - Which actions does the government take in attracting the attention of smallholder farmers to involve them climate change adaptation by applying CSA? Such as trainings, extension activities, pilot/demonstration projects, brochures, website, social media, etc.
  - How does the government support smallholder farmers to implement CSA practices?
- What are the challenges faced to improve climate change adaptation by smallholder farmers?
  - Are there specific challenges for CSA? If yes, could you explain?

3. Collaboration of government, NGOs, and private companies to promote CSA practices to smallholder farmers

- How do governmental organizations, NGOs, and private companies collaborate to support farmers for climate change adaptation?
  - Are there specific collaboration activities focusing on smallholder farmers? If yes, could you explain?
  - Are there specific collaboration activities related to CSA? If yes, could you explain?

Appendix 4. Characteristics of Smallholder Farmers

Number	Age category	Education Level	Crop type		Total and size (ha)
			in the Field	in the Yard	
1	Old	Senior high school	• Chili, sugarcane, maize, *porang* • Agroforestry: *porang*, chili, jackfruit, avocado, coconut tree, coffee, soursop, teaks	Mango, chili, starfruits, jack fruit, *porang*	1
2	Old	Elementary school	Sugarcane, maize, ginger	Chili, long beans, banana, coconut trees, papaya, dragon fruit	0,75
3	Old	Senior high school	Sugarcane, maize	Teak, chili, long beans, cassava, ginger, banana, peanuts	1
4	Old	Elementary school	Maize, singkong, *porang*	Pisang, coffee, orange, longan, eggplants	1
5	Old	Elementary school	Sugarcane, maize, *porang*	Chili, banana, mango, dragon fruit, cocoa, coconut trees	1
6	Old	Elementary school	Rice	Sugarcane, maize, cassava	0,375
7	Old	Elementary school	Sugarcane, *porang*, maize, cassava	Banana, star fruit, mango, chili, longan	0,13
8	Old	Junior high school	Sugarcane, maize, cassava	Long beans, mango, ginger, lemongrass, coconut trees	0,25
9	Old	Elementary school	Sugarcane, *porang*, maize, teak and cassava	Banana, jack fruit, star fruit, mango	0,25
10	Old	Elementary school	Sugarcane, teak, *paraserianthes*	Coffee, ginger, mango, banana	0,421
11	Old	Elementary school	Sugarcane, maize, cassava, teak, *paraserianthes*	Chili, eggplant, jack fruit, lemongrass, coffee, *porang*, ginger	0,35
12	Old	Senior high school	Sugarcane, maize	Long beans, cucumber, chili, clove, coffee, vanilla, teak, pepper	1,5
13	Old	Junior high school	Sugarcane, *porang*	Aquaponics (catfish and shallot), banana, cassava, orange, mango	0,504
14	Old	Elementary school	Sugarcane, *porang*, maize	Banana	2

Number	Age category	Education Level	Crop type		Total and size (ha)
			in the Field	**in the Yard**	
15	Old	Senior high school	*Paraserianthes*	Chayote, chili, cassava, banana	0,5
16	Old	Senior high school	Sugarcane, teak, *paraserianthes*	Coffee, ginger, turmeric, banana, coconut tree, jack fruit, mango	0,565
17	Young	Senior high school	Sugarcane, *paraserianthes*	Mango, chili, cassava, lemon grass, jack fruit, coconut trees, ginger	0,1325
18	Young	Junior high school	Sugar cane, maize, cassava	Groundnuts, long beans, *porang*, banana, jackfruit	0,25
19	Young	Senior high school	Sugarcane, maize	Cassava and ginger	0,5
20	Young	Junior high school	Sugarcane, maize, *porang*, cassava	Banana, coconut trees	0,1