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PHAN Thi Thuy

Dissertaion originale présentée en vue de l'obtention du grade de docteur en sciences agronomiques et ingénierie biologique

COMMUNAUTÉ FRANÇAISE DE BELGIQUE
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Promoteur : Professor Philippe LEBAILLY
Co-promoteur : Associate Professor LE Duc Niem
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Résumé

Thi Thuy PHAN. (2021). Systèmes de cultures pérennes dans la province de Dak Lak, Vietnam : pratiques et analyse socio-économique. (Thèse de doctorat en anglais). Gembloux, Belgique, Gembloux Agro-Bio Tech, Université de Liège, 179 pages, 47 tableaux, 43 figures.

Les cultures pérennes jouent un rôle essentiel dans l'économie agricole, car elles fournissent des biens destinés à l'exportation et des emplois pour la main-d'œuvre, tout en contribuant de manière significative à l'essor économique au niveau national.

Le Vietnam a connu un fort potentiel de développement des cultures pérennes, et atteint ainsi une croissance explosive des produits agricoles. En termes de cultures pérennes, le Vietnam se classe désormais parmi les cinq premiers exportateurs internationaux de café, de poivre et de noix de cajou. Le Vietnam est le deuxième producteur mondial de café et le premier exportateur de poivre au monde.

Fait remarquable, les superficies plantées en café et en poivre dominent la production, avec respectivement environ 30 % de la production de l'ensemble du pays en 2018. Au fil des ans, les cultures pérennes ont considérablement évolué étant donné la dynamique habituelle des besoins. Malgré ses avantages et les tendances positives de son développement, la production provinciale de cultures pérennes a dû faire face à de nombreuses contraintes dues à la fluctuation des prix, aux tendances climatiques imprévisibles et à l'incidence des parasites et des maladies. Par conséquent, la production de cultures pérennes nécessite des recherches plus approfondies afin d'obtenir davantage de preuves.

Sur la base d'une enquête systématique, de discussions de groupe, d'entretiens avec des informateurs clés et d'une observation participative, ce projet de recherche a été entrepris pour évaluer les pratiques et la socio-économie des systèmes de cultures pérennes, à savoir les monocultures et les systèmes de cultures intercalaires. Les objectifs de ce projet sont de comprendre l'évolution des systèmes de cultures pérennes dans le temps et l'espace, et d'identifier les avantages socio-économiques des différents systèmes en se concentrant sur les cultures de café et de poivre. En outre, le dernier objectif de l'étude consiste à trouver les déterminants qui influent sur la décision d'adoption de l'exploitation. Les résultats fournissent des références essentielles aux agriculteurs et aux décideurs politiques sur la mise en œuvre ou la décision de planter une culture pérenne particulière et sur les stratégies à adopter. Les résultats montrent que les cultures pérennes ont considérablement évolué en termes de types de cultures, de cultures cultivées, de taille des exploitations, de types de systèmes et d'augmentation de la surface totale cultivée. En outre, sous l'effet de moteurs tels que la transformation socio-économique, les changements politiques et le mouvement écologique, les systèmes de cultures pérennes ont bien changé. En effet, depuis de nombreuses années, les systèmes de cultures pérennes ont connu une évolution en cinq

étapes, à savoir les grandes plantations de café et d'hévéas ; les systèmes de cultures pérennes qui sont des exploitations agricoles d'État et des coopératives ; les systèmes de cultures pérennes intensifiées ; les systèmes de cultures mixtes et les systèmes de cultures pérennes spécialisées et diversifiées. Actuellement, les systèmes de cultures pérennes sont mis en pratique en tenant compte du changement climatique, de la commercialisation et des pertes de terres fertiles. Ces systèmes comprennent les monocultures et les cultures intercalaires, qui sont deux modèles représentatifs des systèmes de cultures pérennes, qui sont étudiés. Simultanément, l'évaluation comparative des avantages socio-économiques entre deux monocultures (monoculture de café et de poivre) et un système de cultures associées (culture intercalaire de café et de poivre) a montré que la culture intercalaire est plus efficace que la monoculture dans le contexte de contraintes sur les ressources clés, de risque et d'incertitude. Il est respectivement démontré que les cultures intercalaires ont non seulement un rendement économique élevé et une limitation du risque économique en raison de la volatilité du marché, mais aussi qu'elles présentent les avantages d'un emploi saisonnier prolongé et qu'elles attirent les femmes en tant que travailleuses agricoles dans les petites exploitations. En d'autres termes, la culture intercalaire du café et du poivre est l'option la plus souhaitable pour obtenir des avantages socio-économiques dans les systèmes de cultures pérennes. En outre, les classifications dans les différentes approches et groupes de production sont également organisées pour clarifier ces performances économiques par une analyse coût-avantage. Les autres résultats obtenus montrent que les approches de cultures intercalaires, en particulier les plantations intercalaires de café (ICF), génèrent plus de revenus économiques que les plantations intercalaires de poivrons (IPF), tandis que la production groupée de café (GpC) semble plus appropriée pour les petits exploitants que la production groupée de poivrons (GpP).

Dans le même temps, les conclusions de l'analyse de régression logistique binaire et multiple mettent en évidence les facteurs qui influent sur la prise de décision concernant l'adoption des exploitations. Ces facteurs comprennent les caractéristiques des ménages, les bénéfices des exploitations agricoles et les profils des cultures.

Cette étude fournit des informations qui permettront aux agriculteurs de développer une planification productive en ce qui concerne le choix de systèmes de cultures pérennes appropriés, et d'aider les décideurs politiques à élaborer des stratégies de production de cultures pérennes à petite échelle à Dak Lak. En outre, les facteurs mis en évidence ici sont pris en compte dans le développement des cultures pérennes.

Mots-clés : Systèmes de cultures pérennes, café, povre analyse socio-économique, province de Dak Lak, Vietnam

Abstract

Thi Thuy PHAN. (2021). Perennial crop systems in Dak Lak Province, Vietnam: Practices and socio-economic analysis. (PhD Dissertation in English). Gembloux, Belgium, Gembloux Agro-Bio Tech, University of Liège, 179 pages, 48 tables, 45 figures.

Perennial crops play a valuable role in agricultural economics, as they provide goods for export and jobs for the workforce as well as contribute significantly to economic prosperity at the national level.

Vietnam has a high potential for perennial crop development, and thereby achieve an explosive growth in agricultural commodities. In terms of perennial crops, Vietnam now ranks among the top five international exporters of coffee, pepper and cashew. Vietnam is the second-largest producer of coffee worldwide, while it is the leading exporter of pepper globally. In 2018, the planted area of the dominant perennial crops (coffee, pepper, rubber, tea and cashew nut) reached around 2.2 million hectares (ha) nationwide, an increase of 9,000 ha compared to 2017. The Western Highlands has the largest region of perennial crop production with an area of 1.151 million ha. Dak Lak province has favorable conditions of soil (1,450 ha of basaltic soils of volcanic origin, which equals two thirds of the total basaltic soil area nationwide), as well as weather and amount of arable land, which creates an advantageous situation for the culture of perennial crops.

Remarkably, the planted area of coffee and pepper dominated production at about 30% of the whole country's production in 2018, respectively. Over the years, perennial crops have changed considerably being usual dynamics of requirements. Despite its advantages and positive development trends, provincial perennial crop production has faced numerous constraints due to price fluctuation, unpredictable climatic trends, and incidence of pests and diseases. Thus, perennial crop production needs further research to ensure more evidence.

Based on a systematic survey, focus group discussion, key informant interviews and participatory observation, this research project was undertaken to evaluate the practices and socio-economics of perennial crop systems in Dak Lak province, namely monocultures and intercropping systems. The aims of this project are to understand the distinct stages of perennial crop systems and to identify the socio-economic benefits of different systems concentrating on coffee and pepper crops. Additionally, the remaining aim of the study finds determinants affecting the farm's decision of adoption. The results provide critical references for farmers and policymakers on implementation or decision to plant a particular perennial crop and strategies. The findings show that the type of crop that was planted by the farmers evolved considerably in terms of crop types, crops grown, farm size, type of system and an increase of total cultivated surface. In addition, under driving forces including socio-economic transformation, political changes and ecological movement, perennial crop systems are well changed. Indeed, for many years, perennial crop systems have

experienced an evolution through five stages, namely large-scale coffee and rubber plantations; perennial crop systems which are state-owned farms and cooperatives; intensified perennial crop systems; mixed crop systems, and the specialized and diversified perennial crop systems. At present, perennial crop systems are put into practice which take into account climate change, marketing and losses of fertile lands. These systems include monocultures and intercropping, which are two representative models of perennial crop systems which are investigated in this study. Simultaneously, a comparative assessment of the socio-economic benefits between two monocultures (coffee and pepper mono cropping) and an intercropping system (coffee and pepper intercropping) is presented in which the intercropping is more efficient than the monoculture under the context of constraints on key resources, risk and uncertainty. Respectively, intercropping is not only demonstrated to have high economic returns and limitations of economic risk due to the volatile market but also to have the benefits of extended seasonal employment and attraction for women as farmworkers on small farms. In other words, coffee and pepper intercropping is the most desirable option to obtain socio-economic benefits in perennial crop systems. In addition, the classifications in different approaches and groups producing are also organized to clarify these economic performances by cost-benefit analysis. The further results are obtained that intercropped farm approaches, especially in intercropped coffee farms (ICFs) generate more economic earnings than intercropped pepper farms (IPFs) while group producing coffee (GpC) appears to be more appropriate for smallholders than group producing pepper (GpP) does.

At the same time, conclusions from binary and multiple logistic regression analysis highlight factors affecting decision-making of farms' decision in adopting. These factors include household characteristics, farm profits and crop profiles.

This study supplies information that will allow farmers to develop productive planning with respect to choosing suitable perennial crop systems, and assist policymakers in forming small-scale perennial crop production strategies in Dak Lak province. In addition, the factors highlighted here are taken into account in the development of perennial crops.

Keywords: Perennial crop systems, coffee, pepper, socio-economic analysis, Dak Lak province, Vietnam

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PHAN Thi Thuy
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List of Abbreviations

- CBA : Cost and Benefit Analysis
- CBIS : Coffee based intercropping system
- CCAFS : Research Programme on Climate Change, Agriculture and Food Security
- CPI : Coffee and pepper intercropping
- DARD : Department of Agriculture and Rural Development
- DPI : Department of Planning and Investment
- DIPS : Status Determination and Protection Information Section
- EM : Ethnic minority
- EU : European Union
- FAO : Food and Agriculture Organization
- FGD : Focus Group Discussion
- GDP : Gross Domestic Product
- GpC : Group-producing coffee
- GpP : Group-producing pepper
- GSO : General Statistics Office (of Vietnam)
- GO : Gross Output
- HH/hh : Household(s)
- IC : Intermediate Cost
- ICF : Intercropped coffee farm(s)
- ICC : International Coffee Council
- IDH : Sustainable Trade Initiative
- IPC : International pepper community
- IPF : Intercropped pepper farm(s)
- JICA : Japan International Cooperation Agency
- LURC : Land-Use Rights Certificate
- MARD : Ministry of Agriculture and Rural Development

- MCS : Mono coffee system(s)
- MCF : Mono coffee farm(s)
- MFS : Mixed farming system (s)
- MPF : Mono pepper farm(s)
- MPS : Mono pepper system(s)
- MLR : Multinominal logistic regression
- NFI : Net Farm Income
- NIAPP : National Institute of Agricultural Planning and Projection
- OECD : Organization for Economic Cooperation and Development
- PCS : Perennial crop system
- PGI : Protected geographical indication
- PPD : Plant Protection Department
- PSO : Provincial Statistical Office
- SCPI : Sustainable crop production intensification
- SI : Sustaianble intensification
- UNDP : United Nations Development Programme
- US : United Sate
- USD : United State Dollar
- VAST : Vietnam Academy of Science and Technology
- VICOFA: Vietnam Cocoa and Coffee Association
- VND : Vietnamese Dong
- WASI : Western Highlands Agricultural and Forestry Science Institute

1

Introduction

1.1. Background and problem statement

There are various definitions of cropping systems and interactions with farming resources such as land, labor and capital as defined by previous authors (Diepart and Allaverdian, 2018; Rana and Rana, 2011). Furthermore, the cropping system is an essential component of the farming system, of which the perennial crop sector is one of the elements of the cash crop system (FAO, 2019). As compared to annual crops, perennial crops can be harvested multiple times before they die or have to be replaced. To many authors, the changes of agricultural, in general, and cropping systems, in particular, are results of climate change, agro-technology, socio-economic transformation, liberalization and globalization (Alexander et al., 2015; Araya et al., 2012; Galati et al., 2016; Hatfield and Walthall, 2014; Nguyen, 2017). Cropping systems not only continuously develop along with the local, the regional and international economic situation but also sustainably adapt to the particular conditions to ensure human needs under population growth (Darnhofer et al., 2010; Hatfield and Walthall, 2014). In other words, these changes require agriculture to move to another place or to develop new practices for survival (FAO, 1997; Fresco and Westphal, 1988; Lebailly et al., 2015). Thus, the major trends and trajectories of different farm types need to be accurately understood and appropriate strategies applied in protecting natural resources and securing households' income by enhancing productivity (Jayne, Chamberlin and Headey, 2014). Subsequently, determining the evolution of cropping systems to support future research might be enclosed to the best service of the rural communities (Herridge et al., 2019). Moreover, socio-economic performance is the major key in identifying the resilience and sustainability of farming systems (Barbier, Burgess, and Grainger, 2010; Zinnanti et al., 2019). Thus, a study about the practices and efficiency of perennial crop systems plays a vital role for accurate understanding.

Perennial crops were introduced in Vietnam mainly at the end of the nineteenth century. These products have currently become major commodities and driving forces for economic growth and export revenue. Statistically, in 2018, the perennial crop growing area reached over 2.2 million hectares (ha). Of which approximately 1.8 million ha produced over 4 million tons including coffee, pepper, rubber, cashew and tea, concentrated largely in the Central Highlands, namely the provinces of Dak Lak, Dak Nong, Gia Lai, Lam Dong, and Kon Tum provinces thanks to the favourable conditions (GSO, 2019b).

Over the past quarter-century, the agricultural sector developed such significance that many countries tried to learn from these Vietnamese successes, in the perennial crop sector, which achieved an explosive growth of export earnings, accounting for approximately 10 billion USD in 2018. Since the 2000s, Vietnam ranked among the top five global exporters of perennial crops products. To illustrate, in 2017-2018, Vietnam was one of the world's largest producers of coffee and the world's leading exporter of black pepper, made up of roughly 1,490 and 100 thousand tons, worth 2,880 and 134 million USD, respectively (GSO, 2019b; ICC, 2019; IPC, 2017). Nevertheless, changes in driving forces such as ecological, technical, socio-economic, political issues resulted in challenges to agrarian systems and perennial crop production. In other words, there is a significant relationship between external variables such as economic reform and, government support (by direct and indirect

policies), and the evolution of perennial crop systems (Han Quang et al., 2017; Lindskog et al., 2005; Pham et al., 2001). Presently, perennial crop systems have consisted of two systems, which include specialization and diversification systems.

Dak Lak province, the place of study, exhibits the unique features with high immigration rates, a diversified ethnicity and abundant resources. These create provincial economic development, agricultural growth and influence perennial crop dynamics. For example, in 2018, Dak Lak had over 1.8 million inhabitants and 47 ethnic groups, including 1.1 million Kinh (or Vietnamese ethnicity) and 300,000 people of indigenous groups of other ethnicity, the rest consisting of other ethnic groups, who have immigrated here. Agriculture comprises 42% of the provincial economy and employs over 66% of the workforces. Perennial crop production, especially coffee, pepper, rubber, and cashew have become important thanks to favourable conditions such as basaltic soil and weather. To illustrate, in 2018, the perennial crop growing area reached over 300,000 ha, increasing 5% in comparison to 2015 (GSO, 2019a). Unfortunately, provincial agriculture, and the perennial crop sector has, in Dak Lak experienced enormous challenges for a long time. For instance, low production output, pest infestation, and the collapse of prices have caused economic losses for producers and traders, and these have discouraged people from investing in the future. Additionally, many previous studies have demonstrated that perennial crop production has faced many difficulties such as high production cost, susceptibility to natural disasters, and vulnerabilities from trade fluctuations (Ha and Shively, 2008; Slater et al., 2007). Consequently, farmers have faced debt, as it is difficult to repay loans. This has also had a large effect on socio-economic stability. Perennial crops aren't easily transitioned into other types of farming strategies due to their long economic lifespans and high upfront capital costs (Gunathilaka, Smart and Fleming, 2018; Phan et al., 2019a). Thus, farmers have recently had to practice strategies to reduce risks, cope with uncertainty, replacement of coffee plantations with other crops have been natural responses of farmers to secure production under vulnerable conditions. Diversification is not only a risk management strategy (e.g. separating risks and creating buffers), but it is also a response to price changes (FAO, 2018a). For example, farmers converted from mono cropping to crop diversification by an estimated 15% in 2019 and this had continued in the following years. Specifically, perennial crop intercropping systems have been encouraging expansion efforts are made to mitigate difficulties and risks of production. This has especially been the case, for example, for coffee and pepper intercropping.

Coffee and pepper crops are considered the main crops in the province, accounting for about 30% of cultivated area and approximately 40% of coffee output of the whole country in 2018 (GSO, 2019a). As previous authors have stated, Ho et al., (2017); Nguyen and Phan, (2017); Phan et al., (2019a), the provincial coffee and pepper have developed considerably by diversified practices in recent years, which has generated different benefit levels. In other words, traditional farming of coffee and pepper has now been transitioning from mono-culture systems (separating coffee and pepper) to the intercropping system, where coffee and pepper are intercropped. Initially, this system has been considered to have economic potential. Nonetheless, farm diversification isn't always easy, as there are no clear profit options, and there are financial costs for

alterations as well as the reallocation of labor to other activities. That is why, there must be an accurate understanding of alterations to these cropping systems. Going forward, practices of perennial crop systems and measurement of socio-economic benefits of different systems focusing on coffee and pepper are essential analyses in order to provide empirical evidence for farmers so that they can choose appropriate systems and essential for policymakers to assist in the management and development of strategies for perennial crops.

1.2. Research questions

With the significance and identification, analysis of the perennial crop systems is an important content in order to have appropriate strategies on sustainable development. The research questions are

(1) How have perennial cropping systems evolved in Dak Lak province?

(2) What are the practices and socio-economic performance of selected perennial crop systems involved in coffee and pepper?

(3) Which factors affect the decision to adopt a perennial crop on a farm in the research site?

1.3. Research hypothesis

Based on the situation of perennial crop systems at the study site, the following hypotheses are proposed:

(1) Perennial crop systems have changed rapidly from specialization to diversification due to various transformative factors;

(2) There is a diversity of practices and socio-economic efficiency between selected perennial crop systems; and

(3) Adoption of any specific perennial crop system is impacted by many factors.

1.4. Research objectives

1.4.1. General objectives

The aim of the study is to supply a better understanding of perennial crop production. The study evaluates the feasibility of perennial crop production to assist stakeholders in decisions related appropriate cropping systems. Additionally, this study gives advice to the institution and policymarkers in the provincial perennial crops development strategy.

1.4.2. Specific objectives

(1) To accurately understand the evolution of perennial crop systems during specific distinct stages in Dak Lak province;

(2) To provide an overview of perennial crop practice in Dak Lak province and evaluate the socio-economic practicability of selected perennial crop systems involving coffee and pepper;

(3) To identify the primary factors affecting a farm's decision to adopt specific perennial crops and;

(4) To propose adequate advice and recommendations to farmers and Dak Lak province as a basis for perennial crop development strategy

1.5. Scope and scale of the research

1.5.1. The scope of the research

Due to lack of time and finances, this research can not provide a detailed analysis of all perennial crop systems. A description of practices and socio-economic analysis of all mono-cropping and intercropping systems of perennial crop systems involving coffee and pepper is beyond the scope of this dissertation. Nonetheless, this study can involve identification of a pattern of the results regarding the relative efficiency of coffee and pepper intercropping systems.

1.5.2. The scale of the research

My efforts concentrate on the practices and socio-economic analysis of perennial crop systems. It is important to note that the study only interprets the evolution of perennial crop systems at the farm and communal levels. Furthermore, the research takes the farm as its analysis unit in order to determine the practices and socio-economic efficiency with two representative types of perennial crops, coffee and pepper. Within the research, the determinants of the decision to adopt perennial crops on farms include farmers' characteristics, farm endowment and crops' profile.

1.6. Structure of the dissertation

This study consists of eight chapters.

Chapter 1 (the introduction) provides a general overview of perennial crop systems and their circumstances in Vietnam and Dak Lak Province. This chapter is concerned with crop evolution, challenges, practices and economic benefits of perennial crop systems, and provides a background for the explanation of research problems. Based on the research questions, hypothesis presentation is followed by the objectives of this dissertation.

Chapter 2 presents an elaboration of relevant concepts, definitions and findings from previous studies and reports associated with cropping systems and perennial crops. In addition, this chapter discusses reviews of evolution of agrarian systems, especially they relate to farming and perennial crop. Next, background related to socio-economic the performance of crop systems is provided. Finally, a framework of factors influencing farm decisions is provided.

Chapter 3 is divided into two subsections. At first, an overview of the agricultural sector and perennial crop production in Vietnam, in particular with respect to the production and marketing status, is given. Eventually, two representative crops of coffee and pepper are presented in terms of historical development, production status, market issues and the development trends.

Chapter 4 includes two sections. The first part gives information about characteristics of the research site, including geography, and the socio-economic and natural conditions in relation to agriculture and perennial crop sectors. The remaining part presents the research methodology.

Chapter 5 identifies the evolution of perennial crop systems in Dak Lak Province through distinct stages and strategies of perennial crop development. Firstly, in each stage, the driving forces of socio-economic, political, environmental, and technical changes are explained relation to the dynamic of perennial crops. Finally, after analysis

of spatial and temporal evolution of perennial crop systems, strategies are suggested in the future.

Chapter 6 contains three sections. Firstly, a general description of perennial crop systems practices and farmers' characteristics are provided. Secondly, indicators of economic performance in the selected systems based on coffee and pepper crops are identified. Finally, social benefits including job creation, gender labor division, extended employment, labor use efficiency and potential employment opportunity are identified.

Chapter 7 is divided into two sections. The first section provides descriptive statistics of explanatory variables. The remaining section explains the different factors affecting a farm's general and specific adoption decisions of perennial crop systems.

Chapter 8 includes conclusions and recommendations. It summarizes the main results regarding the research questions and offers recommendations. In addition, this chapter gives policy implications to enhance perennial crop practices and improve socio-economic efficiency in different cropping systems, with an eye towards sustainable development.

2

Literature review

This chapter presents a foundation of the literature relating to crop systems, perennial crops, socio-economic performance, determinants of a farm's adoption decisions, and cropping practices around the world. To this aim, this chapter organizes as follows:

The first part provides definitions of the concepts of cropping systems, perennial cropping systems and the classification of cropping systems.

The second part addresses the background of the evolutionary nature of cropping systems, as well as reviews the fundamental principles of socio-economic evaluation.

The third part discusses the background of determinants on choosing farm practices. Finally, some emerging cropping systems in the world are detailed.

2.1. Cropping systems

2.1.1. Definitions

- **System**

In literature, system definitions have been discussed for a long time. Bertalanffy, (1969) and Rosnay, (1979), for example, stated "*a system can be defined as a set of elements standing in interrelations"* or *"a set of elements in dynamic interaction, organized according to one goal"*. Meanwhile, Odum, (1983) defines a system to be an arrangement of components or parts that connects with the process and transformation of inputs and outputs. Similarly, Rana and Rana, (2011) offered a definition that a system is a group in which its components interact and operate together in order to obtain a common purpose. In the realm of agriculture, systems can be considered at many different levels.

- **Ecosystem**

Organisms have potential to interact closely with the physical environment, forming an ecological system or an ecosystem. Additionally, the ecosystem is characterized as a dynamic system with energy flow, nutrient cycling and changing structure (Conway, 1986; Palaniappan, 1996).

- **Agro-Ecosystem**

This type of system has a complex structure (air, soil, plants, animals, microorganisms and everything else) and dynamic along with the interaction between socio-economic and ecological processes. In other words, the agro-ecosystem can be considered as an ecological system which is highly modified for agricultural production (Conway, 1986). An agro-ecosystem includes a field, a household farm, an agricultural landscape of a village, a region or a nation, and comprises several interacting stocks and flows, such as the soil, the weed, the crop production, the evapotranspiration, the harvested product, etc (Bellon, 1995).

- **Agrarian system**

Various concepts of the agrarian system have been defined by other authors. A well-known definition attributed to Professor Mazoyer is that an agrarian system is "a mode of exploiting the environment historically created and sustainable, a system of production forces adapted to the bioclimatic conditions of a given space and responsive to the social conditions and needs of that moment", cited in (FAO, 1999). Correspondingly, the agrarian system is a complex and an open system and includes

two subsystems of the social system, and socio-economic system and the institutional environment. The total of the reciprocal relationships of components between the production systems, and the common social and economic organizations of the whole society form the agrarian system.

- **Farming systems**

There are many interpretations of the concept of the farming system. However, in this study, a farming system as a typical unit of production is taken to mean a combination of factors and activities in terms of agricultural production to direct self-subsistence and sale. The different farming systems have a different relationship with elements of the systems, and distribution of family labor. The farming system is, therefore, affected by various factors such as political, institutional, socio-economic forces (Diepart and Allaverdian, 2018; Shaner, 2019). On the other hand, a farming system can be conceived as a "*population of individual farm systems that have broadly similar resource bases, enterprise patterns, household livelihoods and constraints, and for which similar development strategies and interventions would be appropriate. Depending on the scale of the analysis, a farming system can encompass a few dozen or many millions of households."* Components of the farming system include cropping systems, livestock systems and/or non-farm activities (Dixon, Gibbon and Gulliver, 2001). Therefore, it implies that farming systems are a wide concept than farm systems (Peeters, 2015).

- **Farm system and family farm**

Many other authors conceive of a farm system that consists of a set of resources and resources flows, characterized by a resource management strategy to meet requirements of a farm household (Dillon, Plucknett and Vallaeys, 1978; Dixon et al., 2001). In these conceptualizations, there are interactions between biophysical, socio-economic and human aspects. Farm systems and farm decisions are influenced by important economic, socio-cultural, ecological, institutional, policy, scientific and technical elements. A farm system not only uses but also creates labor and capital, which comprises the cropping system, the livestock system and the farm household (family farm).

The concept of the family farm varies geographically and depends upon contexts. "*Family farming is a means of organizing agricultural, forestry; fisheries, pastoral and aquaculture production which is managed and operated by a family and predominantly reliant on family labor, both women and men. The family and the farm are linked, co-evolve and combine economic, environmental, reproductive, social and cultural functions"* (Garner and Campos, 2014). By way of explanation, the family farm often emphasizes the role of family labor in managing the farm operations. In other words, a family farm composes a people group who individually provides the management, labor, capital and other inputs for the production, and who consumes a part of the farm produce. The linkages between agricultural objectives and economic, environmental, reproduction, social and cultural functions of the family farm, therefore, are into consideration.

- **Cropping systems**

There are various definitions of cropping systems and interactions with farming resources such as land, labor and capital. A cropping system may be defined as a community of plants cultivated in order to achieve numerous human goals (Pearson, Norman and Dixon, 1995). In addition, a cropping system may be characterized by identifying the factors in cropping system assessments (such as plants, land and management); the choice of the performance evaluation (such as yield, ecosystem services); and the factors influencing these outputs (such as rotational effects, price, and climate changes) (Eckersten, 2017). Meanwhile, to Peeters (2015), a cropping system takes place on a plot or a series of plots, including several crops that related to techniques and practices. At the plot level, the cropping system is a subsystem of a farming system together with a livestock raising system (Fresco and Westphal, 1988; Noe, 1988). The cropping system is a land, which includes various components such as soil, weed, crop, pathogen and insect subsystems that transfers solar energy, water, nutrients and labor and other inputs into food and feed.

- **Perennial crops**

As compared to annual crops which provide only one harvest, perennial crops can be harvested multiple times before they die. A wide range of perennial crops are planted for food security (perennial wheat and rice), nutrient supplies, commercial and exporting purposes such as coffee, pepper, rubber, tea and cacao; food and biofuels as sugarcane and for decoration like roses (Crews, 2005; Herzog and Gotsch, 1998; Tregeagle, 2017; Wade, 2013). The perennial crops have a great variance in lifespan. They can produce a crop after three years, as is the case for coffee, pepper, cacao, strawberries.

2.1.2. Classification of cropping systems

Cropping systems describe types and sequences of crops, growing over space and time. In order to maximize crop yields, cropping systems take into consideration the structure of social, economic, ecological and environmental concerns. Thus, cropping systems are highlighted when considering, the conservation of soil, water and sustainability of crop production as well as the spread of households' income (Blanco-Canqui and Lal, 2008; Nafziger, 2009; Schroth and Ruf, 2014). With regard to the negative impacts of land degradation and soil erosion, crop diversification underscores the vital importance of the sustainable development of agricultural systems. Interestingly, cropping systems include monoculture and multiple culture, of which multiple cropping systems principally consist of three subsystems intercropping, segregated cropping and sequential cropping (Devendra and Thomas, 2002).

2.1.2.1. Monoculture systems

This is a general cropping system which applies to the same crop grown in the same field on a continuous basis. In large scale or industrialized farming, this system seems to be more popular due to making planting and harvesting easier. However, mono-cropping systems create a degradation of agricultural land and reduce fertility, biological diversity and crop yields as compared to diversified crops. Additionally, monoculture is defined as having a single crop with no diversity, cultured by intensive practices which leads to concerns about relying on the use of a massive amount of

chemical nutrients (Picture 2.1- Pur Projet, 2016). Meanwhile, the driving forces for agriculture today are to increase soil fertility, decrease input materials, and protect crops against pests and weeds as well as to ensure adequate crop productivity.

Picture 2.1: A coffee mono-cropping system with shade trees

Source: (Pur Projet 2016)

There is plenty of evidence that mono-cropping systems have advantages and disadvantages (Blanco-Canqui and Lal, 2008; Gaba et al., 2015; Schroth and Ruf ,2014).

- **Advantages**

Care and harvest activities are simple

Harvesting time is short

Reduction of farm equipment cost
Generation of large harvests
A specific crop is specialized

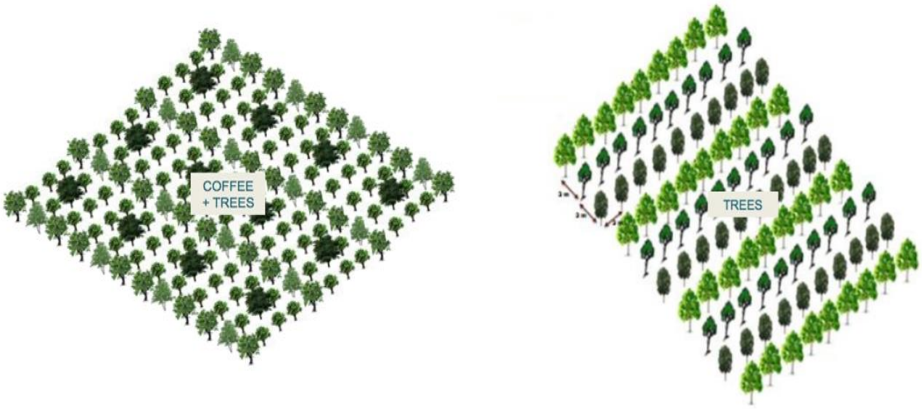
- **Disadvantages**

Cause environmental degradation
Biodiversity declines
Crop yields decrease
Use of inorganic fertilizer and pesticides increases
Soil resilience reduces
Pest and disease infestation increase

2.1.2.2. Multiple cropping systems

This system can produce crops at the same time in the same space. In other words, multiple cropping systems comprise two or more crops or species with a spatial and temporal association. Multiple systems are popular among small farmers in developing countries. In multiple cropping systems, a variety of crops are designed and managed to drive crop production and reduce environmental impact. Overall, multiple crop systems are greater reliability of return, more income stability and profitable than single-crop systems (Andrews and Kassam, 1976, Ho et al., 2017; Phan et al., 2019a, Phan et al., 2019b). In addition, multiple cropping systems are drivers for providing multiple ecosystems services and gains in production (Gaba et al., 2015; Zuo et al., 2014).

The advantages and disadvantages in terms of biological, physical and socio-economic factors are summarized by many authors (Andrews and Kassam, 1976; Blanco-Canqui and Lal, 2008; Lithourgidis et al., 2011; Palaniappan, 1996; Schroth and Ruf, 2014).



Picture 2.2: Multiple cropping systems

Source: (Pur Projet 2016)

- **Advantages**

Create diversified farm products from a small plot
Reduce risk on total crop loss due to adverse climate, diseases or market
Stagger crops plantation in different seasons
Allocate resources thanks to stagger of harvesting time
Reduce soil erosion and environmental degradation
Reduce water evaporation and increasing microbial activity in the soil
Better use of time because of more crops per unit time in the same area
Promote a return to the land and its maintenance
Increase farmers' revenues and income
Move forward, mixed planting system stabilized income and reducing risk
Reduce unpredictable environment or economic pressures
Avoid the variability in prices, climate, and pests and diseases
Spread over a longer period for harvesting

- **Disadvantages**

Competition between plants for light, soil nutrients and water
Harvesting of this crop may destroy the other crops
Leaves, branches from taller elements in a mixed crop system can destroy shorter ones
It is complex for statistical designs on experimental research
The yield of each crop can be lower as compared to monocultures
Some systems require more manual labor
It creates constraints for farmers who have limited economic resources
There is a technical and scientific shortage to manage multiple cropping systems
Lack of knowledge and experience by decision-makers

- **The classification of multiple cropping systems**

Multiple cropping systems can be categorized into three types by summarizing into integrated several species or plants simultaneously in the same area, sequentially in the crop sequence or in the surrounding area. The decision on choosing appropriate cropping systems depends on the importance of socio-economic conditions, human labor and capital resources and access to inputs.

- **Intercropping systems or synchronization**

Following Asten et al., (2011); Rana and Rana, (2011), a system in which crops use the same resources such as soil, nutrient and water, is known as synchronization or an intercropping system. It means a cropping system is called an intercropping system when crops are grown simultaneously. In this, farmers try to provide a favourable environment for all the crops, exploit a positive interaction among them and minimize competition between components. Management practices include land preparation, selection of varieties, fertilizer application, irrigation, weed management, pest and disease control. Additionally, Huang et al., (2019) defined an intercropping system to be an ancient multiple-cropping system that is practised widely among small farmers in developing countries. According to Andrews and Kassam, (1976), intercropping is growing two or more crops concurrently on the same field yearly. Consequently, intercropping systems can include mixed intercropping, row intercropping, strip intercropping and relay intercropping. Furthermore, Gaba et al., (2015) reported on the provision of annual harvest in intercropping systems for which crops were grown simultaneously. The cultivars or plants are mixed or arranged in alternative rows or in strips, where the number of plant species or cultivars can vary. Likewise, Gebru, (2015) also presented the advantages of intercropping systems over mono-cropping systems. Intercropping benefits are increased variety in yield, productivity gains, economic returns, yield stability, social benefits, more efficient used of on-farm resources, pest control and efficient use of fertilizers.

- **Sequential cropping systems or Double cropping**

This refers to growing two or more crops in sequence on the same field per year, to be managed only one crop at a time by farmers. Sequential cropping comprises double cropping, triple cropping and quadruple cropping (Andrews and Kassam, 1976). In parallel, Gaba et al. (2015) called crops which are cultivated in crop sequences relay or sequential cropping systems, with the meaning the crops do not grow together.

- **Segregated cropping or Relay cropping system**

This system is the integration of separated crops, in which crops are planted in independent plots of land (Solís, Bravo- Ureta, and Quiroga, 2009). For example, coffee is cropped alongside some diversified subsistence crops like rice and maize. These authors indicate that plants can be surrounded by a collection of plants having a specific role (Doutriaux, Geisler and Shively, 2008; Ho et al., 2017; Chau, 2007).

2.1.3. Characteristics of cropping systems

A cropping system is a significant component of the farming system, apart from the livestock raising system. For example, perennial crops farm is one of the elements of the cash crop system (FAO, 2019). That is to say, the cropping system is a pattern of farm operations, in which these components interact with farm resources. The main

purposes of cropping systems are for fuel, subsistence and cash earnings. Interestingly, cropping systems establish the relationships among crops, pests, farming practices and all technical management (Noe, 1988). Furthermore, Nafziger, (2009) argued that the cropping system displays the crops, crop sequences and the technical management used on a particular field over a period of years. A cropping system comprises all cropping sequences practised over space and time to be based on the available technologies of crop production (Blanco-Canqui and Lal, 2008).

- **Characteristics of perennial crops and perennial cropping systems**

- Perennial crops have long-term investment and long maturation times. They're not productive economically in the early years of their lives (pre-productive period).
- The pre-productive period varies by type and location of the trees. Often, permanent crops can take from three to seven years after they are planted before they begin to produce a commercially harvested crop. For the perennial crops coffee and pepper, the commercial period is from when trees are 4-years-old to when they are 25- years-old.
- Extended yield period of productivity but steady decreases in productivity.
- Replacement necessary after the final production cycle. This is a consequence of the age-yield relationship. The three phases, or periods include the establishment phase or basis period (the yield rise weakly), the peak period (the constant and maximal yield), and the senescence periods (gradually declining yield gradually) (Devadoss and Luckstead, 2010; French and Matthews, 1971; Mitra, Ray and Roy, 1991).

Perennial crops seem to suffer significant effects of climate change and farmers have difficulty in switching quickly to crops due to high upfront capital costs (Gunathilaka et al., 2018).

- **The role of perennial crops**

Perennial crops provide a variety of important values for humanity including food, like fruits, tree nuts, providing fuel, supplying agronomic benefits, ecological and environmental services, and supporting cultural value (Berry, Arnoni, and Aviram, 2011; Jerry, 2003; Glover et al., 2010; Meyfroidt, Vu and Hoang, 2013; Vossen, 2007).

- **Perennial cropping systems (agroforestry systems)**

These are agroforestry systems which involve productive land use and conserve the best conditions for physical, chemical and biological properties, such as cacao, coffee, rubber and pepper (Arévalo-Gardini et al., 2020; Gomes et al., 2020). Perennial crop systems (as agroforestry systems) are a complicated interconnection of agricultural and forestry elements that can be classified in terms of their components, spatial and temporal settlement, agro-ecological zone and socio-economic aspects (McAdam et al., 2009).

- **The intercropping of annual crops and perennial crops**

Annual crops play a major role in the world's food demands. For example, annual grain crops occupied accounted for about 70% of the world's cropland which provided for around 80% of growing and malnourished world's population, with crops such as maize and cassava (Pimentel et al., 2012). Additionally, annual crops like green beans, soil bean and peanuts also reduce soil erosion and have the potential to add soil. This is why, instead of monoculture, annual crops are often intercropped with perennial crops to take advantages of well-developed eco-agricultural techniques

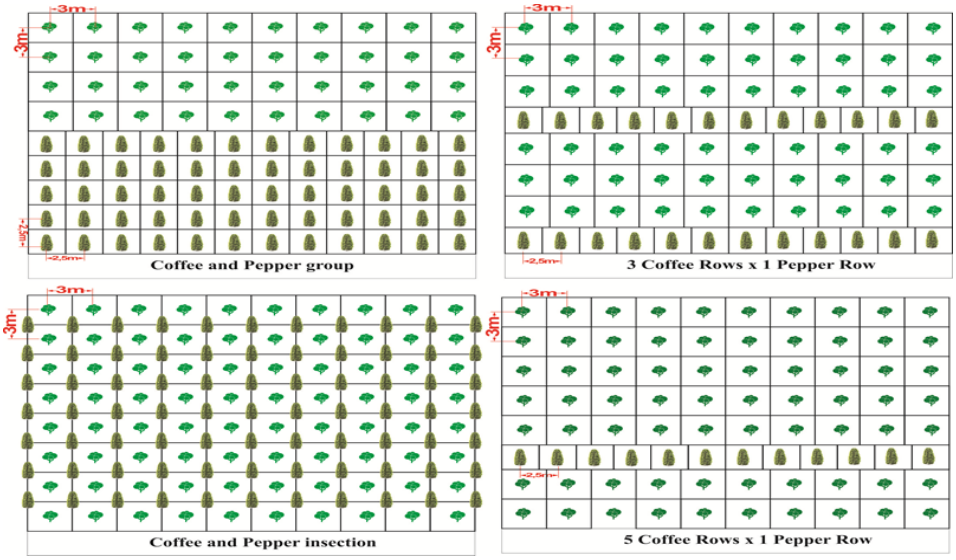
which have potential environmental benefits and agricultural sustainability (Wu and Wu, 2014). In term of real date, annual crops of food, spices or medicine which are intercropped with perennial crops can reduce runoff by 34-89% and decrease soil erosion by 45-94 %. This leads to higher income and may be suitable as a mitigation strategy to cope with the effects of climatic changes (Salah, 2008).

- **The characteristics of coffee and pepper production**

Coffee and pepper crops have long-life cycles, often over 25 years. As with other crops, these lifespans maybe divided into two stages. The first stage is maturation period (three years). During this time, there is a large cost required to establish the crop at a time when yields are low or non-existent. Cost and technical skills play an important role in assuring adequate yield and economic performance for the next years. The second stage is harvesting or economics period. In this period, crops grow steadily and there is a need for the farmers to undertake various critical activities such as pruning, and watering, in order to keep the plants growing according to desired parameters. Material costs are also a major component during this period. The fruit of coffee and pepper trees is harvested once per year, primarily by manual labor, leading to a high demand for labor in the harvest season. After harvest, the products have to be processed and dried. Processing is extremely important to ensure product quality. Finally, according to agricultural experts, these trees need to be rejuvenated or replaced after 25 years because as they age, their yields deteriorate significantly (Scherr et al., 2015). Coffee and pepper can be planted by monocultures, intercropping or diversification.

- **Coffee and pepper intercropping system**

Pursuant to empirical evidence, coffee and pepper can be intercropped via intercropping systems, generating high profit thanks to the presence of economics scope. For example, a coffee orchard with a spacing of 5 × 5 m/6 × 6 m or 8 × 8/9 × 9 meters, respectively, intercrops with pepper in India (Tejaswi et al., 2010). With respect to Vietnam, the recommendation is that intercropping should utilize around 100 pepper trees in the coffee garden as shade trees. Furthermore, coffee and pepper are also grown with the density of 3x 6 m (555 crops per hectare) and 3 × 9 m (370 crops per hectare), respectively. A farmer can also plant 500 coffee and 500 pepper crops per hectare by intercropping of one coffee row and one pepper row (Nguyen, 2010). Furthermore, coffee and pepper intercropping systems also follow two methods including intersection and group (Phan et al., 2019a, Nguyen and Phan, 2017). Meanwhile, Phan et al., (2019b) elaborated some ways of coffee and pepper intercropping in Dak Lak province.



Picture 2.3: Coffee and pepper intercropping

Source: (Phan et al., 2019b)

2.1.4. Evolution of cropping systems

Before discussing the evolution of cropping systems, we should first consider the evolution of agricultural systems. As Klerkx et al., (2012), point out, the evolutionary process of agriculture reflects agricultural innovation arising from combined technological, social, economic and institutional changes. Besides these, several additional factors such as policy, legislation, infrastructure, funding and market developments play an important role (Klerkx, Van Mierlo and Leeuwis, 2012). The growth of the agricultural system should have new technical application and alternative ways of organizing such as reorganizing markets, labor, land tenure and profit distribution. Finally, reference to the evolution of farming systems, it's argued that this can be the result of increased population pressure, higher use of inputs and/or exhaustion of local resources (Schiere et al., 1999). Similarly, cropping systems can evolve over time as does a group of increasing energy inputs, decreasing biological diversity and increasing risk or instability (Pearson et al., 1995).

Meanwhile, Su et al., (2016) revealed that cash cropping associates with the social and natural environment and is affected by various factors. So, understanding the dynamics of cash crop plantations can provide critical input for land use policy. One author has shown that population growth is a prerequisite condition for agricultural development, which may be in part caused by immigration (Boserup, 1965). In addition, this author explained that the cultivated plot is moved to a new place when fertility is depleted. In order for a plot to become a more permanently cultivated, two strategies need to be considered, including increased mechanization or intensification, and diversification. Globally, the transition of agriculture is the result of climate change, agro-technology, socio-economic transformation, liberalization and globalization (Castilla et al., 2019; Galati et al., 2016; Hatfield and Walthall, 2014; Nguyen, 2017). Cropping systems

readily evolve across time and space (Darnhofer et al., 2010). In other words, these changes are required to move to another place or to develop new practices for different qualifications of human resources (FAO, 1997; Fresco and Westphal, 1988; Lebailly et al., 2015). Thus, if the major trends and trajectories of different farm types are accurately understood, appropriate strategies for natural resources protection and securing households' income ensure (Jayne et al., 2014). Identification of the evolution of cropping systems to support future research will also provide benefit to rural communities (Herridge et al., 2019). It should also be noted that family farming in agriculture is closely associated with and rooted in the geographically diverse history of the region. In other words, family farming is so varied in different regions and countries, that it is hard to characterize it in a simple and quantifiable way. For example, East Asian countries can be defined as smallholding agriculture, which is an adaptation to the high population density and scarce land resources. Consequently, under differing contextual settings, farmers develop their own range of solutions in order to maximize their output while treating nature with respect. In Asia and the Pacific region, households often practice different farming systems to adapt to distinct local conditions, marginal land conditions and climatic variability. Beside monoculture, diversification is also a farm strategy to manage production risks. According to the FAO, the evolution of a small farm is intrinsically linked to the process of economic development (FAO, 2015b). Therefore, farming systems can be significantly different between countries.

The stages in the evolution of a particular farming system are reflective of the differences in the stages of development between and across countries. Overall, throughout all evolutionary stages, producers are usually making decisions involving both risk and profits.

2.1.5. Assessment of socio-economic performance of cropping systems

Indicators for evaluation of the efficiency of cropping systems include Land Use Efficiency or Assessment of Land Use, which are used to present the available resource effectively such as Multiple Cropping Index (MCI), Area Diversity Index (DI), Cultivated Land Utilization Index (CLUI) and Crop Equivalent Yield (CEY) (Ray et al., 2005). However, these indexes only express biological sustainability in an area while cropping systems also need to be economically viable and profitable (Rana and Rana, 2011). In addition, an author expressed that economic performance is a major component of farm investment decisions and strategies (Quah and Mishan, 2007). An analysis of crop economics is required to provide a good comparison of different cropping systems. In particular, monetary profits need to be considered in order to have a better understanding of the economic justifiability. Accordingly, better indicators include gross returns, net returns, per day return, and benefit-cost ratio. Other authors have concluded that the profitable assessment of cropping systems is a means to accurately comprehend the attractiveness and contribution of crops to the development of production systems (Budidarsono, Kuncoro, and Tomich, 2000; Papendiek et al., 2016). With respect to perennial crops, economic assessments according to following (Barral et al., 2012; FAO, 2016a; McConnell and Dillon, 1997) have been proposed, in which input indicators need to be evaluated, including start-up cost and annual cost.

- **Establishment costs**

This costs items can be referred to as establishment expenses, preproduction cost or start-up costs. The start-up costs are those expenses incurring during the pre-production period which are related to establishing the crop farm before the commodities produced. In particular, these costs can be incurred for commodities that are produced or completely harvested within a single year as annual crops, or over several years as perennial crops. To obtain comparable cost and revenue estimates, start-up expenses need to be allocated to the year or years in which production takes places. All cost items include direct cost, indirect cost, land, labor and capital.

+ The first item is the land cost. In the study context, the land is owned by a family or has a contract with companies or enterprises. Therefore, the land cost is only preparation cost without land fees.

+ The next item is material inputs such as seeds or seedlings, fertilizers, pesticides, and other expenses.

+ The last item is labor cost, including paid and unpaid labor.

- **Annual costs** include intermediate costs, depreciation cost, labor cost and interest paid.

The first category is the intermediate costs (IC). These arer inputs which are used during the productive period. Normally, material inputs vary considerably with quantities of seeds, fertilizers, pesticides and fuel for irrigation. The costs depend on purchase prices from farm supply companies, government agencies or are supplied by the farm itself. Input costs are estimated by multiplying volumes of purchase input and unit prices (the prices inclusive all tariffs and taxes). In cases, inputs are held by producers, the price will follow the local market. If the input volumes or prices aren't available, they can be valued from farm expense records.

The second category is depreciation. The depreciation calculation relies on the replacement value. In the farming business, the depreciation costs include depreciation of plantations, fixed equipment and machinery (which depreciate according to their own service life) (Barkaszi et al., 2017; FAO, 2016a).

The third category is labor cost, including paid and un-paid labor. This is an essential cost in all agricultural activities in general, and cropping systems in particular. This cost comprises hired labor, family labor and exchange labor. Hired labor cost is the sum of all wages which are paid to employees in terms of salaries or payroll-related taxes or social contributions (health and security). This cost is computed by multiplying the number of workdays and unit wages paid. Regarding perennial crops, the requirements of highly skilled labor or management could play an important role in crop maintenance.

The fourth category is the interest payment. This is the amount of money paid for capital use. The interest rate is the price paid for the use of the money during a loan period.

- **Economic returns at the farm level**

Gross Product (Gross Output-GO)

Many literature reviews document the concept of gross output. It is generally defined as the production value of products or services. Clearly, GO is the full value of

commodities or services, which the farm business creates during a given year together with suitable allowance and other support payments (e.g. government funds). Accordingly, the valuation of output depends on the perspective of the producer, after consideration of the subsidies that have been added and the indirect taxes that have been subtracted (Ball et.al., 2016).

Net Farm Income (NFI)

NFI includes returns over cash and non-cash costs. For smallholders, NFI is primarily based on the returns over cash costs, representing the income available to the household at the end of the cropping or agricultural season with the non-cash cost being the potential income considered as unsold produce that the household consumed (Mechri, Lys and Cachia, 2017).

Profits

Profits are the rewards of production which remain for the operators of farms after reduction inputs, wages paid to hired labor, rent paid to landowners, interest paid on loans and depreciation from the value of sales. Profits reflect the changes in market prices and costs felt by producers that their decision to produce more or less in response. Furthermore, profits explain structural changes and provide the incentive for innovation, as reported by (Hill and Bradley, 2015).

Labor Requirement

The workforce involves demands for each system from all activities of perennial crop production. A number of workers is needed for crop activities, comprising land preparation, application of fertilizers, pesticides and herbicides, weed control, harvesting and post-harvesting activities.

Labor productivity is a measure of the per-unit labor that creates outputs, which is the income per labor unit (Hennessy et al., 2013; Latruffe et al., 2016). Moreover, in agriculture, labor productivity assesses the number of units of output (s) produced per unit of labor consumed in the production process. The quantity of labor can generate a higher output, creating growth in labor productivity. Moreover, there is a positive relationship between labor productivity and farm incomes. For instance, the labor constraints in terms of quantity and quality affect farm income and profits, especially seasonal labor during the entire cropping season (Mechri et al., 2017). The process of economic performance is shown in Figure 2.1.

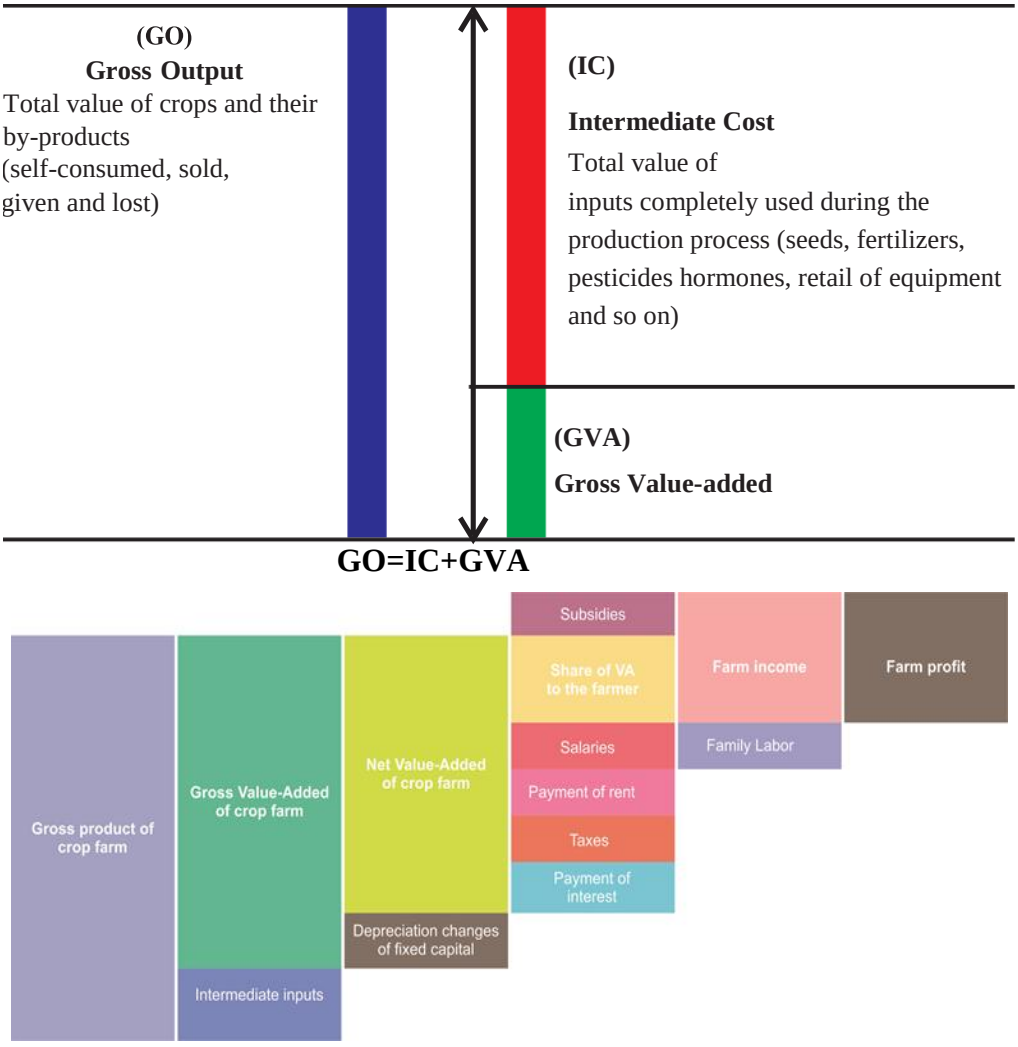


Figure 2.1: The distribution of economic indicators

Source: Adapted from (Diepart and Allaverdian, 2018; FAO, 2016a; Hill and Bradley, 2015)

- **Social considerations**

As the FAO has stated, the aim of social analysis is to make development interventions by considering local contexts with respect to livelihood, to secure the interests of an unempowered population. Furthermore, social analysis in agriculture is necessary to enhance the potential for agricultural growth, increase in farmers' assets, and help escape poverty and resilience to hardship. Social analysis is concerned with livelihoods, institutions, vulnerability, gender, poverty, stakeholders, and review (FAO, 2011). In addition, social sustainability relates to employment and livelihood stability in the local communities (Manara and Zabaniotou, 2014). Regarding quantitative indicators for social benefits, job positions per unit area and

employment creation are considered (Manara and Zabaniotou, 2014; Torres et al., 2016). In terms of cropping systems, extended seasonal employment for farmworkers and more salary also link to social benefits (Johnston et.al., 1995).

2.2. Determinants on farm's decision of adoption

Choosing different cropping systems can be considered as the adoption of technologies and reorganizations for which cropping-plan decisions have effects on annual and long-term productivity, the profitability of farms and dependence on multiple spatial and temporal factors (Dury, 2011). Furthermore, the decision-making process of tree planting relates to land use and the choice of crops to be grown (Nevo, Oad and Podmore, 1994). The aims are to allocate resources and use more assets efficiently. For this reason, the farm's adoption decisions are affected by various factors that are crucial to take into account crop production (Dury, 2011). Additionally, an understanding of these determinants has implications for policymakers when identifying the suitable strategies and trying to increase the efficiency of policies at the farm and community levels. A conceptual depiction of the farm's adoption decisions is shown in Figure 2.2.

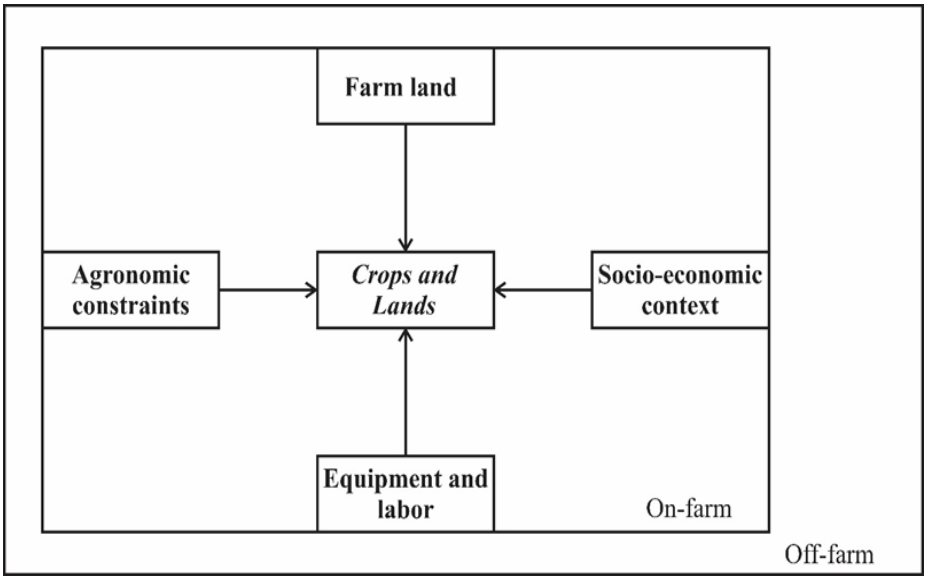


Figure 2.2: Conceptualization of the farm's decisions on crop planning

Source: (Dury, 2011)

Within an agricultural context, there are four categories of influences on crop choice. These are household characteristics (age, education, gender, attitude and personality), farm endowments (farm type, farm size and debt), social factors (agricultural extension staff, governmental culture, policy environment and impact of a range of institutions) and product features (Brotherton, 1989; Edwards-Jones, 2006; Mathijs, 2003; Vanslembrouck, Van Huylenbroeck and Verbeke, 2002). Concerning cropping systems such as new tree planting or applying diversified crop systems, adoption seems a decision, in which household characteristics, field endowment, biophysical elements,

social-institutional support and the perspective of farmers have significant impacts (Hoang et. al., 2017). Meanwhile, Ketteler (2018) has reported that physical factors (diseases, weather, growth cycle), economic determinants and socio-personal factors are also input into farmers' decisions. Furthermore, as Teklewold et al. (2013) have stated, the adoption of sustainable agricultural practices is influenced by the characteristics of plots, households and village. In addition, Meraner et al. (2015) affirmed that households, economic profiles and geographic characteristics are determinants of farm diversification. Another author has argued about adoption constraints which include environmental, technological, market price (sudden price fluctuation), policy factors (e.g. interest subsidies) and farmers' features (Trivedi, 1992). As mentioned, perennial crops require high start-up and annual costs to maintain their productivity as well as to have a long lifespan. Thus, adoption decisions that are implemented during production include crop diversification, crop establishment, soil conservation and management (Gunathilaka et al., 2018).

- **Household characteristics**

Theoretically, household characteristics are common determinants affecting tree-planting decisions on a system. These include age, gender, education, training, experience, other income and ethnicity. For example, previous studies have shown that the potential to shift from one cropping system to another correlates with the age of the operator (e.g. diversification or tree planting) (Hoang et al., 2017; Meraner et al., 2015). Interestingly, Su et al. (2016) found that female, old-aged labor or with low agricultural workforce intensity correlated with perennial crop plantations. In Vietnam, for example, cultures associated with ethnicities and minority ethnic people are admitted participating less in crop growing in Vietnam (Sikor and Baggio, 2014). Some authors have confirmed that education and training influence farmers' decisions to shift their cropping systems (Thanh and Yapwattanaphun, 2015; Phan et al., 2019a; Salam, Noguchi and Koike, 2000). In addition, income sources have a relationship with the adoption of different intercropped farm approaches (Phan et al. 2019b). In parallel, off-farm income source have an influence on the tree-planting choice (Salam, Noguchi and Koike 2000). Sall, Norman, and Featherstone (2000) also showed that knowledge impacts adoption decisions. Experience gives information and allows producers to appreciate the advantages and disadvantages in production (Sodjinou et.al., 2015).

- **Farm endowments**

Farm endowments are farming resources that assist management of farms related to land, capital and labor. As Dogliotti, Van Ittersum and Rossing, (2006) indicate, farm resource endowment significantly impacts on possibilities for sustainable development. Correspondingly, Hoang et al., (2017); Mottet et al., (2006); Nguyen et al., (2017) found that farm endowments played a substantial role in the decision-making of involving crops with these endowments including family labor, economic size and farm assets.

Family labor: Garner and Campos, (2014) stated that family labor is free and affects the decisions made regarding production. Family labor may have a negative or positive

effect on family farming systems. The more the work done by family labor on the farm, the higher the probability of diversification (around 0.4%) (Meraner et al., 2015).

Economic size can be measured by profitability. Trivedi, (1992) identified that earnings of plantations affects farmers' decisions on replanting or new planting. For instance, diversification boosts returns by approximately 0.2% as compared to others means (Meraner et al. 2015). Economic status also affects crop choice decisions relating to sustainable agricultural practices (Thanh and Yapwattanaphun, 2015; Verburg et al., 2004). Other, economic factors have been found to correlate with diversified farming systems (Bowman and Zilberman, 2013). When studying the determinants of profitability, many authors have suggested that price development, management, financial capacity, farm resource quality, farm operations and skills are general factors (Le et al., 2018; Lososová and Zdenek, 2014; Phan et al., 2020).

Farm assets include available assets in terms of water for irrigation, investment and basic machinery, which are defined according to the amount of money allocated to productive assets (Hoang et al., 2017). This is important, for example, when perennial crops might need a higher amount of water, especially in a dry season. This is consistent with Greig, (2009) with respect to choosing commercial or subsistence farms. Meanwhile, some studies argued that apart from capital, land – use rights (LUR) are considered as farm assets, for example in the Central Highlands of Vietnam (Muller and Zeller, 2002; Thai, 2018a).

- **Crop profiles**

The crop profile is one of the sub-categories of agronomy. It has an influence on the farm's decision of what crops or what systems will be practised. Moreover, factors such as crop losses and pests and diseases have a significant influence on farm adoption decisions (Meraner et al., 2015; Xiao et al., 2015). For example, crop failure can be an impetus to adopt other systems. Pest, altered crop yield and crop losses were reported to have significance on farm-level decision-making by Anim-Kwapong and Frimpong (2004). In the same way, land degradation can lead to crop replacement with a different crop (Schroth and Ruf, 2014). Pest and disease status as well as the age of trees have been discussed as determinants for farmers' decisions relating to the cropping system by Ketteler, (2018); and Phan et al., (2019b).

Table 2.1: The most important determinants of making decision on cropping systems at the farm level

Categories	Sub-categories	Determinants
Socio-economic context	*Households' characteristics*	Age Gender Education Ethnicity Training Other income Experience
Farm endowment	*Farm characteristics*	Family labor Economic size

Agronomy	*Crop profiles*	Assets Pest and disease status Crop failure Ageing of tree

2.3. Some emerging trends in cropping systems at the small-scale level in the world

As reported by the World Bank, the world will need about 70% - 100% more food by 2050 whilst population and consumption continues to increase (Godfray et al., 2010; World Bank, 2008). Meanwhile, the instability in climate and market prices will affect production. To meet this demand, crop intensification and diversification by increased resource-use efficiency will be obligatory, all the while taking into account the social implications, preserving biodiversity and reducing the environmental footprint (Bowman and Zilberman, 2013). Most developing countries are dependent on the agricultural sector. Therefore, in these countries, the role of agriculture will primarily focus on food production, employment, export earnings and labor replacement. Cash crop plantations have recently been expanding globally (Su et al., 2016). Cash crops support rural livelihoods and have an accelerating effect on the rate of economic growth. The contribution of cash crops to increased agricultural production adds to the income of rural households and sustainability.

Two of the five main household strategies involving cash crops, intensification of existing production patterns and diversification, enhance farm livelihoods and help eradicate poverty (FAO, 2011). In Vietnam, for instance, cash crops, especially the main export crops of coffee, rubber, black pepper and tea play a vital role in terms of farmers' welfare, rural income, agricultural employment and the rural economy (FAO, 2016).

2.3.1. Intensified cropping systems

According to FAO, (2011), intensification is one of the main five farm household strategies affecting livelihood improvement and alleviation of poverty. This focuses on the food, cash crops, livestock and other productive activities by increasing physical or financial productivity. In recent decades, most of the efforts to boost production and raise economic returns have been achieved by improving and developing modern agricultural materials such as new seed varieties, irrigation, as well as improvements in inorganic fertilizers and pesticides. Intensification of cropping systems as sustainable intensification (SI) principally refers to achieving more efficient use of productive materials, emphasizing technologies like high-tech precision agriculture, alternative irrigation and drying (in rice growing, for example) as well as efficient pest and nutrient management to decrease agrochemical inputs (Heaton et al., 2013; Sharma, 2015). SI helps farmers to become less dependent on external costs and creates various innovations that are farmer-centred for agro-ecological crop management (Adhikari et al., 2018). Sustainable crop production intensification (SCPI) assists in the designation of more sectors for the same area of land, reduces negative environmental impacts, conserves natural resources and

enhances healthy ecosystem services. In other words, SCPI is an eco-friendly approach to combine traditional knowledge of growers with modern technologies for small-scale producers (FAO, 2016b). In Asia, intensification of cropping systems by using technical innovation and climate-smart agriculture systems creates these enhancements in terms of crop phenology, production, water use, soil dynamic (Gaydon et al., 2017; Hochman et al., 2013; Ladha et al., 2009). This has been applied to cropping systems to manage climate risks in India (Hochman et al., 2017). In Vietnam, various authors have affirmed that sustainable crop production enhancement has had economic returns and has reduced environmental costs.

For instance, the climate-smart rice cropping systems have helped water (15-30%), reduced of methane emissions (50%) and maintains the flooding in rice paddies until 15 days after transplanting and flowering (Tivet and Boulakia, 2017). With respect to coffee, sustainability-certified coffee production increases economic benefits and reduces environmental harm. In this way, coffee farms can decrease negative aspects such as high use of fertilizer containing nitrogen and problems with water irrigation and pesticides by more than 50% while receiving the benefits. Moreover, more eco-efficiency is found in the sustainability certified farms in comparison to conventional farms (Ho et al., 2018).

2.3.2. Diversified cropping systems

Crop diversification as a mean addition to crop outputs under different situations. As FAO, crop diversification is defined as the changes in farm enterprise patterns in order to expand productivity, stabilizes smallholders' income and contributes to climate-smart agricultural pillars (FAO, 2018a). The addition or expansion of enterprises is relevant to diversification. Moreover, through crop diversification, farms can produce agronomic benefits in regards to pest management and soil quality. Feliciano (2019) points out, crop diversification is the best choice to reduce uncertainties in farmers' income by obtaining cost-efficient benefits. Crop diversification is considered to contribute to the Sustainable Development Goals of no poverty, gender equality and reduction of poor farmers' vulnerability to climate change.

In developing countries, a key livelihood strategy for rural households is income-source diversification. In achieving this, crop diversification is a central element of the broader income diversification strategy. Crop diversification is identified to promote climate change adaptation, positive impacts on the ecosystem and economic performance. Furthermore, crop diversification is a strategy to make farmers more resilient in general, which is one of five key principles for sustainability in food and agriculture (FAO, 2015a; Pelling, 2010). For example, macadamia crops intercropped with coffee have achieved higher yields and economic benefits in Brazil (Perdoná and Soratto, 2015). In Eastern and Southern Africa, the cropping system diversification has enhanced productivity and built great resilience. For instance, in Zambia, cropping systems diversification has improved productivity and adaptation to climate change (FAO, 2019).

Maggio, Sitko, and Ignaciuk, (2018) examine determinants of diversification from the policy perspective, those that encourage diversity in cropping systems and changes to

land use policy. These include the important influence of the private sector, output access, and proximity to public markets.

In humid tropics of Asia, for example, tree crop diversification is often chosen as the farmers' strategy to maintain the farmer's income stability by adding more lucrative crops (Schroth and Ruf, 2014). The Asia-Pacific Region has the largest number of family farms in the world, accounting for 74% of the world's family farmers. Yet, most of them (around 84%) are working in small plots of less than two hectares on average. Under the constraints of scarce resources, farmers attempt diverse strategies to maximize their output with respect to the environment. Farmers in India, Nepal, Bangladesh and China, for example, have adopted a scope economy by combining livestock, cash crops, market gardening and forestry (Ye and Pan 2016). Additionally, Papademetriou, (2001) demonstrated that multiple cropping systems are able to boost food production potential, by approximately 30 tons per year, an increase of the cropping intensity by 400–500 percent. In the Central Dry Zone of Myanmar, one researcher showed that the lack of crop diversity is exposed to market price fluctuations and the lack of balance between broadleaf and cereal crop results in pests, diseases and yield losses (Herridge et al., 2019). In Vietnam, crop diversification is a shock-coping strategy for rural households because of increasing returns to scale and reductions in the marginal utility of inputs for producing other crops (Nguyen, 2017).

3

Agricultural sector and perennial crops in Vietnam

This chapter presents an overview of agriculture and perennial crop systems in Vietnam to clarify its association with the research objectives.

The chapter is divided into three sections. The first section gives a snapshot of Vietnamese agriculture in terms of economic growth (GDP), export and employment. The second section presents the production and export status of the crop sector in Vietnam, focusing mainly on export commodities. In the third section, details regarding the introduction of perennial crops, mainly coffee and pepper are illustrated with respect to historical development, efficient production, export market, and challenges.

3.1. Vietnamese agriculture

The transformation from central planning towards market orientation, thanks to "Đổi Mới" policy in the mid-1980s, has played a central role in Vietnamese socio-economic successes. Over the past quarter-century, the Vietnamese economy made impressive achievements. For example, the Gross Domestic Product (GDP) jumped by 7.31% in 2018 compared with 2015-2017. During this time, there has been rising employment, poverty reduction, income improvement in both rural and urban areas and decreasing malnutrition. Sustainable growth increased by about 3–4% during the period 2013–2018 (GSO 2018). Agriculture has been a key contributor, comprising cultivation, aquaculture, livestock, and forestry production. This sector obtained the highest growth during the period 2015–2018, a growth of 3.76% in 2018. The crop and livestock sectors provided 0.36 per cent point of the growth rate of value-added and contributed about 30 billion USD to export turnover in the whole economy in 2018. A significant amount of the population (more than 60%) live in rural areas and depend heavily on the agricultural sector, accounting for over 47% national employment.

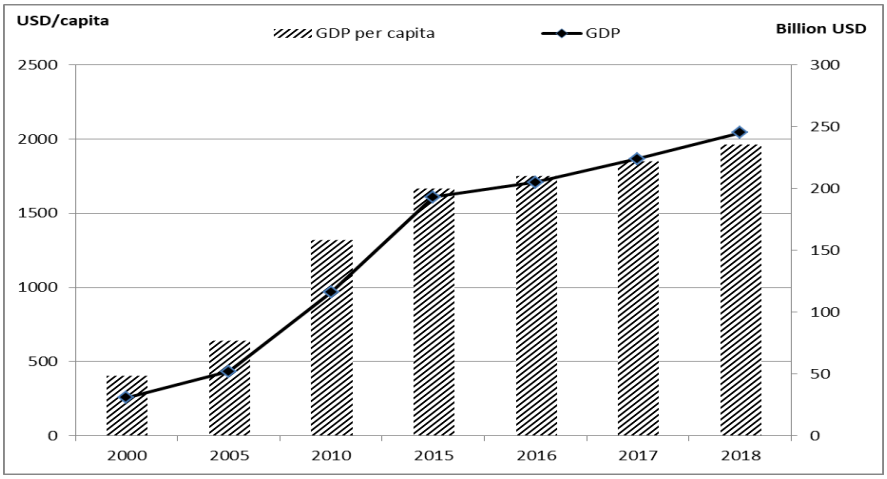


Figure 3.1: The share of agriculture GDP over period of 2000-2018

Source: (GSO, 2019b)

The export earnings of Vietnam's agroforestry and fishery was around 40 billion USD in 2018 exceeding the whole-year national plan and was higher than the previous years.

Interestingly, the GDP contribution of agro-industrial sector expects to increase by 51 billion USD from 2018 to 2020. Vietnamese government goal is to improve the sales value-added products in order to become a strong exporter in the world. Currently, the increase of cultivation, forestry and fishery products has been approximately 4% from 2012-2018. In which, the cultivated value moves up 3% and animal husbandry jumps up 4% in 2018 as compared with previous years (Figure 3.2). These results provide important insights about food security, alleviation of poverty, export earnings, employment and increasing the share of national GDP. Significantly, the country now ranks among the top five global exporters of coffee, cashew, rice and pepper.

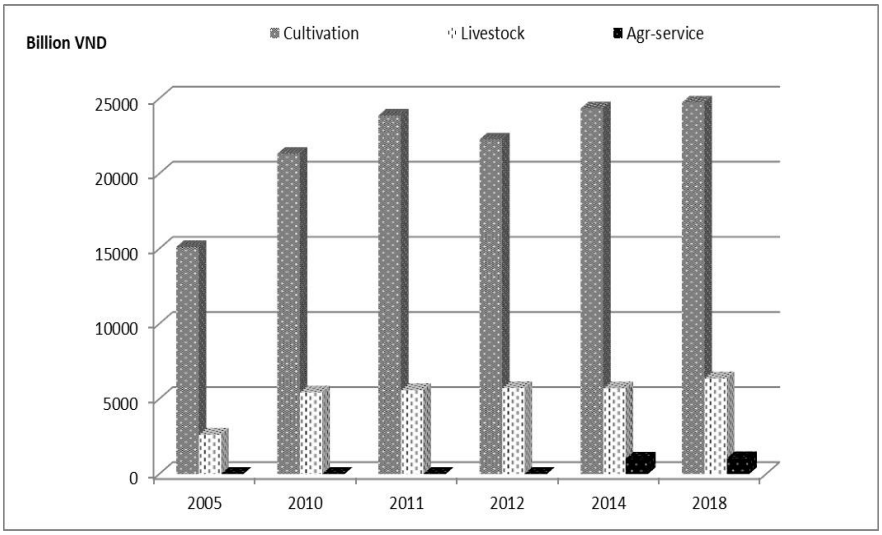


Figure 3.2: The contribution of GDP to the agriculture sector from 2005 to 2018

Source :(GSO, 2019b)

In this context, in order to advance agricultural growth, agricultural production will need to focus on more conservative measures, rather than on measures that are designed to increase the scale or capability of production. For example, although Vietnamese yields have been higher than other Asian countries, these successes have had negative effects on the environment, especially overexploitation of resources and overuse of chemical inputs. Therefore, agriculture needs to turn to new technologies or choose appropriate systems to maximize benefits, minimize input costs and increase demands. Multiple factors, as producers, stakeholders and government will need to simultaneously integrate all their efforts.

3.2. Crop sector

As previously stated, over the past decades, crop production has had a significant impact with regard to reducing hunger, increasing farmers' income and exporting earnings. Based on sustainable intensification (SI), most crops are produced to maximize productivity. However, due to many factors (such as reduction of the area and conversion of land use), the cultivated area and outputs of some crops have

experienced extensive fluctuation, such as that seen in rice, vegetables, annual crops (cassava, soya bean) and perennial crops (Table 3.1). Declining areas under rice paddy cultivation are an example. These covered 7 thousand ha and accounted for approximately 44 thousand tons in 2018, a decline of 257 ha and 1,200 tons compared to 2015, due to the changes of land use purposes and the changes in production structure. Similarly, the output of cassava was about 10 thousand tons in 2018, down 461 tons from 2015 because of decreasing cultivated areas (Table 3.1). On the other hand, a few perennial crops and fruit areas may have been able to respond to the global market. For instance, the planted coffee and pepper increased by 45 and 48 thousand ha in 2018 in comparison to 2017. Generally, though, crop production is faced with troubles and challenges from climate change (e.g. such as drought, saline intrusion), infectious pests, diseases, and environmental problems. Soil and water pollution caused by excessive fertilizer application and pesticide residues are an issue (Nguyen, 2017).

Table 3.1: The production situation of main crops in Vietnam

Unit: Thousand ha, tons

Crops	2015		2018		2018/2015 (%)	
	Area	Productivity	Area	Productivity	Area	Productivity
Paddy	7,827	45,179	7,570	43,979	97	97
Maize	1,150	5,230	1,039	4,905	90	94
Cassava	550	10,400	515	9,939	94	96
Soybean	100	146	53	81	53	55
Vegetables	890	15,303	961	17,093	108	112
Peanuts	200	448	186	459	93	102
Coffee	643	1453	688	1,626	107	112
Pepper	102	177	150	225	146	146
Rubber	985	1,012	965	1,141	98	113
Cashew	290	352	301	260	104	74
Tea	134	1013	123	987	93	97
Sugarcane	284	18,322	296	17,836	95	97
Fruit trees	827	-	950	-	114	-

Source:(GSO, 2019b)

With over 65% of the total population living in rural areas which depend on agriculture, exports have a critical role in maintaining and developing domestic products, and providing for market expansion. They give stable value to the national economy in general, and household livelihood in particular.

These products are the major export commodities, occupying nearly 25% of Vietnam's total export value, with rice, maize and coffee begin the main products. In particular, rice, which could be said to be emblematic of Vietnam, is the most essential staple food, and contributes to approximately 20% of total agricultural exports (over

3.5 billion USD) (GSO, 2019b). Cassava, the second most important food crop after rice, is a primary source of feed for Vietnam's livestock (nearly 1.9 billion tons). Meanwhile, coffee has played an extraordinary role in its contribution to perennial crop products, and has become one of the major agricultural export products, contributing 3.3 billion USD to export earnings in 2018 (Figure 3.3). Coffee export has contributed considerably to the economic growth of Vietnam, the reduction of trade deficits, and has helped with the alleviation of problem of poverty (ICC, 2019).

There are currently eight product items which constitute the major exports including vegetables, cashew, coffee, tea, rubber, rice, cassava and pepper.

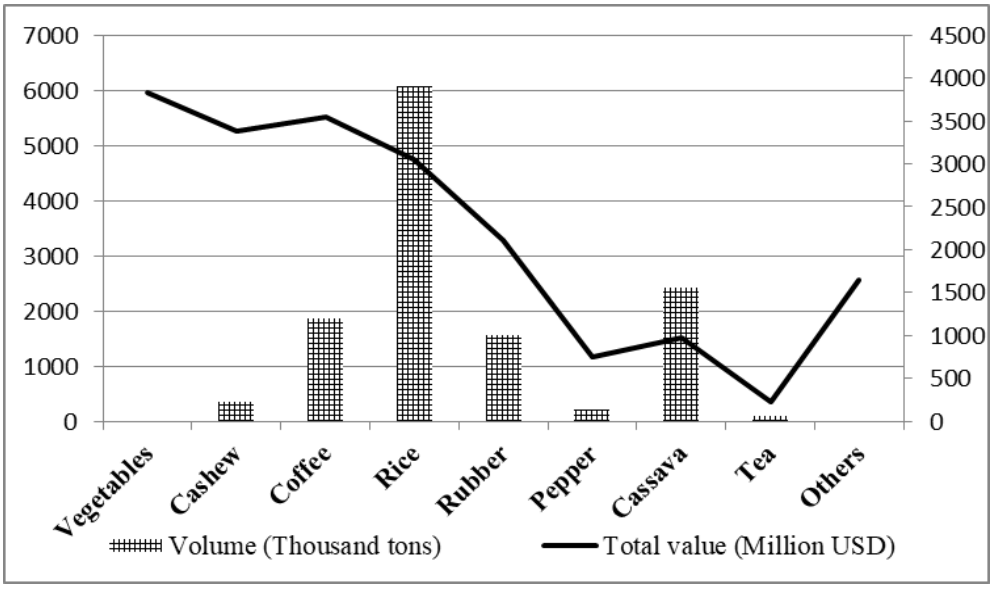


Figure 3.3: The export contribution of Vietnamese main products in 2018

Source: (GSO, 2019b)

3.3. Perennial crops sector in Vietnam

As previously stated, perennial crops are a major contributor to agriculture in Vietnam. According to statistical data, these planted areas reached over 2.2 million ha and produced around 4 million tons in 2018. For example, harvested coffee areas accounted for nearly 600 thousand ha (equalling over 85% of the national area), located largely in the Central Highland areas such as Dak Lak (190,000 ha), Lam Dong (162,000 ha), Dak Nong (135,000 ha), Gia Lai (82,000 ha) and Kon Tum (13,500 ha). Around 90% of this is accounted for by the Robusta variety thanks to suitable conditions while Arabica accounts for only 40,000 ha. Since 2013, the coffee yield per ha has decreased steadily because of the increasing age of coffee tree stock, heavy rain and drought. Regarding rubber, it has occupied the highest area under cultivation compared to other crops, accounting for about one million ha in 2018, concentrated mainly in the Southeast and Central Highlands. Nonetheless, due to falling prices and

climate change, the area and output have gone down considerably since 2015 (Figure 3.4 and 3.5). Cashew and pepper grown by many households occupied a smaller proportion of the total perennial crop area.

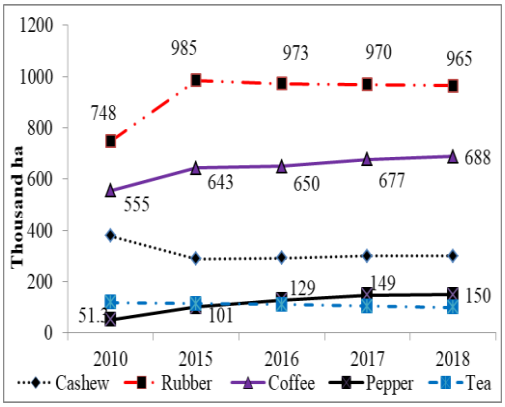


Figure 3.4: The area of perennial crops in Vietnam during 2010-2018

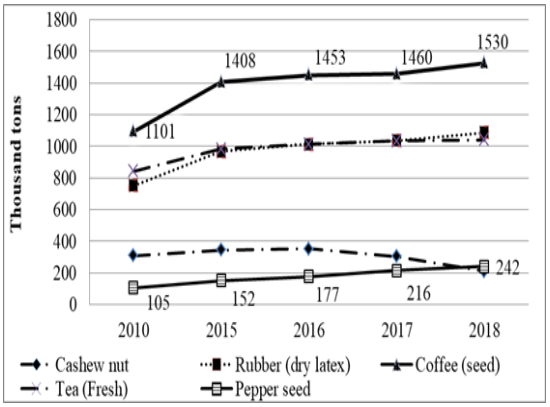


Figure 3.5: The output of perennial crops in Vietnam during 2010-2018

Source: (GSO, 2019b)

In terms of marketing, according to MARD, the Vietnamese Ministry of Agriculture and Rural Development, the 2018 context was very unstable, specifically in the context of the ongoing US-China trade war. The agricultural world market subsequently recorded a profound decline in export prices, more in line with 2017 values, a result of fierce competition among exporters. Despite this difficult situation, these products still found a market in various destinations, including China, the EU, the US, Korea, and Japan. In particular, a majority of coffee is exported to the Asian market from Vietnam, accounting for around 55% of the value. Vietnamese commodities like coffee, rubber and cashew are also transported to other countries such as North America and the EU (Figure 3.6). For example, Vietnamese coffee is exported to 80 countries and territories around the world and estimated to total 3.5 billion USD of export turnover (about 14% of the global market share and 10.4% of exported coffee value) in 2018. According to statistical data, Vietnam's rubber exports increased in both volume and value in 2018, compared with the data from 2017, with China being the main destination. In terms of cashew exports, Vietnam reached nearly 3.5 thousand tons, worth over 3.3 billion USD in 2018, up about 5% in volume but down over 3% in value compared to 2017 due to the decline of the export price (Table 3.2).

Table 3.2: Vietnam's perennial crop export

Unit: Thousand tons, Billion USD

	2017		2018	
	Quantity	Value	Quantity	Value
Cashew nut	353	3,516	373	3,366
Coffee	1,566	3,500	1,878	3,537
Tea	149	233	127	218
Pepper	215	1,118	233	759
Rubber	1,381	2,250	1,564	2,092

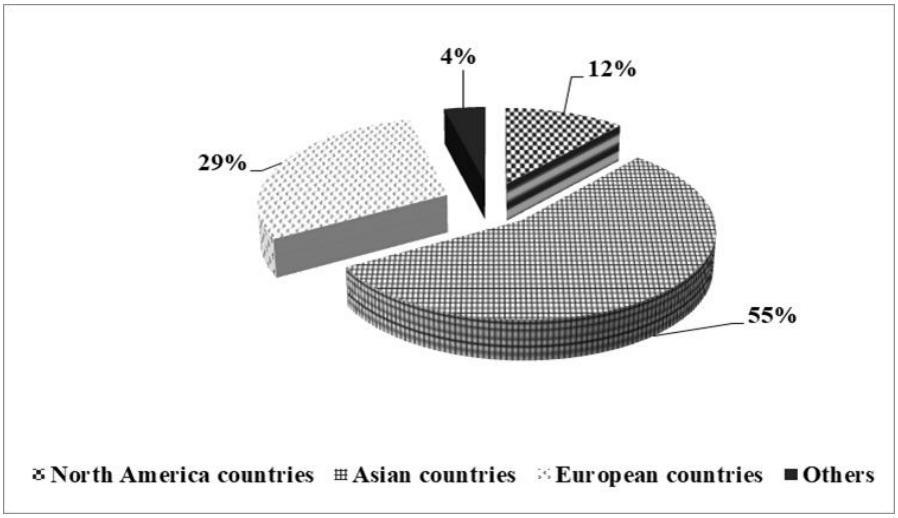


Figure 3.6: The shares of perennial crop commodities by international markets in 2018

Source: (GSO, 2019b)

3.3.1. Coffee sector

3.3.1.1. Historical production of coffee

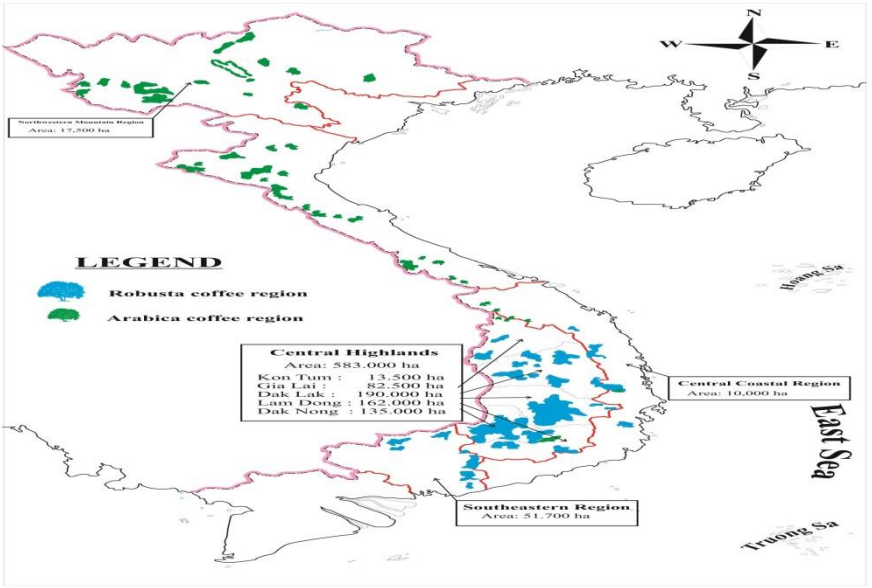
Thanks to its location in the tropical and subtropical climate region and having a large area of well-draining basaltic soil, Vietnam is suitable for coffee growing. Initially, coffee was tested in Northern provinces such as Ninh Binh, Thanh Hoa, and Nghe An. Later, coffee was moved to Southern provinces and the Central Highlands. In the 1900s, the Robusta coffee variety (*Coffea canephora*) was introduced in the Central Highlands. From that date, the coffee-growing has expanded significantly nationwide. Yet, for a long time, due to a lack of development in farming, such as farm practices of dependence on natural resources and poor quality seed, the output was still

low. For example, in 1986, the total coffee area was 50 thousand ha while the output only reached around 16 thousand tons.

This sector developed and evolved dramatically after Vietnam's Renovation policy (*Đổi Mới*), aiming to become a key agricultural commodity with the assistance of government subsidies. In the end, the Central Highlands became known as the main coffee region, where coffee production expanded widely. Besides state-owned farms, private coffee farms were also a part of the dramatic expansion. Consequently, at the present day, the Vietnamese coffee sector has greatly expanded in terms of area, productivity and export earnings. Currently, Vietnam has become the leading exporter in Southeast Asia and the second-largest producer in the world, after Brazil. For instance, the coffee cultivated areas accounted for 688,000 ha in 2018, with the average nationwide coffee yield being around 2.18 tons per hectare. The Vietnamese government is implementing policies to stabilize the area by assisting with reducing input costs, enhancing quality and creating sustainability. In the future, the aim will be to focus on the reduction of coffee cultivation in the unsuitable regions, rejuvenation of old coffee farms and conversion into other crops, to raise efficiency and application of technology.

3.3.1.2. The distribution of coffee zones in Vietnam

As indicated above, the coffee cultivation has evolved to grow mainly in the Central Highlands, the Southeast region, the Northern Midland, Mountainous regions and the North Central Regions. In 2020, the predicted area is estimated to be about 60,000 ha of Arabica and 440,000 ha of Robusta. The distribution of coffee zones is shown in Picture 3.1.



Picture 3.1: The coffee zones of Vietnam in 2018

Source : (Author adapted from ICC, 2019)

3.3.1.3. The performance of coffee production

As previously stated, Vietnam's coffee sector has focused on Robusta varieties, which are lower in production costs, higher in productivity and higher in the resistance to pests and diseases compared to the Arabica varieties. Interestingly, Vietnam's average coffee yield is higher than the global average thanks to favourable weather. Moreover, coffee output in 2018 increased by 49,000 tons in comparison to that of 2017, probably due to increasing the area under cultivation (Table 3.3). Climate change and conversion to more lucrative crops have recently influenced coffee output, in addition to the fact that falling coffee prices also have a discouraging effect on farmers on looking after their plantations, probably leading to a lowering effect on the bean's quality.

To solidify the country's global market position, a government decision which proposes supporting policies, known as Decision No. 4653/QD/BNN-KNN has been initiated. This is designed to improve high-quality coffee products through the years 2018–2023, with a vision towards 2030. In other words, the decision highlights the aim for increased yields. Consequently, there has been rising quality and added value of coffee products nationwide until 2020, with priority to regions such as Central Highlands, North Central region, Midlands and Mountainous areas. Initiatives are being implemented to enhance high-quality commercial coffee-growing areas, improve the processing, storage and preservation facilities and promote linkages between farmers and businesses.

Table 3.3 : Vietnam's Robusta coffee output

Items	2010	2015	2016	2017	2018
Total harvested area (thousand ha)	511.9	593.8	597.6	617.1	626.2
Yield (tons per hectare)	2.2	2.4	2.4	2.6	2.6
Output (thousand tons)	1100.5	1453.0	1460.0	1577.2	1626.2

Source : (ICC, 2019)

The share of coffee in Vietnamese GDP

For many years, coffee has become one of Vietnam's economic sectors, contributing to the revenue of the national GDP generally and the agricultural sector specifically. For instance, coffee export value heated up from 34.2 in 2013 to 35 billion USD in 2018 (Table 3.4). However, the value in 2018 is to be lower than in 2017 because of a decreased price is a main factor.

Table 3.4 : The coffee share in Gross Domestic Product

Items	2013	2014	2015	2016	2017	2018
Agricultural share in GDP (Billion USD)	34.2	36.7	36.5	37.2	38.3	35
Coffee share in GDP (Billion USD)	4.1	3.5	4.0	4.7	4.8	3.5
Share of coffee /Agricultural GDP (%)	12.0	9.5	11.0	12.5	12.6	10.0

Source : (GSO, 2019b)

3.3.1.4. Export, market and commodity situation

Like many developing countries which produce coffee, Vietnam's coffee production accounts for a sizeable share of export earnings and contributes to the national economic growth by generating income and jobs as well as contributing to poverty alleviation. Since 2013, Vietnam has been the world's biggest Robusta producer. Unfortunately, fluctuation of the international coffee price and climate change have affected the turnover during the same period.

Despite the globally reduction in purchasing power and the world's economic difficulties, the coffee sector reached performance. For example, the volume and value of coffee accounted for about 1,400 thousand tons and 3 billion USD in 2018.

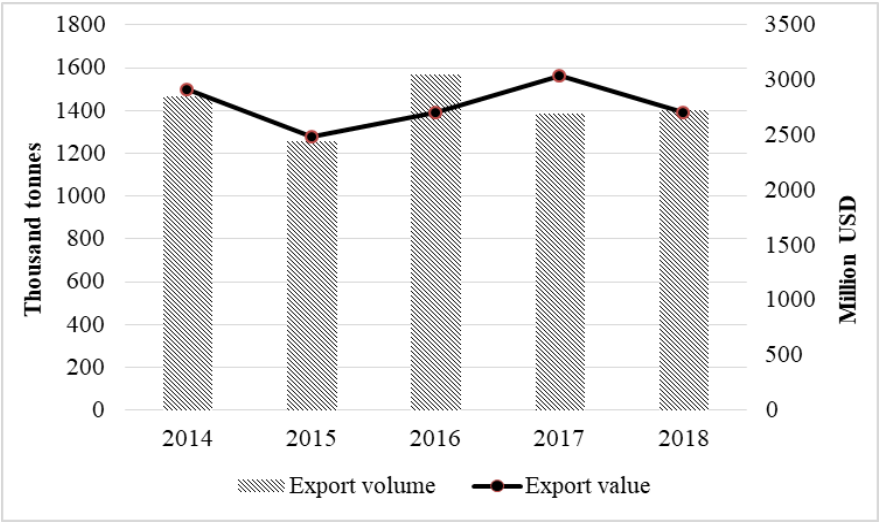


Figure 3.7 : Coffee export of Vietnam

Source : (ICC, 2019)

Experiencing over 150 years of cultivation and development, coffee production has held a major place within the exported agricultural products of Vietnam. Vietnam's coffee is now exported to various regions all over the world, such as Europe, The United States and Asia. In addition, Vietnamese instant coffee is now available in 70 countries and territories worldwide, totalling 1,490,000 tons and 2,880 million USD in 2018 (Figure 3.7). For instance, 165 thousand tons were delivered to the German market with a return of 305 million USD in 2018. Meanwhile, over 105 thousand tons were bought by the Japanese market with sales of reports 205 million USD (Table 3.5). The largest retail Walmart chain in Chile, Brazil, Mexico and China also sell Vietnamese coffee products. The more popular instant coffee brands which are favoured at home include such brands as Trung Nguyen, Vinacafe, and Me Trang (Picture 3.2). In recent years, exports to Asian destinations have increased dramatically, from 10% in 2017 to 20% in 2018 (ICC, 2019). Coffee commodities are mostly beans and instant coffee. However, economic competition between Vietnam and other countries has had a significant influence, resulting in various challenges for Vietnam's coffee industry. In the future, national programs will need to be considered to improve competitiveness and coffee quality.

Table 3.5 : Main importers of Vietnam's coffee in 2018

Country	Volume (Thousand tons)	%	Value (Million USD)	%
USA	170.0	11.4	315.0	10.9
Germany	165.0	11.1	305.0	10.6
Italia	140.0	9.4	270.0	9.4
Spain	115.0	7.7	220.0	7.6
Japan	105.0	7.0	215.0	7.5
Indonesia	67.0	4.5	120.0	4.2
India	55.0	3.7	100.0	3.5
France	31.0	2.1	54.0	1.9
Algeria	75.0	5.0	140.0	4.9
Philippenes	30.0	2.0	55.0	1.9
Russia	75.0	5.0	155.0	5.4
Others	462.0	31.0	931.0	32.3
Total	1490.0	100.0	2880.0	100.0

Source : (ICC, 2019)

Roast coffee Instant coffee

Picture 3.2 : The coffee commodity of Vietnam

3.3.1.5. Several challenges of coffee production in Vietnam

Vietnam would like to stabilize coffee cultivation at 600 thousand hectares and improve product quality instead of physical expansion. Vietnam's coffee-growing area has exceeded the Master Plan, accounting for 662,000 ha in 2018 (GSO, 2019b). Although Vietnam's coffee reached a high position in the world, coffee production has witnessed some troubles as:

- Climate change

Coffee production has experienced several disasters due to climate change. A tropical storm in 2007, heat and drought in 2013, are examples. Furthermore, rains from December 2015 to February 2016 reached only 40%, below the previous years, causing a

decrease in water level in the reservoir from 15% to 35% as compared to the average level. Moreover, the expectation is that droughts will increase in frequency and intensity, while the available water for irrigation will decline (FAO, 2016b). According to CIAT (International Center for Tropical Agriculture), rising temperatures and shortened rainy seasons could affect 50% of Vietnam's coffee area by 2050. Hot, dry weather also increases pests and diseases which contribute to crop losses (World Bank, 2011a). A more unfavourable environment will reduce land fertility and the amount of water for irrigating land used for coffee cultivation.

- Ageing coffee trees

Old coffee trees have difficulty in producing a maximum yield, and do not lead to a reduction in production costs. Statistics show that nearly a third of coffee trees are aged between 15 and 20 years. Around a quarter of trees are aged more than 20 years old, leading to concern about the challenges this may present to the coffee sector. At the same time, over 90% of farms belong to smallholders who are faced with a lack of finances for rejuvenation. Therefore, to facilitate coffee cultivation, the Vietnamese Government has specialized policies including subsidizing price of coffee nursery, agricultural irrigation, insurance, transportation and infrastructure.

- Excessive of agro-chemical fertilizer and inefficient use of irrigation

In order to reach maximum yields, there is excessive application of fertilizer and pesticides (Scherr et al., 2015). This not only quickly causes the exhaustion of coffee trees but also results in dramatic increase in polluted soil, pests, and diseases. In addition, inefficient use of water has been identified in a previous study (Amarasinghe et al., 2015).

- World competition and low prices

Although Vietnam has an advantage in being able to produce coffee, and despite attaining a high position of production in the world coffee sector, the capacity of its competitiveness is limited. Among the reasons are that if the quality of Vietnam's coffee is low, that can greatly influence the coffee export price. Additionally, hygiene practices and food safety are commonly inadequate due to the lack of awareness of the importance of food hygiene and the limited funds available to manage. Furthermore, poor distribution network and poor market penetration of Vietnamese coffee brands led to Vietnam coffee prices being lower than competitors such as Brazil, Indonesia, Honduras, Peru (Nguyen, 2016; ICC, 2019). According to Porter's Diamond, main factors affecting the competitiveness of Vietnam's export coffee are production factor conditions (natural conditions, capital, infrastructure), national conditions, related and supporting industries of coffee export, firm strategies, structure and rivalry; the role of the government (land policy, orientation and planning policy).

3.3.1.6. Trends in coffee production systems

Vietnam's coffee orchards are operated using two major systems including specialized and diversified systems. A specialized coffee system is a coffee system with only one crop. Nowadays, besides conventional farms, programmes for sustainable farming and certified-coffee production such as UTZ (UTZ certified), 4 C (Common Code for the Coffee Community), Viet GAP (Vietnamese Good Agricultural

Practices), RFA (Rainforest Alliance) and FLO (Fair Trade Labeling Organization) have been introduced widely to generate more efficiency (Ho et al., 2018). For instance, by the end of 2017, there were over 200 thousand ha of certified coffee grown, amounting to about 600,000 tons of green coffee (equallings 30% of coffee output nationwide).

However, these programmes have been applied for large-scale farms such as company-owned or state farms, but the reason why small farms have less motivation to grown certified coffee is less the guarantee of a better price from certified coffee production instead of improving yields. For example, having less motivation for small households, some countries such as Ethiopia is common (Mitiku, Nyssen and Maertens, 2018).

In reality, coffee households tend to diversify their farms through different methods. For diversified coffee systems, there are two main types of intercropping: (1) intercropping of coffee trees with other industrial crops such as pepper, cashew (called a synchronized system); (2) segregated systems (a system where different crops are planted in separated plots) (Ho et al., 2017; ICC, 2019). Moreover, these approaches are considered beneficial in that they create stable income for the coffee planters by diversifying products, creating more jobs, mitigating price risks in the global price crisis, and reducing water evaporation and soil erosion in a time of increasing climate change (ICC, 2019; Phan et al., 2019a). Up to now, Vietnam has over 100,000 ha of such diversified systems, of which over 30,000 of coffee-based intercropped systems are in Dak Lak Province. Additionally, the Vietnamese Government has already created a master plan to review and rezone the coffee area to raise the volume, and enhance product value, despite increase in volume with the physical expansion. In this plan, the replacement of old coffee trees with new varieties and facilitating a switch to other crops in regions is taken into account. Specifically, the Sustainable Coffee Development Plan up to 2020 and vision to 2030 was developed in 2014, setting out goals for coffee cultivation nationwide to be 600,000 hectares, goals for better pest and disease resistance and goals for creating new environmental and safety standards for material inputs such as fertilizers and pesticides. In parallel, MARD has consistently introduced high-yield, and high-quality Robusta coffee varieties, namely TR4, TR5, TR8, TR9, TR11, TR14, TR15 and TRS1, which yield from 4 to 7 tons per hectare and are resistant to coffee pests and diseases such as leaf rust and fungal disease.

3.3.2. Pepper sector

3.3.2.1. The historical development of pepper

In Vietnam, black pepper was stated initially cultivated in the 17th century. By the end of the 19th century, it was developed in a relatively large area in Phu Quoc, Hon Chong and Kien Giang Province by the Chinese people (Barat, 1952). At the beginning of the 20th century, pepper cultivation had been expanded into other provinces such as Ba Ria Vung Tau, Quang Tri, Quang Nam by the French. From 1940 to 1970, the pepper production reached around 400 ha and about 600 tons per year.

After 1975 Reunification, the global pepper price rose significantly, leading to its expansion into the Southeast, the Central Highlands and other regions, accounting for nearly 9,200 ha. After that, during the period from 1991 to 1995, the area cultivated

with pepper then notably declined due to the decreasing international price. From 2004, the price had recovered and increased sharply. Consequently, pepper areas amounted to about 52,500 ha in 2004, mainly in the Southeast region and the Central Highlands, of which Dak Lak ranked second highest nationally with over 11,000 ha (Nguyen, 2016). In recent years, however, pepper production has faced enormous risks due to plunging prices. Therefore, instead of expanding cultivation, Vietnam is trying to improve pepper quality and expand export markets to include places such as the EU, America and other countries.

3.3.2.2. Pepper zone in Vietnam

Presently, the Southeastern regions like Binh Phuoc, Dong Nai and Ba Ria Vung Tau and the Central Highlands provinces such as Dak Lak, Dak Nong, and Gia Lai are the main production areas. Figure 3.8 displays the percentages of areas devoted to pepper cultivation in some major provinces.

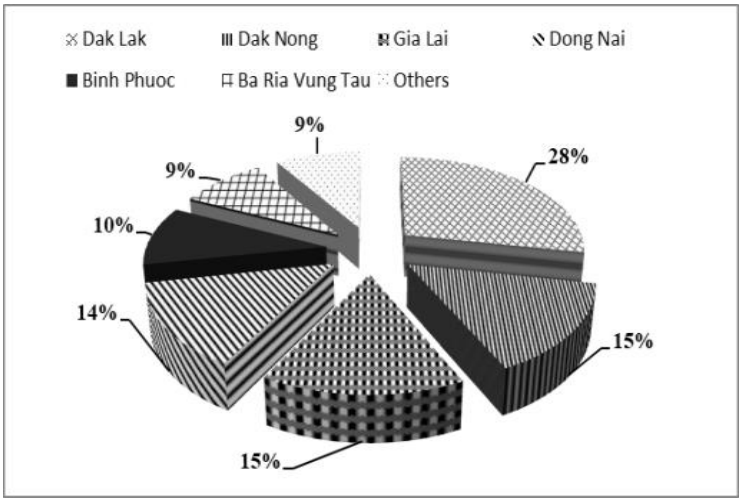


Figure 3.8: The share of pepper growing area by provinces in 2018

Source: (GSO, 2019a)

3.3.2.3. The performance of pepper production

Pepper is the most popular spice in the world, comprising about 34% of the total value of global spice production. Currently, pepper demand is rising thanks to commercial activities in the vibrant pepper market. Black pepper has become a very attractive spice thanks to its aroma, taste qualities and health benefits, and so it is often referred to as "black gold". It accounts for one-third of the international spice production (van Ruth et al. 2019). Pepper appears black because of the enzymatic oxidation of polyphenolic substrates which are contained in the pepper skin. White pepper, then, is produced from black pepper by taking away the outer skin (Nair, 2011).

Vietnam is one of the larger pepper exporting countries, in addition to Brazil, Indonesia and India. Remarkably, Vietnam's pepper accounts for 40% of total global pepper production, of which black pepper was estimated a major proportion with 89% of total production in 2018 (GSO, 2019b). The pepper sector is extremely

important for its contribution to Vietnam's agricultural sector. It has been a high economic value crop which has generated considerable profit and helped reduce poverty. From 2010 to 2018, the pepper cultivation area grew significantly, from 44,300 ha to 107,200 ha in 2018 (Table 3.6). This enhanced socio-economic conditions in some regions, notably for the ethnic minority community. However, since 2016, a rapid decrease in price has caused challenges and uncertainties for growers. According to the Vietnam Pepper Association, the application of pesticides on pepper has recently increased, resulting in fear of consumption, especially within international markets. In order to develop sustainability, more efforts with be required to address to farming and entrepreneurial issues, and the government will need to implement measures to increase the value of pepper products.

Table 3.6: Pepper production during 2013-2018

Indicator	2010	2015	2016	2017	2018
Total planted area (thousand ha)	44.3	67.8	81.8	93.5	107.2
Yield (tons per hectare)	2.4	2.6	2.6	2.7	2.4
Output (thousand tons)	105.4	176.8	216.4	252.6	255.4

Source: (GSO, 2019b)

3.3.2.4. The exporting and commodities

In the last three years, the pepper price has decreased, leading to declining value, although at the same time the volume of exports has increased. The decline in price can be explained by many reasons. For instance, from 2015-2018, there was an increase from 8-10% in supply but the demand jumped only 2% (Ministry of Industry and Trade, 2019). Moreover, the exported pepper turnover in 2017 reached 1,117 billion USD leading Vietnam to become the world biggest exporter. However, this figure recorded a sharp decline of 62% due to the global crisis in 2018 (Figure 3.9). In the domestic market, the pepper price dropped close to the value of the production cost, leading to difficulties that resulted in losses and difficulty paying debts for pepper growers.

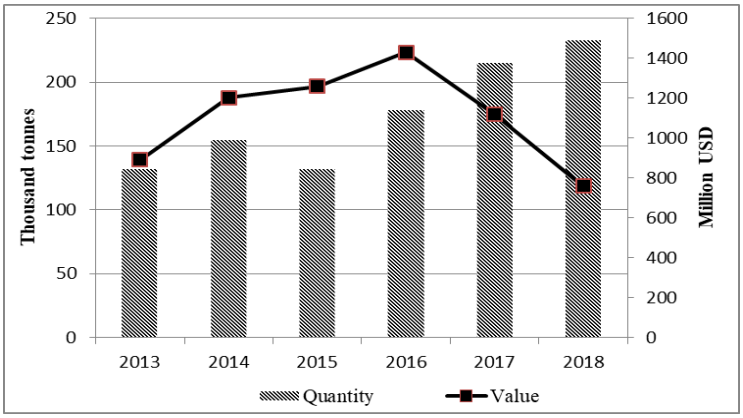


Figure 3.9: Export volume and value of pepper aspect

Source: (GSO, 2019b)

Besides the oversupply pressure and great competition from major producing countries such as Brazil and Indonesia, there has been a disturbing deterioration in terms of trade in general in Asia that has damaged profit. This deterioration in international trade has been happening over the long-term. Consequently, the Import-Export Department of the Ministry of Industry and Trade has forecast that Vietnam's pepper sector will face challenges in the coming years and it will be hard to return to the "golden age" of exporting pepper. Fortunately, the Vietnam-EU Free Trade Agreement (EVFTA) may provide a good opportunity for Vietnam's pepper industry to increase exports to EU countries. To take advantage of this opportunity, businesses, managers and pepper growers must regularly to improve product quality, food hygiene and safety requirements of the importing countries (Nguyen Thanh, 2019).

Table 3.7: Key destinations of Vietnam's pepper in 2018

Countries	Quantity (Thousand tons)	%	Value (Million USD)	%
United States	44.0	18.9	53.0	20.2
India	20.3	8.7	2.6	8.3
Pakistan	10.2	4.4	1.6	4.2
Germany	8.0	3.4	9.7	3.9
UAE	9.8	4.2	8.4	3.7
Netherlands	6.5	2.8	7.6	3.6
Thailand	5.1	2.2	20.3	2.7
Egypt	7.1	3.0	9.1	2.5
United Kingdom	4.5	2.0	8.3	2.4
Korea	5.2	2.2	8.0	2.4
Japan	3.2	1.4	5.0	2.0
Others	21.5	9.3	73.3	9.7
Total	**232.8**	**100**	**758.8**	100

Source: (GSO, 2019b)

Until now, Vietnamese pepper has traded in over 109 destinations worldwide. This has occurred with a rapid increase in volume, despite a decline in value. Vietnam's major markets are the US, Germany, UAE, Pakistan and India, making up to 60% of the world's exports. For instance, sales to US destinations reached around 53 million USD (21% of total pepper export value) in 2018 (Table 3.7).

With regard to pepper commodities, most black pepper products dominated at about 85–90%. However, with respect to quality, it is estimated that only 39% of these brands, meet international standards such as the American Spice Trade Association (ASTA), the European Spice Association (ESA) and Japanese Spice Association (JSA). For the rest, the Fair Average Quality standard is applied, and is only accepted in Western Asia, the Middle East and Africa (NIAPP 2017). In the future, pepper products must move forward with a higher quality, up to the ASTA standard.

To penetrate various markets and meet strict requirements, it is, therefore, required that processing and exporting have a well-prepared plan. The attributes suited to particular markets should be included in the branding for pepper producers and presented to show the ability to provide them reliably in the long-term. However, according to experts, Vietnam's pepper hasn't acquired reputable national branding yet, and lacks diversified export products in the world that would improve economic competitiveness. Most of the pepper products are viewed as basic commodities, leading to a low value and small-sharing market.

Black pepper

White pepper

Picture 3.3: Main raw products of pepper commodities

3.3.2.5. The challenges of pepper production

According to the Vietnam Pepper Association (VPA), the pepper sector is facing uncertainties and risks due to declining selling price. Meanwhile, the world's pepper output is forecasted to grow and the price to keep falling. Furthermore, production lacks sustainability because of excessive fertilizer use, and pesticide application causes the problem of food safety. Pressure caused by increasing restrictions on chemical or pesticide residue in markets like the EU and the US presents a difficulty. For instance, in previous years, the maximum residue limit (MRL) for pepper products was 0.1 parts per million (ppm), but the European Council (EC) is petitioning to impose an MRL of 0.05 ppm. Additionally, the cultivated pepper area in Vietnam has been expanded significantly to include unfavourable land, leading to concern about pest and disease outbreaks. In addition, on such marginal land, there is a reduction in pepper quality, often accompanied by insufficient experience or expertise into intensive cultivation, or with the constraints of cost and labor. Technical knowledge essential for pepper production may also be limited such as that which is necessary for irrigation systems and choosing seedlings.

3.3.2.6. The development trend of pepper in Vietnam

Vietnam's pepper planted area has greatly enlarged from 35,000 ha in 2001 to more than 150,000 ha in 2018. Notably, this figure exceeded the ministry's plans, adding 50,000 ha nationwide by 2020. In particular, good prices some years ago, motivated farmers to greatly increase their yields by planting more, and using more fertilizer and pesticides. Therefore, the tendency toward overexploitation has led to more risk.

To solve this situation, areas should not be increased further but restructuring towards sustainable development, and good agricultural practices is necessary, including such measures as Vietnamese Good Agricultural Practices (VietGAP) and Global Good Agricultural Practices (GlobalGAP) to improve quality and food safety. In addition, this sector needs to create a better linkage network related to production, processing, tracking and consumption. At the same time, there must be awareness of pepper cultivation to enable shifting practices. For instance, in Binh Phuoc Province, a sustainable pepper cooperative of Rainforest Alliance (RA) has been established with 510 participants, and estimated o involve 688 ha. In parallel, other provinces such as Dong Nai, Dak Nong, Ba Ria-Vung Tau and Gia Lai have formed cooperatives of clean and organic pepper orchards. The use of alive trees as pillars on which to train pepper plants is desirable, extending the life expectancy from 20 to 50%, expanding the cycle of irrigated water (around 20–30%), being stable yield and reducing losses crops with reference to wood and concrete pillars. Likewise, since pepper is by nature an understory plant, the using if shading and drip irrigation needs consideration as well.

In summary, to enhance the performance of pepper production, experts suggest that correct treatment of seedlings, the correct method of raising trees, the management of fertilizers and diseases, and the reduction of pesticides all need to be implemented. Improvement and enhancement of linkages for pepper production is a *sine qua non* in the development of the value chain. Finally, an enhanced involvement of local authorities in all aspects is beneficial including as a requirement planning and linking production and consumption. Simultaneously, government involvement in providing more incentive policies to promote the sustainable development of pepper production in the coming time is important.

4

Research site and Methodology

This chapter primarily deals with research methodology and comprises two parts. The first part is to introduce the Central Highlands and Dak Lak province characteristics, concerning geography, socio-economic and cultivation aspects. The second part of the chapter is to present the methods used to research the questions posed by the study objectives. These include the study approaches, research design, the sample size, fieldwork procedure, data collection and the methods of analysis.

4.1. Research site

An overview of the Central Highlands

The Central Highlands is in the Southwest of Vietnam, a relatively low plateau with an altitude of about 500 metres above sea level. It borders Laos and Northeastern Cambodia on the West, and it includes five provinces, namely Kon Tum, Gia Lai, Lam Dong, Dak Nong and Dak Lak. Most of the provinces are mountainous, enclosed by high-level ranges and massifs, being part of the Truong Son Mountain Range which extends throughout Vietnam. Additionally, the Central Highlands is divided into three sub-regions, including the north (Kon Tum and Gia Lai), the centre (Dak Lak and Dak Nong), and the south (Lam Dong). The centre has a lower altitude and higher temperature than the other sub-regions, due to this lower altitude. Interestingly, the average annual temperature is around 20 °C with a moderate climate all year round. Therefore, this region has some advantages in terms of weather as compared with others in Vietnam.

The Central Highlands has a total area of 5,451,000 ha, covering 16.5% of the whole country's area, in which 1450,000 ha of the basaltic soil (estimated at two-thirds of total basaltic soil of Vietnam). Over half of the cultivated lands are planted with perennial crops (equalling 53% of the total planted area) such as rubber, coffee, black pepper and cashew. The Central Highlands is the biggest perennial crop region and the country's largest coffee producer. Dak Lak is the largest perennial crop area, having 29% of the total perennial crop areas and approximately 88% of the coffee-growing area in the Central Highlands. Furthermore, this plateau is also moderately forest, with 2.8 million ha of total forest lands and 1.7 million ha of productive forest in 2018 (GSO 2019b).

Regarding the socio-economic development, the Central Highlands is among the lowest populated areas and population densities in Vietnam, and with over 80% of the ethnic people who live in the Central Highlands (GSO, 2019c). In 2018, this region had about 5.8 million people, and 108 people per km^2, much lower than the whole country average (286 people per km^2). Additionally, the labor force was about 2 million people while the number of agricultural workers was about 10,000 including over 70% of perennial crop households (GSO, 2019b). Unfortunately, the Central Highlands also had the highest poverty rate in the country, apart from the Northern Mountains region (World Bank, 2018).

4.1.1. General information of Dak Lak province

4.1.1.1. Geography

Dak Lak province is in the centre of South Central plateau, around 600 – 800 m above sea level. The province lies between 107º28'57" E and 108º59'37" E longitude

and between 12º9'45"n – 13º25'06" N latitude (Dak Lak Provincial People's Committee 2012). It's almost all contained within the Southwest of the Truong Son Mountain range. The upland areas account for 35% of the total natural area, concentrated on the South and Southeast. The North is bordered by Gia Lai province; the South has bordered by Lam Dong province. To the East, it is enclosed by Phu Yen and Khanh Hoa province. To the West, the province reaches the Cambodia border and Dak nong province. It has a long border of about 73.4 km with Cambodia (GSO, 2019a). Dak Lak is well –served by highway networks; this allows good connections with the infrastructure of Ho Chi Minh city and other provinces, like Khanh Hoa, the central coast or Phu Yen, and allows availability and practical access to transport for companies.

The total area of the province is 1,303,048.53 ha, equal to 3.9% of the total area of the whole nation. Dak Lak province contains 15 administrative districts (Buon Ma Thuot City, Cu Mgar, Cu Kuin, Ea H'leo, Krong Nang, Krong Pak, Krong Bong, Krong Buk, M'Drak, Ea Kar, Ea Sup, Buon Don, Krong Ana, Lak and Buon Ho Town (Figure 4.1). Most areas have a moderate elevation, and about 35% is highlands and mountains. In addition, Dak Lak province can be divided into six agro-ecological zones defined by elevation, including the areas of Ea Sup plateau subregion (28.4%); Buon Me Thuot – Ea H'Leo plateau subregion (16.2%); M'Drak hill and plateau subregion (15.8%); the plateau subregion along with the Krong Ana – Srepok river (14.5%); Chu Yang Sin mountainous area (4.0%); and Rlang Dja mountainous area, respectively (GSO, 2019a).

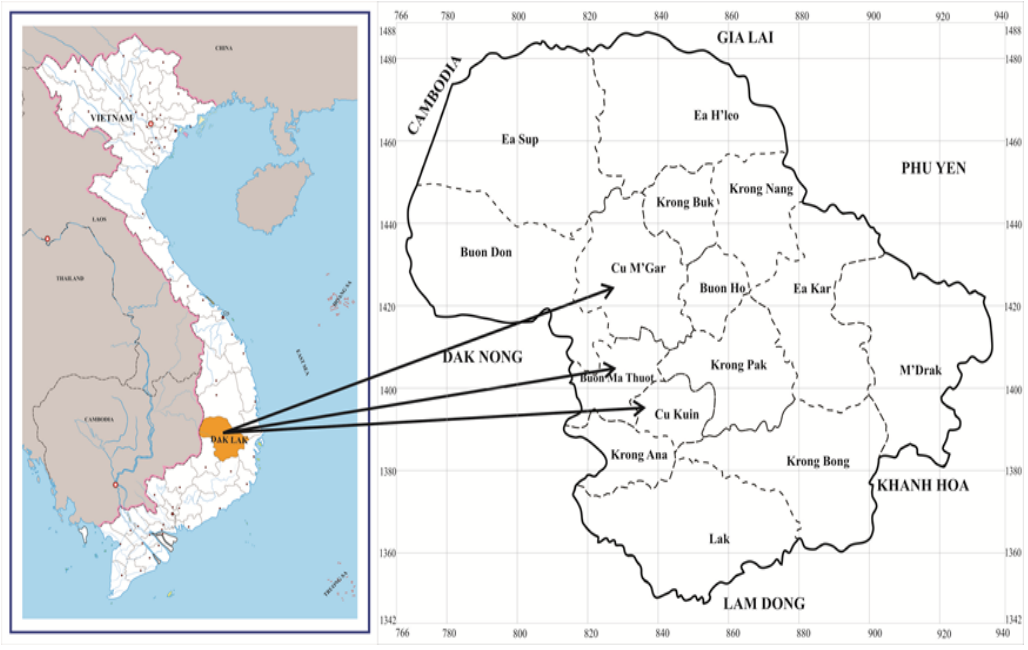


Figure 4.1: Map of research sites

Source: Political Map of Vietnam

4.1.1.2. Climate

Like many other provinces of the Central Highlands, Dak Lak weather is affected by the tropical monsoon climate. The climate can be characterized by two distinct precipation seasons, the rainy and dry seasons. The rainy season is from May to October, during which July, August and September have the highest rainfall. The dry season is from November to April of the following year with often only an insignificant amount of rainfall, low humidity, and frequent drought. Among these months, March and April witness the hottest and driest weather. Varying with the difference in elevation, the climate on a plateau 500m high is relatively temperate and rainy, while that on a plateau over 1000 metres is cooler in all year round. Thanks to the presence of a large amount of vegetation, many rivers, lakes and streams, the temperature is quite stable, with an average of 24 ℃. There is a difference of 5ºC between the hottest month and the coldest one. In a year, the average rainfall is 1600 mm -1800 mm. These features give a Dak Lak a relatively uniquire climate in comparison to other parts of Vietnam. However, this kind of climate can create both advantages and disadvantages with respect to agricultural production, especially for perennial crop cultivation.

4.1.1.3. Water resources

Water resources available in the province includes reservoirs (20.8%), rain (28.5%) and groundwater (50.7%). Over 70% of local water resources are used for agricultural production. Moreover, the large lakes and reservoirs like Lak, EaKao, Ea So to afford water for agricultural production and living households. Statistically, the province has 771 irrigation systems comprising 600 lakes, 117 dams and 54 pumping stations. These systems provide water for around 240.5 thousand ha (equals to 76.7%) for rice cultivation and other crops areas. In hilly and mountainous areas, water supply is problematic construction of irrigation systems is costly. Since rainfall varies considerably from season and year to year, there may be drought in the dry season and widespread flooding in the rainy season. Statistically, total supply water is about 38.8 billion cubic metres, of which the rainfall supplies about 15 billion cubic metres. Groundwater is currently the main source for irrigation systems for annual and cash crops, through wells. Thus, a dramatic increase in perennial crops and forest destruction have lead to decreasing groundwater levels. For instance, in previous years, the groundwater table has been 10 m deep, but currently, farmers have been having to drill wells or from 80 m to 120 m depth to get water.

4.1.1.4. Land use

As of 2018, this province had over 1.3 million ha, ranking fourth in size after the provinces of Nghe An, Gia Lai, and Son La Province. Dak Lak is an agriculture-based province where the proportion of agricultural land is around 88% (about 1.16 million ha), of which most is basaltic soil (345 thousand ha) suitable for growing perennial crop. Additionally, productive land is more than a haft of all forested, and fished in terms of area (Figure 4.2). The average land area estimates at 0.62 ha per person, higher three times than that of a whole nation.

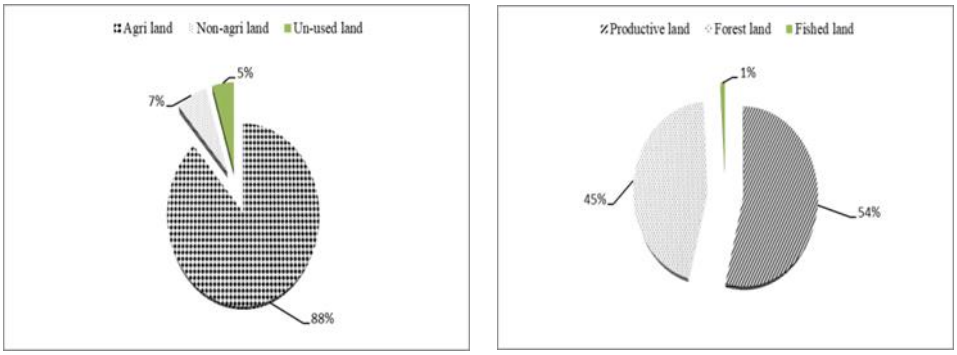


Figure 4.2: The land structure by purpose in 2018

Source: (Dak Lak PSO, 2019)

Recently, the most dramatic change in the land use pattern has been the transfer to cultivated areas from other land use. For instance, in 2007, forested land occupied around 1,000 thousand ha but this figure decreased by about half in 2018 (Figure 4.3). One reason behind this change was that the land was concerted into perennial crop cultivation. Such changes need to be taken consideration when assessing the balance of land use in the forthcoming years.

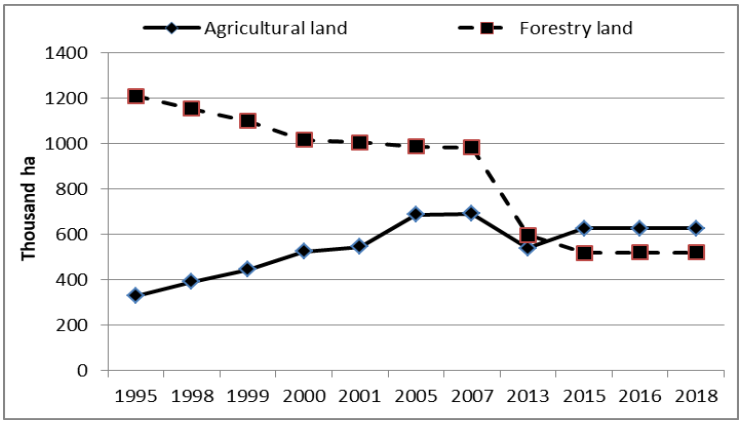


Figure 4.3: The agricultural and forestry status during 1990-2018

Source: (Dak Lak PSO, 2000, 2005, 2010, 2019)

4.1.1.5. Soil resources

Dak Lak province is endowed with Acrisols, Ferralsols and other types of soil such as Fluvisols, Gleysols and Luvisols, which, although derived from basaltic rock, are relatively more fertile. Fluvisols form from the sedimentation of rivers, streams while Gleysols are distributed more in low-lying areas of Lak, Krong Ana and Krong Bong districts. Acrisols, the largest group among the soil groups, are present in all districts of Dak Lak. Ferralsol is a red basaltic soil which is the second-largest soil group in Dak Lak (after Acrisols), accounting for 55.6% of the total red soil area in the Central Highlands. This soil has good drainage and is well-structure, containing a

deep layer of about 70 cm deep which, retains some moisture and nutrients. Consequently, this red soil is suitable for cultivation with valuable perennial crops such as coffee, rubber, tea, pepper, and fruit trees, thanks to low bulk density and good water retention.

4.1.1.6. Forestry

Situated in a region with suitable climatic conditions and geographical characteristics, Dak Lak has abundant forest resources. The province has about 608,000 ha of forestland, including 595,000 ha of natural forest and 14,000 ha of planted forest, which is the largest proportion in Vietnam. Most of the forested area is distributed in all districts, especially near the border with Cambodia. Saved wood accounts for 1,200 cubic metres and contains a few remnant populations of mammals. The forestland has played an important role in socio-economic development, a source of livelihood for indigenous minorities, and has had a role in national security. Overall, it could be roughly said that productive forest area has taken up a large proportion of area in Dak Lak. However, in recent years, there has tended to be excessive forest exploitation by illegal logging and usurping forest areas to plant cash crops, due to a lack of enforcement by forest management near local communities (Meyfroidt et al. 2013). In response to those issues, the Prime Minister stated, "The government places restrictions on entry to national parks, and forbids use of 2,253 ha of this land for other purposes, except those uses related to national defense and security. The Government condones a shift from areas low forest productivity to annual and perennial crops."

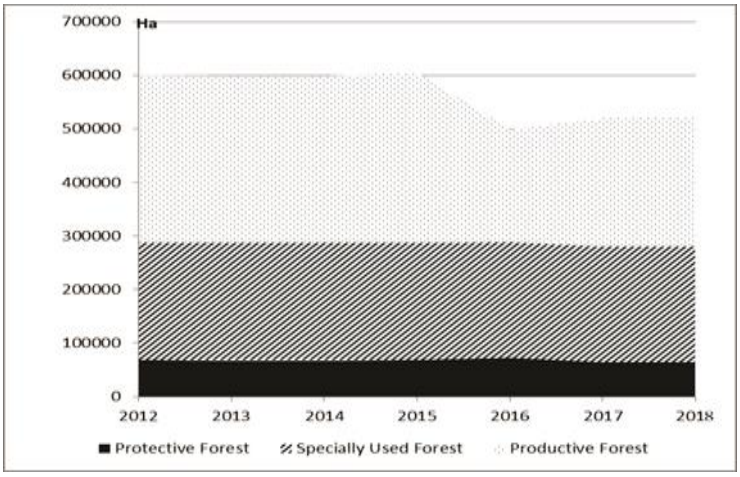


Figure 4.4: The forested land area by purpose use (2012-2018)

Source: (Dak Lak PSO, 2014, 2017, 2019)

4.1.2. Socio-economic situation in Dak Lak province

4.1.2.1. Population and labor force resources

The estimated figure of the provincial population was about 1.92 million people in 2018, a growth of 23,000 people (equalling 1.02%) in comparison to 2017 (Figure 4.5). In Dak Lak, there are 47 ethnic groups including 65% Kinh people (the majority ethnic group in Vietnam), and another 29% being E De, M'Nong and Gia Rai people. The

average population in Dak Lak is nearly 147 people per kilometre squared, much lower than other provinces in the Mekong delta area. The majority of the population lives in the rural area, accounting for 75.6% (about 1,147 million people) (GSO, 2019b).

Regarding the people of working age, they aged 15 years and over in 2018 was significant, amounting to 1.18 million people (about 60.4% out of total population in Dak Lak) and occupying 20% of the Central Highlands employed people amount, which provided a large potential workforce for economic activities. Around 60% of people worked in the agricultural sector, which is higher than the national agricultural laborer average. However, in 2018, skilled employees reached only 14%. The provincial migration rate was estimated at 4%, higher than in 2017. As a general recent trend in Vietnam, labor has moved from rural to urban areas and also nearby provinces to look for employment opportunities, which can occasionally cause shortages of workers in agricultural production, especially in the harvest season.

Remarkably, Dak Lak has the biggest spontaneous inter-provincial immigration rate as compared to other provinces in Vietnam, estimated at 9.7 ‰ (around 17,600 people in 2013) (Figure 4.5 and 4.6). Fortunately, from 2013 to 2018, the number of migrants decreased, accounting for 2,300 people in 2018. According to Dak Lak People's Committee, the migration situation is the main factor contributing to deforestation, perennial crop expansion and land conflict. Dak Lak province intends to build a resettlement area and allocate farmland to help migrants stabilize their lives.

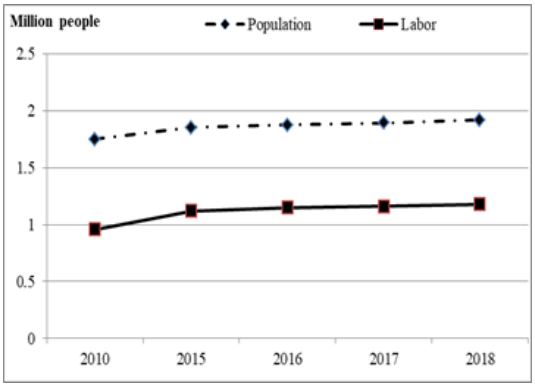


Figure 4.5: The population and labor situation in Dak Lak province from 2011 to 2018

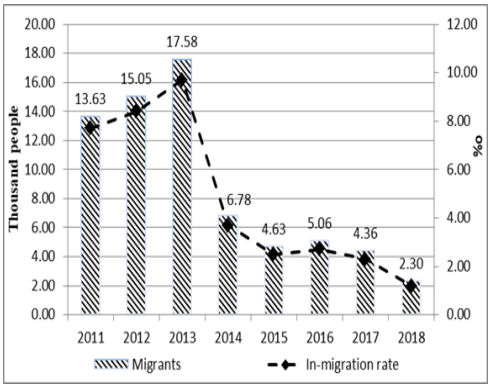


Figure 4.6: Migration situation in Dak Lak province during 2011-2018

Source:(Dak Lak PSO, 2017, 2019)

4.1.2.2. Economic development

Dak Lak's economy has developed significantly after the *Đổi Mới* policy was implemented. In recent years, the provincial economy has maintained a high and relatively stable growth rate. The economic structure has shifted rapidly by restructuring among income groups. In 2018, the Gross Regional Domestic Product (GRDP) reached approximately 70,000 billion VND at present price while the growth rate was estimated at 7.52%, higher than in 2017. The economic growth was around 33,000 billion VND for the service sector, 12 billion VND for the industrial-construction sector and 25,000 billion VND for the agricultural-forestry-fishing sector.

The economic output of the agricultural, industry and construction sectors accounted for 42.51%, 16.01% and 41.48%, respectively, in 2018. The poverty rate was about 2.5 in 2018, lower than in 2017. To sum up, for the 8-year period of 2010-2018, the economic growth increased thanks to the nation's efforts, especially agriculture rose by 3.13% (Dak Lak DARD, 2015; DPI, 2018).

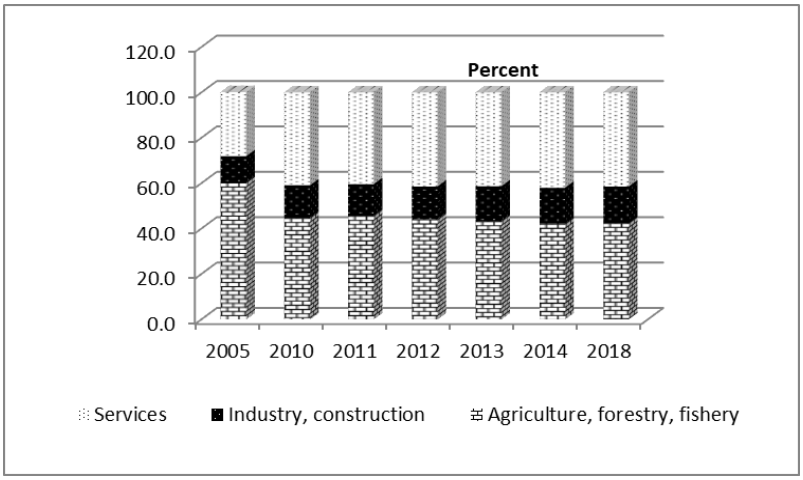


Figure 4.7: The GDP distribution of Dak Lak province by economic aspects

Source: (Dak Lak PSO 2010, 2015, 2019)

4.1.2.3. Agriculture and crop sector

The provincial agricultural sector has played an important role in economic development. Currently, agriculture contributes a large part to an average household's income. Recently, the agricultural sector stabilized has experienced steady growth, making up 4.94% per year, higher than the average rate of the whole nation (3.37%), from 2005 to 2014. Notably, the share of agriculture on the Dak Lak GDP achieved 19,468 billion VND (equal to 42%) in 2018. Interestingly, many specialized production regions have been established that provide commodities and export earnings, derived from perennial crops and forestry products. The total value of commodities accounted for 600 million USD in 2018, equal to 95.5% of the provincial export turnover (Figure 4.8).

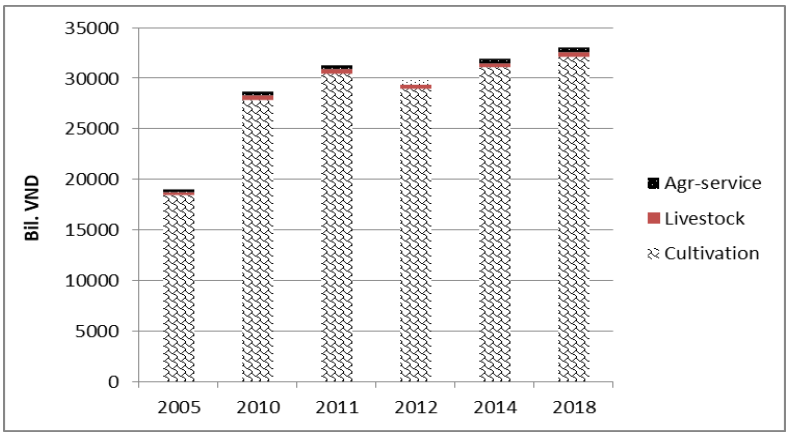


Figure 4.8: The GDP structure of sectors in the agriculture

Source: (Dak Lak PSO 2010, 2015, 2019)

In terms of crop sector, Dak Lak province has introduced many important commodities such as coffee, pepper, rubber, cashew, rice and cassava. The results have recently undergone significant development in terms of annual crops and perennial crops.

Most other annual crops are grown for subsistence purposes only, rice and cassava are exception. For rice, Dak Lak is 24th in Vietnam, but corn is 2nd only to Son La province. Perennial crop areas occupy most of the total area, including coffee, rubber, pepper and cashew, accounting for more than 70% of the total cultivated area. In 2018, this figure was over 300,000 ha, a small increase of over 2,000 ha as compared to 2016. Dak Lak is a major producer of coffee and pepper. Cultivated land with coffee and/or pepper includes over 24,000 ha, equal to around 30% of the nationwide area (Table 4.1).

Table 4.1: The planted areas of perennial crops in Dak Lak in 2018

Items	Coffee		Pepper		Rubber		Cashew	
	Thous.ha	%	Thous.ha	%	Thous.ha	%	Thous.ha	%
1. Area of harvesting								
Vietnam	688	100	150	100	965	100	301	100
Central Highlands	583	94	95	88	256	37	75	26
Dak Lak	203	30	38	25	38	4	23	8

2. Productivity								
Items	Coffee (seed)		Dried pepper		Rubber		Cashew nut	
	Thous.tons	%	Thous.tons	%	Thous.tons	%	Thous.tons	%
Vietnam	1,626	100	255	100	1,142	100	260	100
Dak Lak	478	30	78	31	31	3	23	9

Source: (GSO, 2019)

4.1.2.4. Export situation of perennial crops in Dak Lak

Dak Lak is well-known for coffee and other valuable export crops, which had an export volume of over 191,000 tons (equal to 10.6% of total coffee output nationwide) with a value of 365 million USD in 2018. Dak Lak coffee products can be found in 62 countries and territories (Dak Lak Provincial People's Committee 2019a). Besides traditional production, speciality coffee products were concentrated on for the development in 2018-2019 to improve coffee value in the national and the international markets (Dak Lak Provincial People's Committee 2019a). Unfortunately, due to the fluctuation of market prices in the world, in 2018, the export turnover experienced a large decrease in value, adopting 20 million USD in comparison to 2015, declines during this time primarily involved coffee and rubber. For instance, the coffee sector underwent a rapid decline, accounting for 113 thousand tons and 76 million USD during 2015-2018. Nevertheless, cashew and pepper sectors earned more about 35.3 and 5.6 million USD, respectively during the same period thanks to areas increase.

Table 4.2: The share of total volume and value of main commodities in Dak Lak

Unit: thousand tons and million USD

Commodities	2015	2016	2017	2018
1. Coffee				
Output	340.0	309.0	222.0	227.0
Value	504.0	647.0	492.0	481.0
2. Rubber				
Output	14.0	9.0	7.0	7.0
Value	43.0	29.0	17.0	14.0
3. Pepper				
Output	7.0	4.0	5.0	5.0
Value	25.0	26.0	33.0	35.0
4. Cashew				
Output	0.5	0.4	0.6	0.8
Value	2.8	2.5	3.9	5.6

Source: (Dak Lak PSO 2019)

4.1.3. Advantages and disadvantages of perennial crop production in Dak Lak

The advantages and disadvantages of perennial crop development in Dak Lak province are as follow (Dak Lak DARD, 2015):

- **Advantages**

Farmers have experience in cultivation, especially with perennial crops and other cash crops.

Natural conditions are suitable for specialized and diversified crops such as perennial crops and fruit trees.

The agri-service network of production and consumption facilitates access to the Central Highlands and South region markets.

Global and domestic demands have been increasing in recent years.

- **Disadvantages**

Most farmers produce on a small scale, which has raised concerns about the difficulties of the implementation of technological improvement.

Limited irrigated systems can't mitigate drought and cause economic losses. Privately funded water systems are costly.

Recent price increases for material input items and high rates of ageing of established trees have resulted in high production costs and low productivity.

The fluctuation of international market price in particular recent declines, has discouraged farmers from investing in their farms and has reduced household income.

Production often has to cope with large challenges in terms of climatic variability.

The specific requirements of commodities to be sold on the international and domestic markets may force farmers to have to change their production.

4.2. Research methodology

4.2.1. Study approaches

- **The system approach**

This study concentrates on the evolution of perennial crop systems (PCSes). According to the FAO, (1999) agricultural system process, in particular those of cropping systems, vary from region to region, and from state to state. Changes in these vary with the time, and with the local, regional and international economic situations. Therefore, an analysis of the evolution of perennial crop systems as related to n analysis of the ecological, socio-economic and political contexts is needed. Application of a system approaches is to understand all the elements of complex PCSes and the changes that occur under the socio-economic context of the region and at the farm level (Lacoste, 2017). Through this approach, the homogeneity, heterogeneity, and complexity of family farming will be specified with the aim of an explanation of why all farmers in a locality react in the same way or not in terms of technical advice, innovations and policies (Barral et al., 2012). In other words, due to flexibility and adaptation to different forms of agricultural production in the family farm, the systems approach aim here is to investigate the forces that led to past changes in the differentiation of farming systems (Mazoyer and Roudart, 2017). In this study, a classification and evolutionary analysis of perennial crop systems based on various criteria is presented.

- **The holistic approach**

Agriculture and cropping systems can evolve considerably and in a complex way, varying with the region. In response to this situation, it is necessary to understand the real problems, history and practices of perennial crops in the research sites. In a holistic approach, the evolution of cropping systems as it relates to modification in agricultural policies, technologies and economic transformation is based on recognizable events. Historical cropping systems changes involve development in the types of cultivated crops, cropping calendar, fertility management, equipment, water management, employment opportunities, transportation infrastructure as well as the population, land tenure policy, markets, natural disasters, social and political changes.

- **Participatory or bottom-up approach**

A participatory or bottom-up approach is suitable for rural research as it fills the gaps of a top-down approach. This approach considers the real needs of local populations in diagnosing, planning and managing the process of agricultural and rural development projects. In addition, this approach is characterized by flexibility and interaction, and exploring local knowledge and perceptions is integral to the method. In the farming system research, the participatory approach is essential because it seeks to understand farmers' objectives and their farming practices, adoption decisions and acceptance of innovations. It creates an opportunity for the researcher and local people to share experience and knowledge. This study uses an assessment of stratification and evolution of zoning region in Dak Lak province, characteristics of perennial crop systems, and surveys farm practices and the constraints of the systems. The participants include farmers of all ages, experience level, the study includes from local leadership.

4.2.2. Research design

In order to investigate the objectives, five steps were used in the research design as the illustrated in Figure 4.9

Step 1: To analyse the development of perennial crop systems from the past to the present, this study is based on the agro-ecological development, socio-economic transition, and institutional changes in Dak Lak Province that explain how to cultivate and develop practical perennial crop systems in the area. By using quantitative data, changes in perennial crop systems are revealed covering the local history across time and space. Tools including chronograms diagrams and timelines are suited to represent the information. In other words, this evaluation can show what conditions are necessary for the appearance, evolution and development of various crops and the variety of systems based on political, economic, and demographic factors.

Step 2: To identify the practices of selected perennial crop systems

With traditional agriculture, there is a need to explore local practices in greater depth (Stock 2012). This process describes the characteristics of cropping systems such as the planting calendar, density, varieties and species planted as well as household' profiles. To implement this, a descriptive statistics (means, percentages, charts, and growth rates) are used to present an overview and explanation of perennial crops practices.

Step 3: Assessing the socio-economic benefits of perennial crop production

This step assesses and explains the differences in socio-economic performance between selected systems. The socio-economic benefits are the main core of the analysis of development when choosing appropriate systems and making an investment decisions in situations of limited resources. Furthermore, to have a thorough understanding of perennial crop production, categories of groups and approaches are classified to compare the economic performance.

Step 4: To determine the driving factors of farms' decisions when adopting crops.

Practices and socio-economic benefits are inputs that farms use to make decisions on adoption. The farm's decisions to adopt play an important role in adjustment, adaptation and coping with unfavourable conditions. Modern farmers need to have

much information to make effective decisions regarding choices of crops. These decisions are probably based upon speculation on the "future market", in which farmers don't necessarily try to maximize productivity but rather the long term benefits (Lindskog et al. 2005). Using quantitative and qualitative data, determinants are identified.

Step 5: The empirical evidence from the study, is directed at giving suggestions and recommendations to farmers and policymarkers on perennial crop development strategy.

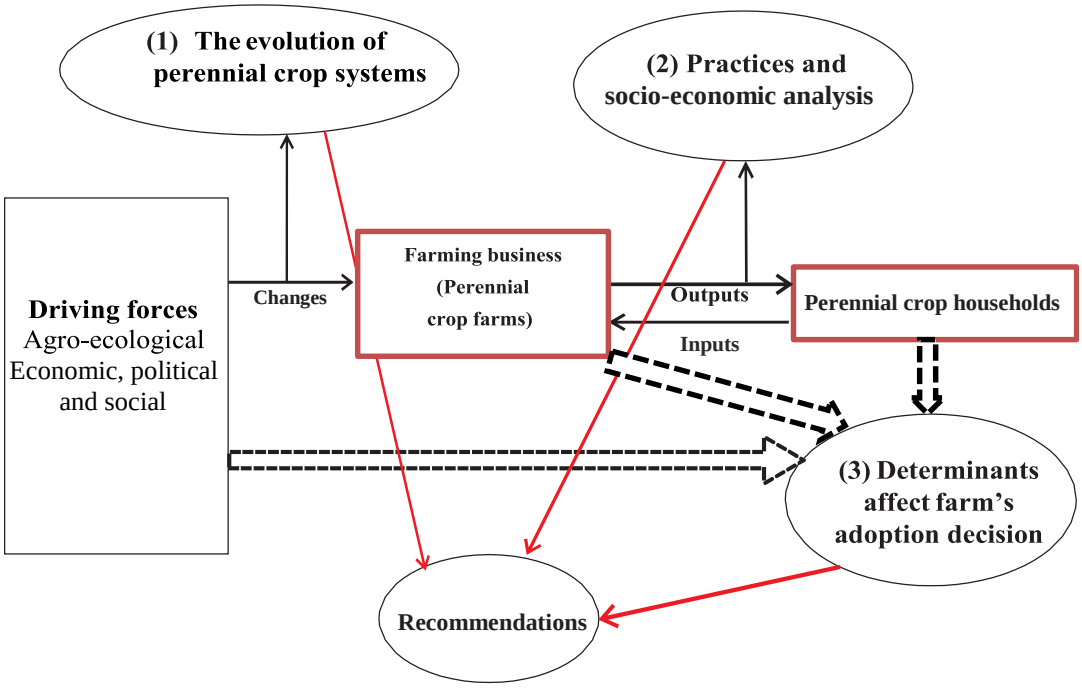


Figure 4.9: Analytical framework of the study

4.2.3. Sample size

4.2.3.1. Selection of study sites

- *Stratification of sub-agroecological zones based on the level of classified fertility capacity*

When classifying zones, they should have similar characteristics with the object the identification and localization of agro-ecological and socio-economic situation in the evolution of the different systems (FAO, 1999). For agricultural situations, cropping system analysis is carried out on smaller communes or villages to identify common resources and suitably examine cropping systems (Diepart and Allaverdian, 2018). This study was conducted in Buon Ma Thuot city, CuMgar and CuKuin districts of Dak Lak Province which have similar fertility and suitable weather (the largest of the coffee areas is CuMgar; the third largest of the pepper areas is CuKuin; and Buon Ma

Thuot city has a long history of perennial crop production). Additionally, the two districts are near Buon Ma Thuot city and so that have favourable market conditions, transportation, agri-services (Table 4.3 and Map).

Table 4.3: Coffee and pepper area by district in Dak Lak in 2018

District	Coffee (Thousand ha)	Pepper (Thousand ha)
Buon Ma Thuot	***12.2***	***1.8***
CuMgar	***36.0***	***4.3***
Cu Kuin	***12.7***	***5.0***
Ea H'leo	31.0	7.2
Ea Sup	0.04	0.07
Krong Nang	24.3	5.7
Krong Buk	20.0	1.3
Buon Don	4.7	1.3
Ea Kar	8.5	4.4
M'Drak	2.0	0.6
Krong Pak	18.0	1.5
Krong Bong	5.5	0.1
Krong Ana	10.0	1.5
Lak	4.0	0.2
Buon Ho	14.5	3.9

Source: (Dak Lak PSO 2019)

Because the agro-ecological approach has a critical role in designing farming systems and cropping systems, sub-agro-ecological zones need to be chosen when doing an evolutionary analysis of perennial crops. Dak Lak province can be broken down eight agro-ecological zones by soil type, rainfall patterns and altitude (Karimov et al. 2016). However, based on other sources including formal documents (VAST 2015) (see map), and discussions with key informants and agricultural experts at provincial and district levels, the region can be divided into three zones by fertility capacity classification as shown in Figure 4.10.

Zone 1: Area highly favourable for perennial crops, such as Buon Ma Thuot city, CuMgar, Cu Kuin, Krong Ana, Krong Buk, EaHleo, Krong Ana, Krong Pak districts (dark orange and orange sites).

Zone 2: Area moderately favourable for perennial crop growing (light orange sites)

Zone 3: Area unfavourable for perennial crops (purple and other sites)

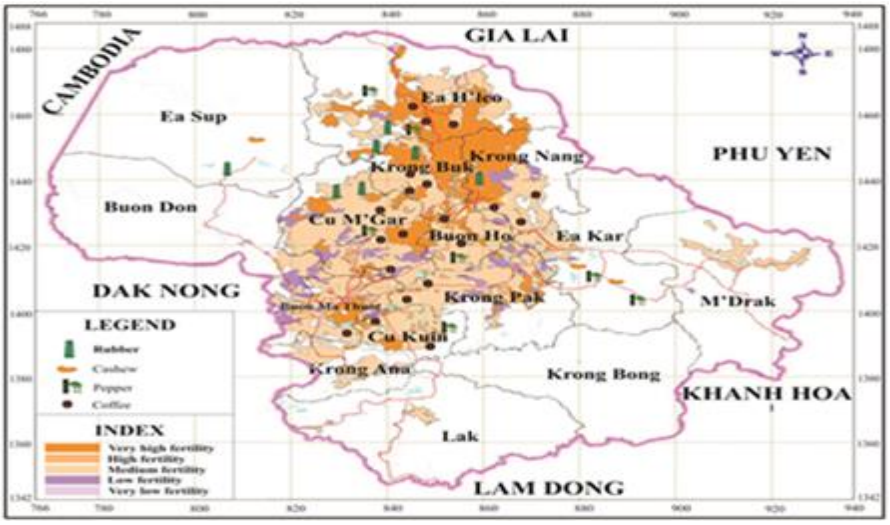


Figure 4.10: The development of perennial crops in three fertility zones

Source: Dak Lak Provincial People's Committee, 2019 and adapted from Le et al. 2017

Classification of systems based on coffee and pepper

When Barral et al., (2012) studied cropping systems, the author argued that it was better to restrict the number of cropping systems in order to obtain the specified finding rather than implement many cropping systems due to limited time and resources. Based on secondary data, previous studies, and participatory meetings with administrative staff at the provincial and district levels, following historical and economic criteria, data concerning mono-crop systems and intercropping systems focusing on coffee and pepper are readily available. Therefore, monoculture and intercropping systems are represented in this study. Coffee and pepper fields have been the main contributors to provincial economic growth, corresponding to almost 30% of the nationwide area for each in 2018. Overall, three selected cropping systems of mono-coffee systems are used; as well as mono-pepper systems and coffee and pepper intercropping.

4.2.3.2. Collection of data at surveyed households and plots

According to statistics, over 90% of producers are smallholders with an average of 1.5 hectares in Dak Lak province (GSO, 2019). Therefore, in order to have an exact and detailed analysis, data from selected households who had coffee and pepper farms from 0.5 to 2 hectares with farm ages over three years were collected.

- **Sampling**

The sampling was carried out by the randomly. As per Diepart and Allaverdian, (2018), there are no rules about the sample size in studying cropping systems, sampling depends on time and resources. Salvatore and Reagle, (2002) argued that the sample size could be collected based on the population, with the number of households (n) = 0.1 N (population size) and statistical units having the same probability of being selected. For instance, if the sample rate equals 10%, this means the sample size represents 10% of the

population (FAO, 2016a). Accordingly, from the list of households, 86 interviews were selected. Because each household often owns more than one plot in the surveyed region, the total number of households (86 heads) was smaller than the total surveyed plots. 90 plots were selected from the list (Figure 4.11).

For the socio-economic analysis, 90 plots of three systems including mono-coffee system (only coffee crops on the farm-MCS), mono-pepper systems (only pepper crops on the farm-MPS), and coffee and pepper intercropping (pepper crops being grown at the interspersed with coffee holes and/or a small sub-area integrated in the plantation-CPI) were used to identify general characteristics of households and systems, farming activities, farming practices, establishment and annual costs, social benefits and a farm's decision on adoption (Figure 4.11).

Furthermore, in order to have more data and internal observations of economic performance of coffee and pepper crops, from the surveyed farm list, categories of planting approaches or methods and groups are also classified. Regarding the planting approaches, two approaches with 120 plots, including a mono-growing approach (a mono-coffee farm (MCF: n=30); a mono-pepper farm (MPF: n= 28)) and an intercropped-growing approach (an intercropped coffee farm (ICF: n=30); an intercropped pepper farm (IPF: n=30)) were assessed to provide a comparative analysis of the economic performance of crop cultivation. Regarding groups, several were classified. First, a group producing coffee (GpC: n=62) for specialized coffee production and diversified coffee production, and second a group producing pepper (GpP) for specialized pepper production and diversified pepper production were selected to identify the differences in the costs and profits and to evaluate the evolution of the economic performance of each group during two years: 2016/2017-2017/2018. All sample sizes and processes are illustrated in Figure 4.11.

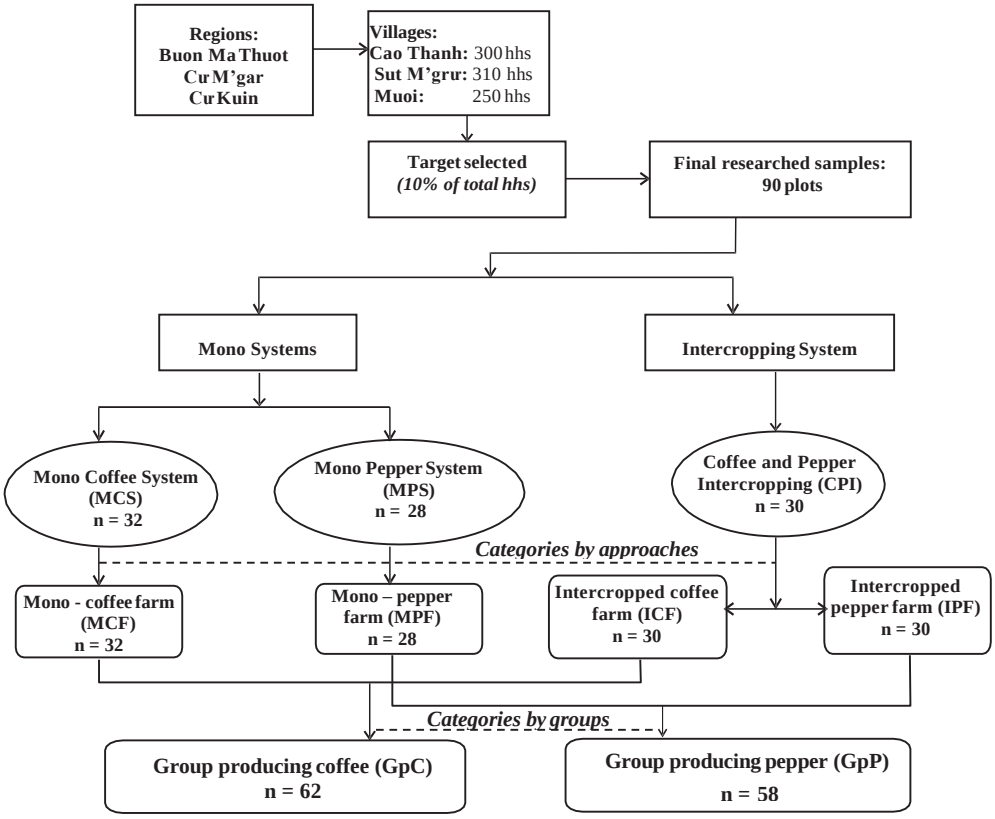


Figure 4.11: Stratifies researched samples in Dak Lak province

As well as having a long economic lifespan, perennial crops also require high start-up costs (Gunathilaka, Smart and Fleming, 2018; Song, Zhao and Swinton, 2011; Tregeagle, 2017). The additional information about the initial investment of MCS, MPS and CPI in the first three years needed to be obtained through a supplementary interview of thirty-seven farms from the selected list of 86 households (who also holds farms were from one to three years old) by random sampling (Table 4.4).

Table 4.4: The distribution of sample in supplementary interview

Regions	MCS	MPS	CPI	Total sample
Buon Ma Thuot	5	4	4	13
CuMgar	4	6	3	13
CuKuin	3	4	4	11
Total	12	14	11	37

4.2.3.2. Fieldwork procedure

In order to glean a clear picture of perennial crop practices and have diverse opinions and findings, both quantitative and qualitative data need to be supplemented (Jamshed, 2014; Ulmer and Wilson, 2003).

The design of the study consisted of three parts: A) Preparatory, B) Qualitative and quantitative phase, and C) Supplementary phases.

In terms of the preparatory stage, it included two steps. The initial activity consisted of collecting all information of secondary data from the province to district level. Secondary data relates to the research sites and situation of perennial crop production, and was obtained from available official statistical sources such as Vietnam and Dak Lak statistical yearbooks, maps, historical books, and previous annual reports. In addition, several books and other publications including dissertations, and formal reports contributed to reviewing the evolution and production of perennial crops. In addition, unofficial sources, such as local documents, websites, and articles related to perennial crop issues, allowed additional complementary data to be included. Importantly, the secondary evidence provides a real picture of perennial crop development during distinct stages associated with socio-economic transformation, ecological conditions, technical changes, market prices and the political situation. Finally, the activities of the remaining parts comprised of two things: Key informant interviews (KIs) and focus group discussions (FGDs). With regard to KIs, this process involved elderly people, local leaders, and experienced farmers (both men and women), who are directly involved with perennial crop evolution, in order to describe in detail those transitions. The aim was to reconstruct the changes in villages' history regarding agriculture, specifically those changes which concern alteration to land tenure and perennial crop practices across time and space. In other words, this step helps to recognize the drivers of recent evolution of perennial crop systems. Through these activities, the major trends, trajectories of perennial crop systems and the differentiation processes are able to explain so that cropping system development can be envisioned in the future. The content of these activities concerns the evolutionary perspective of the local region, the main crops, yields, technology and the identification of relevant "types" of cropping systems in the area. Turning to FGDs, this activity was conducted in each of the three selected villages. A mixture of participants consisted of men, women, younger, and more experienced farmers. Each FGD comprised six participants, and there were a total of nine FGDs. The qualitative aim concerned information related to development in cropping systems over time and space. In particular, the current perennial crop systems, key drivers of changes, and the effect of transition on livelihoods, occupations, land ownership, perennial crop growers, crop calendars was assessed, as well as strategies for coping with constraints for perennial crop production. Moreover, a Participatory Rural Appraisal tool was conducted in the villages by using a timeline - critical events were mapped and assembled in chronological in order to review a period. These tools facilitate discussions and obtaining data specified within a historical context that helps to outline the flow of perennial crop evolution and perspective across time. In addition, general information regarding the establishment of farms and farm operations was also gathered by questionnaires after having been field-tested twice on research sites in

order to refine them. This step took place mainly from August 2017 to May 2018 (2016/2017 crop year). The survey data includes household characteristics, information on cultivated areas, cropping calendar (scheduling of care, fertilizer and pesticide application, irrigation, and harvesting), and production information of perennial crop farms (costs and returns, hired labor, permanent labor, and sales of crops), as well as the opportunities and constraints. Meanwhile, the second questionnaire surveyed places with a focus on newly-planted farms (from one to three years). This survey collected information about the established costs for each cropping system including land preparation, materials (e.g. seedlings, nurseries, fertilizers, pesticides, assets, labor and other costs.

In the second phase, a repeat survey of the quantitative and qualitative data relating to farms operations was carried out from January 2019 to May 2019 (2017/2018 crop year) in order to gather more information, confirm and/or find out the changes in perennial crop production which had occurred by using semi-structured and structured interviews. At the same time, information about how and why farmers decided upon adoption for their farms was identified. In this survey, farmers identified the driving factors on farms' decisions in adopting.

Finally, in the supplementary phase, there were re-interviews for the respondents using a similar questionnaire to confirm any changes in perennial crop system production and farms' decisions. This process was carried out from November 2019 to February 2020. In addition, the researcher returned to the research sites annually to do in-depth interviews with key informants, as well as keep in touch with households by cell phone to understand practices accurately, their decisions and their aspirations.

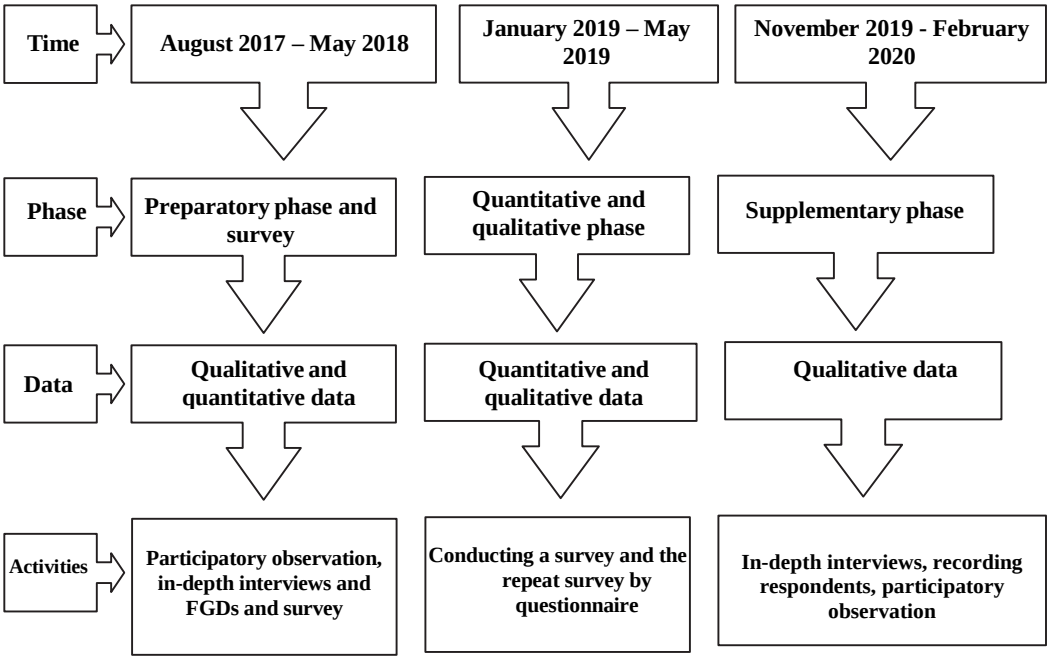


Figure 4.12: A procedure of the fieldwork process

4.2.4. Data analysis methods

4.2.4.1. Documenting the evolution of perennial crop systems

This aim is to know and understand how perennial crop systems operate. It starts from a general to a detailed assessment while the preceding stages follow from regional and farm levels.

The aim is to recognize the differences of perennial crop systems during transition periods and the adaptation of perennial cropping systems. Periods are decided upon by reconstructing perennial crop system activities while changes in these activities connect with socio-economic and political transformation. In order to satisfy the research aims, chronological, historical and timeline event methods were used to diagnose according to spatial and temporal assessment (Barral et al., 2012; Diepart and Allaverdian, 2018).

4.2.4.2. The cost-benefit analysis (CBA)

CBA can be used to allow a systematic approach for identifying production decisions. In the same way, CBA generates empirical evidence on whether or not to implement an investment under limited resources (Martínez and Saín, 1983; Quah and Mishan, 2007). CBA helps to enhance understanding of the supplement of perennial crop production by assessing the farm-level profitability of distinct systems. Additionally, due to a long lifespan, perennial crops spend at least three years in the establishment stage. Consequently, to initiate a cost-benefit analysis, two components of initial and annual of costs are needed following (FAO, 2016a; Newton et al., 2012). In order to evaluate the performance of perennial crop systems (MCS, MPS and CPI)

and the finances pertaining to a particular system, we need to have a good understanding of their cost and benefits.

In terms of production costs, these were estimated, including establishment and maintenance costs per hectare.

- *Establishment cost*

The total start-up costs include the expenses and asset purchases associated with a farm's start-up operations. These expenses comprise cost items such as indirect cost, capital and labor cost. The estimation method is similar to calculating variable costs. In this study, this cost includes preparation of land (hiring contractors to cut trees, ploughing and cleaning operations), materials costs (pillars, hole, seedlings, fertilizer, pesticides, others) and labor cost.

- *Annual cost*

The annual costs include the amount for intermediate expenses (fertilizer, pesticide, fuel irrigation, transporting, packaging and others), depreciation, interest payment, hired labor fees, property taxes and insurance. In this research, these costs were calculated perennial crop financing for all selected systems (MCS, MPS and CPI), approaches (mono-approach and intercropped approach) and groups (GpC and GpP).

The methods used to gather the basic data and calculate the direct cost.

+ Intermediate costs (IC)

$$\mathbf{IC = \sum_{i=1}^{n} Total\ product\ x\ Unit\ price\ (1)}$$

Where n is the number of material inputs. It is recommended to include the cost of coffee and/or pepper to measure per hectare and per year.

Depreciation cost of assets (D_{asset})

This cost specificfies depreciation from the infrastructure, including machines, wells, pipes and storehouses. Due to lifespan of these assets being variable, the depreciation of each type of asset is calculated by the formula:

$$\mathbf{D_{asset\ (e.g.\ machines,\ well,\ storehouse)} = \frac{P_1 - P_{(T)}}{T}}$$

In other words, the lifespan of assets is different for each and different according to the life expectancy of perennial crop orchards.

Here T is the expected life service (assuming different the lifespan of machines in this study). $P_{(T)}$ is the estimated asset price at the end of the lifespan.

Depreciation cost of capital assets (D_2)

In this situation, the pre-production cost is allocated for three years from the beginning of the crop lifespan. The approach is similar to the depreciation cost of capital assets when using a linear method.

$$\mathbf{D_{orchard}} \quad \frac{\mathbf{PPC - SV}}{\mathbf{N - H}}$$

Here: $D_{orchard}$ is the annual portion of the establishment cost

PPC is start-up cost which is allocated during the pre-production years.

SV is the value of the enterprise at the end of the production cycle. In this case, SV = 0 (because the cost contributes to at the dead crop period).

H is the length of years of the crops' pre-productive period (H=3 years)

N is the length of years of the productive period (N=25 years. It is recommended to replace the crop as the yields deteriorate significantly after this time) (Hurri and Ngoc, 2015).

+ Labor cost

Labor cost = number of working days (person-days) x labor price at the local region

Return indicators

Economic performance indicators are fundamental requirements in order to invest and make decisions. At the farm level, costs and returns provide economic assessment for farm households' operations and refer farms' decision in the best practices in the same regions with similar characteristics and endowments (FAO, 2016a).

+ Gross output (GO) is the total revenues of production outputs

$$\mathbf{GO = P_i * Q_i} \qquad \mathbf{(3)}$$

P_i: is the market price of i products (the prices calculated based on the price paid after harvest); Q_i is the product quantity of i products.

+ The value added (VA): Value added is the gross output deducted from Intermediate cost. It is calculated by the following equations:

Value added (VA) = Gross output (GO) – Intermediate cost (IC) (4)

+ Net Farm Income (NFI)

NFI = Value Added – (hired labor cost + interest payment + depreciation) (5)

+ Profit

Profit = Net Farm Income – Family worker (6)

In addition, to take into account that the price of coffee and pepper might vary, a sensitivity analysis of perennial crop systems with different coffee and pepper prices was performed to calculate the Gross Output and Profit. The sensitivity analyses include: (1) Scenario 1: Good: the coffee and pepper prices increase (2) Moderate: the coffee and pepper prices are constant (3) Bad: the coffee and pepper prices decrease.

- *Methods identifying the social benefits of three perennial crop systems of MCS, MPS and CPI*

At the farm level, apart from the economic assessment, this study also looked at social factors, including gender, job creation, and employment. Regarding gender, the research focused on women, with an emphasis placed on understanding the role of gender in perennial crop systems. In other words, gender analysis focused on the difference between men and women involved in perennial crop practices among the three systems. Meanwhile, the remaining criteria of job creation and employment were considered to compare participants between systems.

- *Methods assessing the economic efficiency of group classification as comparative data analysis*

As previously mentioned, in order to have diverse observations, the economic performance is calculated by a cross-comparative analysis of farm approaches (mono-growing approach and intercropped approach), and groups (group production of coffee and group production of pepper). Accordingly, economic indicators of Intermediate Cost (IC), Gross Output (GO), Value-Added (VA), Net Farm Income (NFI) and Profit were analyzed.

- To examine whether there are significant differences between the means of two or more *non-parametric* and independent variables, several tests (Hansen, 2005; Hoang and Chu, 2008; StatisticSolution, 2013) were used the Mann-Whitney U test and the Kruskal-Wallis Test. In this study, the Mann-Whitney U test was applied to test the differences among the two approach methods (MCFs and ICFs); (MPFs and MIFs); and two group producing methods (GpC and GpP). Meanwhile, the Kruskal-Wallis test was used to test the differences between the three systems (MCS, MPS and CPI).

4.2.4.3. Methodology uses to assess the driven factors to farm's decision in adopting a perennial crop

This study uses a rigorous analysis of both qualitative and quantitative data to determine the probability of farm adoption, and whether the farmer made their decision in adopting a crop or not. In other words, this study aims to identify determinants of farm decisions on adoption by two alternatives: "Adoption" and "Non-adoption". "Adoption" means the farms are involved in any activities such as chopping, adding or removing crops. On the other hand, "Non-adoption" means that there are no such activities present on the farms being assessed.

Moreover, to assess the intensity of a farm's decision in adopting, the author defines three situations: basic adoption, adoption of perennial crops; and a diversified adoption, as shown in Table 4.5.

Table 4.5: The farm's decision on adoption and non-adoption

General adoption		
Non-adoption	**Adoption**	Total
Maintenance of current systems	***Non maintenance of current systems***	
11	79	90

	Intensity of adoption			
Categories	***Basis adoption group***	***Perennial crop adoption group***	***Diversified crop adoption group***	Total
Explanation	Remove or add any crops	Shift completely to new perennial crop systems	Convert totally into new systems by plenty of crops	
Total	41	28	10	79

To quantify the factors affecting the farms' decisions, logistic regression was used to analyse the multi-level determinants of perennial crop system probability. Logistic regression analysis is chosen to qualitatively represent the dependent variables because they are binary and dichotomous while the independent variables are continuous or "dummy" in nature and represented in quantitative and qualitative ways. The independent variables are primarily identified based on literature research and surveyed data, and are presented in Table 4.6.

Table 4.6: Explanatory variables

Explanatory variables	Description	Variable
Dependent variable	General adoption decision	Y
	Intense adoption decision	Z
Households characteristics	Age of household head (Years)	AGE
	Gender (=1 if Male)	GEND
	Ethnicity (=1 if Kinh people)	ETH
	Education (Years)	EDUC
	Training (=1 if training)	TRAI
	Other income (=1 if having other income)	OINC
	Experience (Years)	EXPER
Farm endowment	Profit status (Million VND)	PROFIT
	Family workforce (Laborers)	FWORK
	Capital (=1 if Yes)	CAP
	Land Use Right Certificate (=1 if Cadastre)	LURC
Crop profiles	Pests and diseases (=0 No, =1 Yes)	PETDIS
	Tree age (=1 if over 20 years,=0 otherwise)	AGETREE
	Crop failure (=1 Yes)	CROPF

The binary logistic regression model is an extension of simple linear regression, and is used to estimate the odds in the case of having independent variables, defined by Y, in a binary form (Y=1 to present the occurrence of an event of interest and Y=0 to describe the existence of the non-event).

Simultaneously, the multinomial logistic regression model determines multivariate decisions by estimating the occurrence of probabilities for each alternative, defined by dichotomous variables of Z. To do this, the reference category must be outlined.

General adoption using a Binary logistic model

In the first stage, the binary regression model is the most common approach used to examine the driving factors of the two alternatives, adoption or non-adoption. This means that this model tests the probability of the farm's decision on "Adoption" or "Non-adoption". To put it another way, the binary regression model examines whether the farmer makes the decision to adopt the system or not (Cox and Snell, 1989, Collett, 2002; Cox, 1972). In this case, 100% of the samples are included in the model. Let Y_i represents a dichotomous variable that equals 1 if the farm is adopted and 0 if the farm is not adopted.

A vector of explanatory variables is estimated with parameters, in the following way:

Logit (P)= Log (P/(1-P)) = $\alpha + B_j x_i$

Odds =P/(1-P)

With Y= 1 Farm'sdecision on adoption (1)

0 Farm'sdecision on non-adoption

P is the probability for the occurrence of a farm's decision; α represents the constant, B_j are the estimated parameters for each explanatory variable (j=1, 2, …); x_i is the explanatory variables (metric or dummy); odds is the event's chance of occurrence.

The probability of occurrence of the event is given as:

Prob (Y_i=1) = $e^{(\alpha + Bi\ xi)}$ /1 + $e^{(\alpha + Bi\ xi)}$

Whereas probability of occurrence of the non-event is:

1- P = 1/ 1+$e^{(\alpha + Bi\ xi)}$

Here, x_i represents a vector comprising households' characteristics, farm endowment and crop profile.

Intensity of adoption using the Multinomial logistic regression model (MLR)

In the second stage, MLR is an extension of binary logistic regression, to analyse adoption across more than two categories in the dependent variables. Hence, the MLR permits the determination of the occurrence of probabilities of an event defined by Z. Particularly, Z is the farmers' decision regarding the three farm's decisions in adopting. On the other hand, MR examines which factors are affecting farms' decision on adoption relating to a variety of farm approaches.

To do this, the reference category must be identified (Cox, 1972; Maddala, 1986). Generally, if the dependent variables are presented under M answer categories, the number of the estimated logistic will be (M-1). Furthermore, we can evaluate the probability of occurrence for each of these categories.

In this study, the MLR model allows an analysis of the farm's decision in adopting across three possible answer categories (0, 1, or 2). If the chosen reference category is the 0, the study will have to provide other event possibilities associated with this category, which will be shown by categories 1 and 2.

Z^*_i was divided into three categories: (Z_0, Z_1, Z_2) as follows for the three groups with 0 as the reference category.

Logit(P) = $\alpha + B_{ij}\ x_{ij}$

Z^*_i including
0: Basic adoption (Farms will maintain their current crops when adding or planting new crops)
1: Perennial crop adoption (Farms will converte to new perennial crops)
2: Diversified adoption (Farms will shift planting to a variety of new crops)

The general expression of the logistic is as follows:

$Z_{ij} = \text{Log}\ \frac{Pi}{Pj} = = \beta_{ij} x_{ij} + \varepsilon_{ij}$ j=(0…2), where Z_{i0} =0, therefore, e^{Zi0} =1 (2)

For the three categories, the probability of occurrence for reference category 0 and the occurrence probabilities of the two distinct events based on categories 1 and 2 can be estimated such that the sum of the probability of all the event occurrences will always be 1, in the following way:

The probability of occurrence for category 0 (reference)

$P_{i0} = \frac{1}{1+e^{Zi1}+e^{Zi2}}$ is the probability of occurrence for removing or adding a perennial crop on the current farms (Group 0)

The probability of occurrence for category 1

$P_{i1} = \frac{e^{Zi1}}{1+e^{Zi1}+e^{Zi2}}$ is the probability of occurrence for new perennial crop farms (Group 1)

The probability of occurrence for category 2

$P_{i2}\ \frac{e^{Zi2}}{1+e^{Zi1}+e^{Zi2}}$ is the probability of occurrence for a variety of new crops (Group 2)

5

The evolutionary process of perennial crop systems in Dak Lak province

Perennial crop systems have experienced changes at different stages across time and space, resulting from the transformation of socio-economic conditions, ecological changes, and the political situation. The major aim of this chapter is to present an overview of the spatial and temporal evolution of perennial crop systems in Dak Lak province. An additional goal is to provide empirical evidence in specifying perennial crop systems for policy makers. This chapter comprises two main sections. The first is an evolutionary analysis of perennial crops across five distinct stages. In other words, the trends and trajectories of the perennial crop systems under the influence of drivers are interpreted across time and space. The second section addresses the strategies and prospects of perennial crop development.

The contents of this chapter were already published in the proceedings:

"An overview of perennial cropping system development and economic performance of perennial cropping systems in Dak Lak province", a proceeding given at the Economics, Development and Sustainability, EDESUS, published in the proceedings (2019), VNU University of Economics and Business (UEB) in cooperated with Springer Publishing House.

5.1. Spatial and temporal evolution of perennial crop systems in Dak Lak province

5.1.1. Large-scale plantations of perennial crops during the colonial era

Dak Lak province is suited to growing perennial crops thanks to favourable conditions and abundant resources. Historically, there are records of perennial crops having been initiated as main crops by the French for economic purposes in the Central Highlands and Dak Lak in the 1920s. These were primarily coffee and rubber, beginning the early development of perennial cropping systems (Vietnam Trade Promotion Agency, 2007).

During the colonial era, numerous policies were instigated to set up and expand perennial crop farms. For instance, under those policies, two agricultural plantations-CADA (Compagnie Agricole d'Asie) and CHPI (Compagnie des Hauts Plateaux Indochinois) with over 40 thousand ha of rubber and coffee were established (Nguyen, 2007). At this time, perennial crop areas were primarily developed into large plantations. Also at this time, people from the Red River delta, Quang Tri, Thua Thien Hue, Binh Dinh and other northern regions were forced to move to the Central Highlands as employees (Doutriaux et al., 2008). Between 1926 and 1942, the workforce for perennial crop plantations increased from one thousand to seven thousand people. At the same time, some private farms (around 500 hectares) existed and were held by ethnic minorities. Although the perennial crops production was strengthened for export purpose, agriculture and perennial crop production still relied heavily on natural resources, and was focused on coffee and rubber and basic farming technologies. At this time, private or local land ownership and crop selection can be considered to have been non-existent.

Table 5.1: The coffee and rubber areas before 1960

Unit: Hectare

Items	Agricultural companies			Private sector
	CADA and CDHI	An Nam	Dong Duong	Ede people
Owned area	40,000	8,000	13,200	580
Coffee	260	1,000	668	450
Rubber	-	-	135	125

Source: (Do, 2016)

At the end of 1960, perennial crop production in Dak Lak was controlled by the United States. Land available for cultivation was allocated initially to private producers, at a maximum of around 10 hectares per household. By 1967, perennial crop production had evolved into large-scale plantations, reaching 2,700 tons of coffee (equal 90% of the whole Central Highlands production) (Figure 5.1). At the same time, migrants from the crowed regions were forced to arrive as laborers in Dak Lak. For instance, the percentage of Kinh people jumped from 5% to 50% of the total population between 1945 and 1975 (Nguyen, 2016).

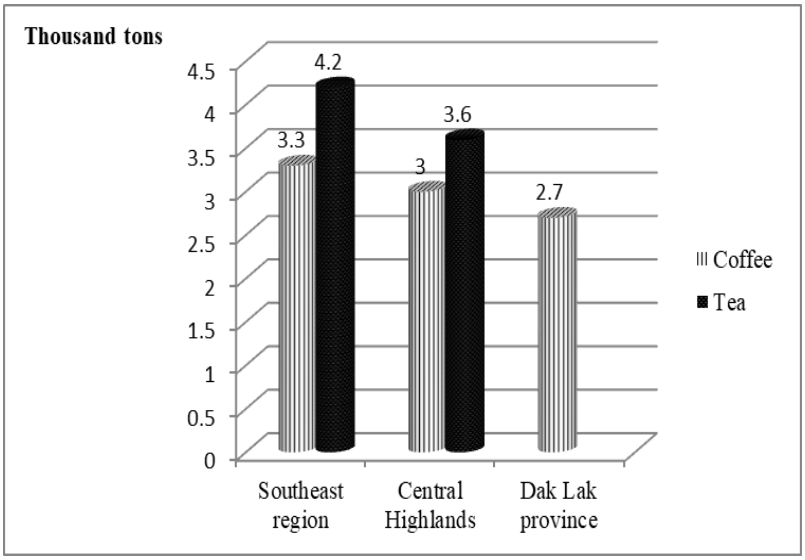


Figure 5.1: The perennial crop productivity in 1967

Source: (Dak Lak PSO, 1986)

To conclude, under the colonial economy, perennial crops were large-scale plantations, with non-optimal plant density, minimal material inputs, and basic agronomic practices. These, and dependence on natural resources led to problems with low production output and lower quality products. Additionally, perennial crop growing area occupied most of the fertility region in Zone 1.

5.1.2. Perennial crop systems during State-owned period

After Southern Liberation in 1975, Vietnam, including Dak Lak had experienced enormous devastation and rapid changes in politics, society, environment and economics (Lindskog et al., 2005). Although the provincial economy was poorly developed and there were difficulties due to the destruction of war, Dak Lak was seen as a new frontier for economic development, in particular for the perennial crop sector (Espaldon et al. 2004) due to its large natural area (equal to 6% of the whole area nationwide at that time). At this time, the province had the lowest density population compared to others, with only 17 people per square kilometre and 344,000 citizens (48% being indigenous people).

In order to urgently deal with the mass hunger, many official programs were implemented to rekindles socio-economic development, such as creating jobs, balancing the population density, and helping the indigenous people to adopt modern practices and lifestyles (OECD 2008). New Economic Zones (NEZs-*Vùng kinh tế mới*) and a long-term population redistribution program (*Định canh-định cư*) were organized. Migrant peasants from the crowded northern delta are moved to Central Highlands and Dak Lak Province (Hardy 2000). About one million people had settled in New Economic Zones by 1975 (Pingali and Xuan, 1992).

This campaign resulted in a large populated increase, in particular of the Kinh people. Additionally, changes in the forested area occurred due to intensive deforestation and shifting cultivable land areas (Dak Lak PSO, 1986; Lindskog et al., 2005). After this, the local government began to pay more attention to the development of perennial crops, especially coffee. When state-owned farms (*nông trường*-SFs) and state forestry enterprises (*lâm trường*-SFSs) were established to manage and promote areas planted with perennial crops, yields and productivity increased dramatically. Specifically, many coffee state-owned farms such as Thang Loi, 10-3, Duc Lap, Phuoc An, were launched, managed by the National Agricultural Company and the Vietnamese government, to cooperate with countries like the Soviet Union, and East Germany (Dak Lak PSO, 1986). Altogether, SFs jumped from 12 in 1978 to 28 units in 1985, absorbing over 70% people involved with coffee production (Luong, 2003). Apart from SFs, cooperatives numbered 184 units, involving about 60 thousand participants in 1985 (Table 5.2). The coffee sector was marked by fast-paced change, comprising over 20,000 ha during 1981–1985 thanks to the rising number of migrants (Figure 5.2).

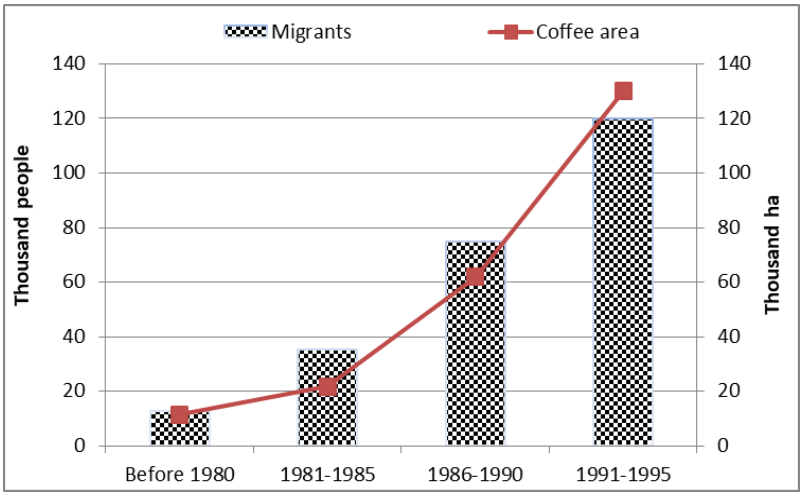


Figure 5.2: The migrated population and coffee area in Dak Lak during the 1980s

Source: (Dak Lak PSO, 1986, 2001)

Table 5.2: Perennial crop state-owned farms

Year	Farm state		Cooperatives	
	Number (Farms)	Producers (People)	Number (Farms)	Producers (People)
1978	12	3,930	17	9,121
1981	19	23,885	122	40,600
1985	28	43,521	184	58,728

Source: (Dak Lak Provincial People's Committee, 1986)

During this period, rubber and coffee can also be identified as the main crops, having an area three times larger than that in 1975. In addition, to provide access to domestic and international markets, pepper and cacao crops were initiated between 1981 and 1985. Unfortunately, due to the rigidity in control by the state administration, long droughts, lack of fertilizers and insufficient technology, there were problems regarding low productivity, high input costs, waste of land and a lack of development. For instance, while the areas of coffee, pepper and rubber were around 218, 0.079 and 10.9 thousand ha, productivity was only at an estimated 21.8, 0.048 and 6.1 thousand tons, respectively, in 1985 (Table 5.3).

Table 5.3: The variance of area and productivity of perennial crops

Years	Area (thousand ha)			Output (thousand tons)		
	Coffee	Rubber	Pepper	Coffee	Rubber	Pepper
1975	11.50	4.50	-	8.80	2.30	-
1976	11.20	3.90	-	7.40	1.00	-
1981	1.10	-	0.01	-	-	0.01
1983	13.70	-	0.06	13.8	-	0.04
1984	-	-	0.08		-	0.04
1985	21.80	10.90	0.08	21.80	6.10	0.05

Source: (Dak Lak PSO, 1986)

In conclusion, ten years after reunification, the policies at national and local levels weren't appropriate due to lack of consistent and realistic perennial crop development. What's more, the inefficiency of enterprises and cooperatives prevented a dynamic nature in the perennial crop sector, leading to a huge budget deficits and low households' income.

Introduction of directive 100 (Contract 100) in 1981 allocating land to households

In respond to the difficulties, the Vietnamese Communist Party promulgated Directive No 100/CT-TW dated 13 January 1981 (Contract 100 – *Khoán 100*). Accordingly, there was an initiation of land reallocation to individuals and households. Cooperatives not only provided farmers with input materials like seeds, and irrigated systems but also had the added responsibly of submitting contracted quotas for outputs. Producers had no incentive to control their production procedures such as planting, caring and harvesting, because they only needed to produce predetermined quotas which were determined by the physical quality of the land (soil, available irrigation services, slope, etc.), the types of crops, national production and market prices.

The result of this policy was that brought more flexible management rights for farmers, the household became a unit of agricultural production and it could decide which crops and how much to grow based on market demand (D'haeze et al., 2005). Later, the program created an increase in perennial crop growing areas (e.g. coffee and rubber-growing areas accounted for over 90% of perennial crop areas in the whole province). Nevertheless, resettlement campaigns resulted in an increase in deforestation rates and changes in agricultural activities. Correspondingly, forested areas underwent a decrease of 21% while considerable increases in agricultural area occurred during the 1980s, amounting to 176,000 ha by 1984 (Figure 5.3). However, perhaps the most striking feature of this programme was that appropriate land use rights were not rapidly allocated due to the long prior period of state control. Likewise, because of lack of intensification and stagnant reforms, perennial crop production was relatively insignificant because of low productivity. To sum up, during this period, perennial crops were developed entirely in the naturally fertile areas in the region. However, most of the plantations still depended on abundant resources.

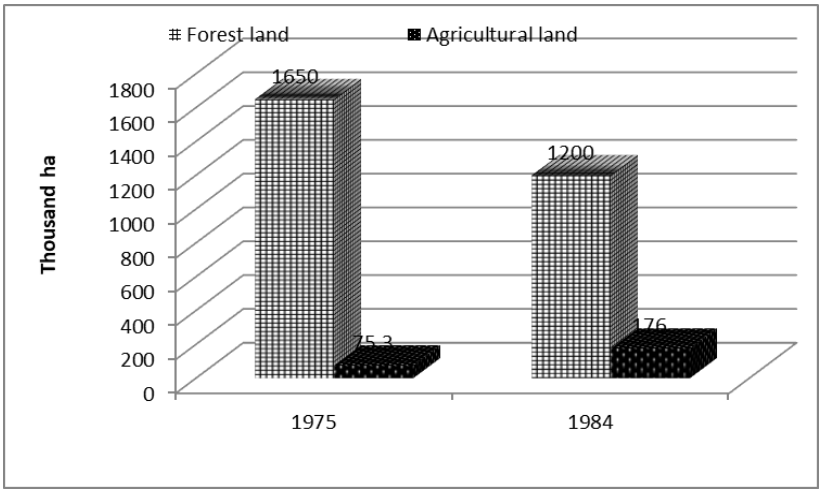


Figure 5.3: The changes of forest land and agricultural land use from 1975 to 1984

Source: (Dak Lak Provincial People's Committee, 1986)

Picture 5.1: A simulation of coffee plantation under State-owned era with massive employees

Source: Adapted by author

5.1.3. Intensive perennial crop systems

From the above observations, one must conclude that the collectivization policy of Vietnam's postwar government turned out to be inappropriate for effective economic development in that period. In order to address this issue, an incredible transformation began with the economic reform, or "Renovation", which was introduced by the Communist Party of Vietnam at its Sixth National Party Congress in December 1986.

For this reform, Vietnam undertook the reform of a planned economy towards market-oriented economy. Initially, land ownership was recognized as a main unit that would facilitate production. For instance, a Land Use Certificate (LUC) established tenure on agricultural land. This assisted farmers in having complete responsibilities and independent choices regarding input decisions on their production potential. One of the incredible impacts of the renovation was that households could "own" their land use rights through five options, including leasing, transferring, exchanging, inheriting and mortgaging, according to the Land Law of 1993 (e.g. this meant accruing rights for 50 years for perennial crop farms instead of 20 years) (Phuoc et al., 2001). Increasingly, agriculture, along with growing cultivated areas, led to outputs and productivity becoming the main components of economic growth, accounting for 66% of the gross domestic products in 1994 (Toan and Iyer, 2003). This seems to confirm the idea that the reforms in transferring land could be considered to have increased the motivation to carry out long-term investments such as those required for irrigation and growing multi-year crops. Notably, Dak Lak Province at this time entered a period of growing in perennial crops. Among main contributors to this were coffee, rubber, cashew and pepper - thanks to the effect of the privatization, economic liberalization, state-sponsored migration, and favourable price increases. Remarkably, at this time, the coffee productivity was two times higher than the period of 1981–1985 as well as the average growth rate increased by 30% annually.

In 1994, coffee could be seen as a "miracle crop" and the price reached a peak of 4,000 USD/ton, which encouraged approximately 80% of coffee households and over one million people to participate. As a result, production rose to around 355 thousand tons in 1999 (equivalent 10% of the production of whole nation) and Vietnam became the world's second-largest exporter (Figure 5.4) (D'haeze et al., 2005; Minot, 1998; Dak Lak PSO, 2001). One of the reasons for the rapid price increase was that frost in Brazil destroyed a large part of the coffee area, causing a sharp reduction in the international coffee supply (Dang and Gerald, 2008).

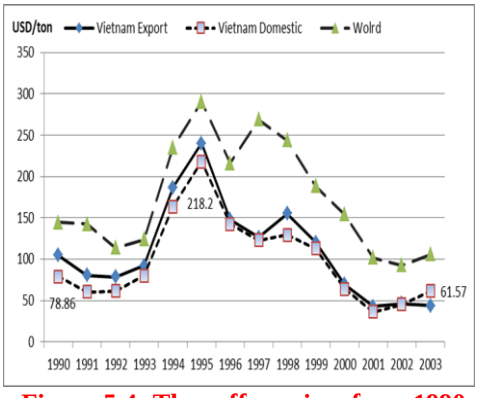


Figure 5.4: The coffee prices from 1990-2003

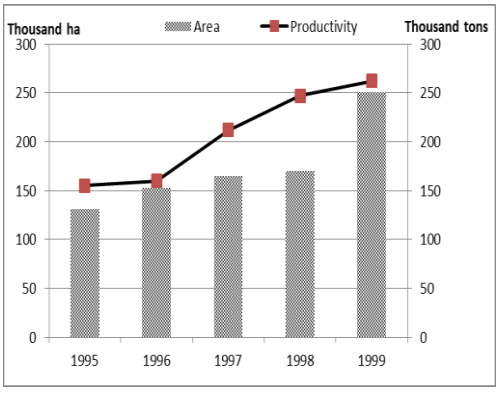


Figure 5.5: The coffee production in Dak Lak province during 1990-2003

Source: (Dak Lak PSO, 1986, 2001)

In addition to the coffee, the rubber, pepper and cashew sectors were also expanding their exports dramatically thanks to Vietnamese government encouragement. Specifically, there was a significant increase in rubber production, from 19,200 to 26,200 thousand ha from 1995 to 1999 (Table 5.4). Meanwhile, tea tended to decrease because of less incentive than the other crops, from 329,000 to 132,000 ha during the 1990s. Among the other reasons that contributed to the development of perennial crops were the introduction of fertilizers, meaningful improvement of rural access roads and markets, and the rapid expansion of irrigated systems. These led to labor- and capital-intensive practices (Oxfam, 2002). Unfortunately, a constraint on perennial crops began to be manifest, especially with respect to coffee, and this was associated with considerable deforestation and the related depletion of groundwater resources (D'haeze et al., 2005).

Table 5.4: The area and productivity of perennial crops from 1995 to 1999

Unit thousand ha, thousand tons

Year	Tea		Rubber		Pepper		Cashew	
	Area	Productivity	Area	Productivity	Area	Productivity	Area	Productivity
1995	329.0	596.0	19.2	4.5	1.0	1.0	9.8	1.8
1996	333.0	640.0	20.5	5.5	2.0	1.3	8.4	2.0
1997	209.0	380.0	25.0	7.1	1.4	1.5	7.2	2.5
1998	215.0	316.0	26.0	7.8	1.7	2.5	6.0	3.9
1999	132.0	285.0	26.2	9.5	5.0	2.7	67.0	3.0

Source: (Dak Lak PSO, 2001)

High deforestation rate

Nevertheless, one should accept that the land-intensive transition from the forest area to grass and cultivated land has exacerbated the problems associated with deforestation. For example, the operation of hundreds of state-owned farms and cooperatives under perennial crop systems indirectly led to concerns about the accelerated deforestation and degradation (Dang and Shively, 2008). In the beginning of the 1990s, there was a motivation market signal to exploit of "barren land" (*Đất trống, đồi trọc*) to grow perennial crops. Specifically, high coffee prices at this time encouraged producers to expand growing areas by reclaiming "waste" land and cutting down forested areas. Consequently, there was an increase of coffee area recorded 14% yearly (Figure 5.5). A measure of the seriousness of the problem was the average amount of forested land destroyed per household was estimated at 1.5 ha during that period (World Bank, 2002). As a result, forest coverage decreased from about 1,700 in the 1980s to 1,000 thousand ha in the late 1990s in Dak Lak province. In the past 20 years, the province lost an average of 20 thousand ha of forest yearly from both the public and private sectors growing coffee and other crops. According to Le and Pretzsch, (2011),

poor management by state forestry companies was a major reason for the decline in area and quality of the provincial forest.

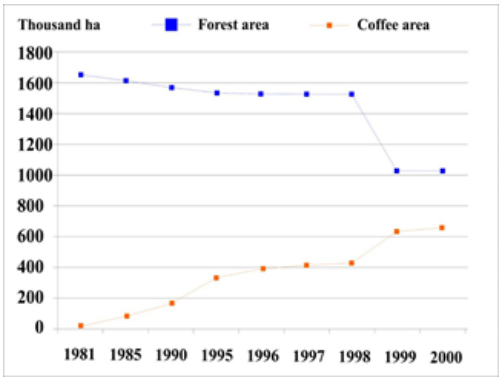


Figure 5.6: The evolution of forest area and coffee area during 1981-2000

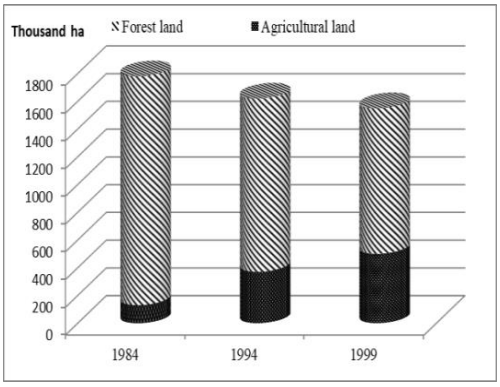


Figure 5.7: The changes of forest land and agricultural land during 1981-1999

Source: (Dak Lak PSO, 2001)

In response to widespread deforestation, the local and national governments undertook some efforts in environmental and biodiversity conversation, landscape preservation and forest protection. In meeting these aims, the Vietnamese Government enacted the Law on Forest Protection and Development in 1991. This defined forest land as belonging to one of three categories: special-use forest, conservation forestry and production forest. Moreover, the Programme 327 (Reforestation Programme), Decision 661/QĐ-TTg about "New planting of five million hectares of forestland" and Decree 2 on the distribution of forestland to households had the goal of forest preservation, with a target to increase forest cover to 42% in 2010 (Jones, Saunders and Smart, 2002). However, limited success was inevitable due to the three reasons of demographic resettlement, socio-economic liberalization and allocation of land ownership (D'haeze et al., 2005).

Rapid population increases due to the spontaneous migration

A contributor to perennial crop expansion was also migration. According to statistical data, over 1,000,000 migrants moved from different regions (Red River Delta, northeastern regions) into the Central Highlands due to state controlled migration (586,000 people) and spontaneous migration (350,000 people) to start coffee growing in the late 1990s (Ahmad, 2000) which was generating higher profits than other crops. By 1999, the provincial population was nearly 1.5 million inhabitants, of which 70% were Kinh people. The density was 94 people per square kilometre, and this increase can be compared to around one million people and a population density of 61 people per square kilometer in 1975 (Salemink, 2018; Oxfam, 2002). To sum up, Dak Lak province experienced the highest demographic growth rate in the country, of which the population increased by 300% over the last 15 years after Liberation in 1975 (Gallen, 2004; Hardy, 2000).

When investigating the reasons for spontaneous migration, many reports revealed that limited income and assets (e.g. land) had a major influence. Migration can address problems associated with livelihood uncertainty, social exclusion due to landlessness, religious persecution, and job loss (Winkels, 2008). One major supporting factor that allows migration to accour, is the existence "migrant networks", and these have been shown to facilitate and encourage the prospect of unplanned migration (Dang, 1998). For instance, one estimate was that 81% of migrants had connections to relatives in the Central Highlands before moving there (Winkels, 2004). The massive migration waves changed the population structure of Dak Lak. Except for improvements in economic standing and access to new opportunities, migrants significantly exploited natural resources and destroyed forest area. Figure 5.6 clearly shows the cause and effect relationship between the loss of forest area and increase in area under coffee cultivation. The population of Kinh people increased and amount of agriculture area both jumped at this time. The population of Kinh people increased from about 400,000 to about 1,500,000 people from 1984 to 2001. At the same time, agricultural area increased from about 100,000 ha to 550,000 ha (Figure 5.8).

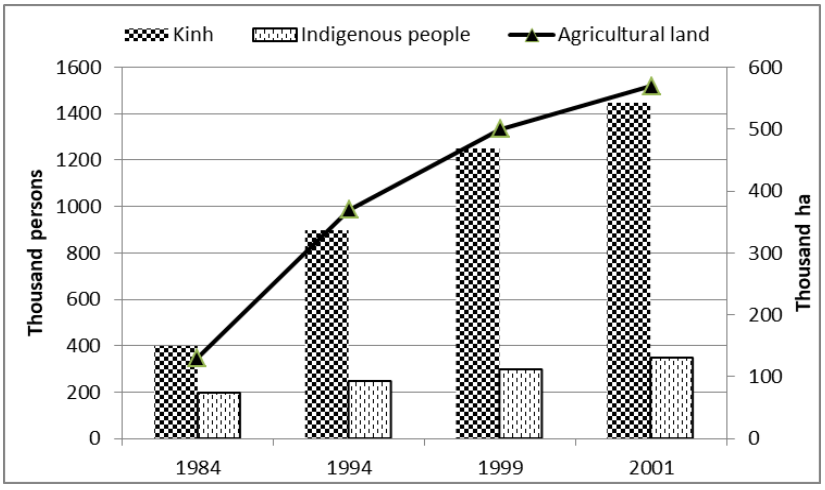


Figure 5.8: The evolution of agricultural land and migrants in Dak Lak province during 1990s

Source: (Dak Lak PSO, 1986, 2001)

To conclude, this period can be characterized by its intensive agricultural expansion, and increase in exploitation of land, fertilizer use and application of technology. Coffee and rubber were cultivated in Zone 1, Zone 2 and slowly expanded into the less suitable (Zone 3). In addition, the other crops such as pepper, cashew, and cacao also developed gradually with mono-crop systems. Meanwhile, perennial crop production was facilitated through policies that promoted better finance, technology and marketing. Apart from this support, the local government also encouraged access to new crops or new nursery and advisory services.

New migrants increased the supply of paid and unpaid labor, but the denser population resulted in perennial crop plantations being set up that caused rapid conversation of

agricultural land from forestland. It is probable that the changes in socio-economic policies and market liberalization were the main drivers leading to the large loss of forestland (Dang and Espaldon, 2001; Hoang et al., 2010). The great need for cultivatable land st this time also meant encroachment mainly by small farms, into the unsuitable zone, which led to lower productivity and high costs. Over time, emerging natural resource issues such as disasters and environmental degradation began to be taken into consideration by the Vietnamese government.

Picture 5.2: A simulation of an intensified coffee production by applying fertilizers and pesticides

Source: Adapted by author

5.1.4. Mixed perennial crop production in the 2000s

Perennial crops were considered to be important cash crops that could take advantages of the high prices in the 2000s. Statistically, 2010 had 59% of cultivated land being perennial crop area, an increase of 3% in comparison to 2005 (Figure 5.7).

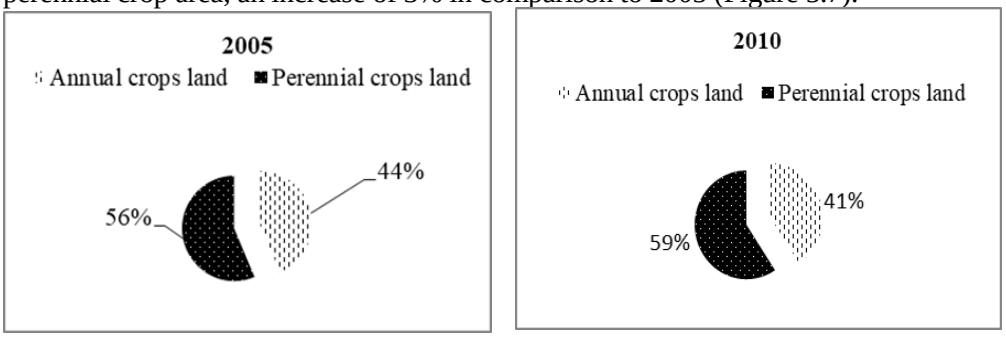


Figure 5.9 : The changes of crop cultivated areas in Dak Lak, in 2005 and 2010

Source:(Dak Lak PSO, 2005, 2010)

Intensive production to maximize yields by using more water, labor and fertilizer was common during this time. Moreover, the growing population continuously provided a labor source for the perennial crop sector, with a growth rate of 6.18 times population (1.8 million people in 2002) and was the Dak Lak had the highest growth in Vietnam (Dak Lak PSO, 2005; Doutriaux, Geisler and Gerald, 2008).

Since 2001, Vietnam has become the second-largest coffee exporter in the world, contributing to 10% of the country's export earnings. Dak Lak Province was the leading coffee exporter at the national level during this period.

Unfortunately, the collapse of coffee price, from 4,000/ton in 1994 to less than 500 USD/ton in 2001, resulted in economic losses for producers and traders, and discouraged investment.

At this time, farmers faced numerous challenges, for example 66% of coffee planters had debts, and 45% of households lacked adequate nourishment (Doutriaux, Geisler, and Shively 2008; Dang and Gerald 2008). Consequently, the crisis due to the reduction in coffee prices forced many farmers into bankruptcy due to lower outputs and higher production costs (Meike and Manfred Zeller, 2006). In addition, coffee producers lacked insurance, has difficulty in negotiating aid for operations without supporting institutions, and so hard to depend on credit organizations, making this a high-risk sector. Now the impact of the intensification of perennial crops combined with natural disasters and the destruction of land was keenly felt. Consequently, the local authorities reacted by setting limits on the coffee-growing area and by encouraging the development of other profitable crops, especially rubber. Following the Rubber Development Strategy of 2009, rubber plantations increased significantly, which again occurred at the expense of forestlands depleting vital forest resources, affecting local livelihood and society (To and Tran, 2014).

Because of natural resource depletion, the perennial crop production was dependent on inorganic fertilizer and excessive irrigation raising concerns about unsuitable resource use, land degradation, groundwater depletion and increased input costs (Lindskog et al. 2005). For instance, the rapid expansion of coffee and high deforestation rates over the past decades resulted in falling amounts of rainfall during the rainy season and increasing temperatures in the dry season compared to the historical average (Cheesman, Son, and Bennett, 2007). Meanwhile, as reported yearly by the UNDP/MARD, in 2003, Dak Lak province experienced five-month drought which affected more than 27 thousand ha of coffee and 40 thousand ha of other crops. The water level in reservoirs, rivers and ponds declined considerably, from two to ten metres. In 2004, the reservoirs contained only 60% water capacity, according to MARD. In 2005, Dak Lak lost about 64 million USD due to drought (Lindskog et al., 2005). Changes in weather patterns (resulting in water scarcity) and pest infestation led to enormous challenges in perennial crop production, especially in coffee production.

In the same way, social inequity emerged (For example, there were the land conflict between migrants and local indigenous people in 2004 due to acquisition of their income-generating opportunities (D'haeze et al., 2005; Winkels, 2008).

Deforestation has accounted for 31% of forested area since the 2000s, which has affected the shift of crop commodities for the international market, especially by capital-endowed migrants (Meyfroidt and Lambin, 2008, 2011; Meyfroidt et al., 2013).

- *Encouragement of farmer's to plant other profitable crops and the development of agroforestry products*

Intensification of perennial crops created increasing the natural disasters and land destruction. In response, the local authority set limits on the coffee plantation areas and encouraged the development of other cash crops. From 2002, the provincial government banned new planting of coffee trees and implement strict crop control requirements through enforcement of Land Use Certificates and bank loan policies (Jermy, Tran and Jeff, 2007).

At the same time, the national programme of socio-economic development during 2001–2010 undertook changes to the cultivation of coffee and rubber trees, the diversification by annual crops and fruits, the encouragement of agroforestry products, and the conversion to other crops in the unsuitable zones. 70% of areas were reforested, concentrated in Zone 3 (Lindskog et al., 2005; Meyfroidt et al., 2013).

A Land Law was promulgated in 2003, which codified the rights to use land as belonging to private households under the management of the state. The land was classified into three categories including agricultural land, non-agricultural land and unused land. Agricultural land was further subdivided according to eight purposes. Land users there had the rights to exchange, transfer, lease, sub-lease, inherit, and donate land use rights, mortgage, and guarantees. In terms of duration, the land rights validity was specified to be up to 20 years for annual crops, and 50 years for perennial crops and forested areas. Under the Land Law of 2003, the structure of agricultural land changed rapidly, especially for the coffee cultivation areas.

- *Mixed farming system*

Perennial crop growth continue in spite of dramatic decreases in coffee prices. Concurrently, through support policies such as facilitation, guidance, extension workers, financing and water policy, other crops as pepper and cashew increased steadily (Figure 5.8). Around 90% of the planted area was owned by small farmers (each farm was about one hectare) and the remainder by state-own farms (De Fontenay and Leung, 2002), focused on coffee cultivation.

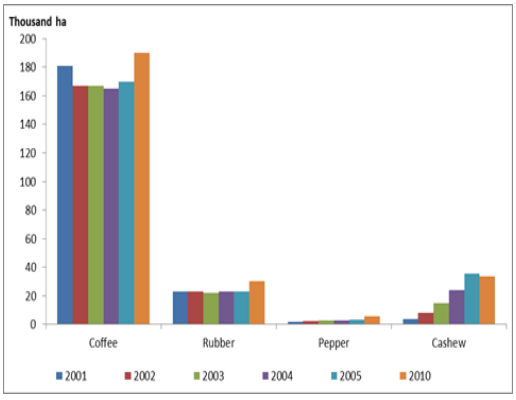


Figure 5.10: The area of perennial crops in 2000s

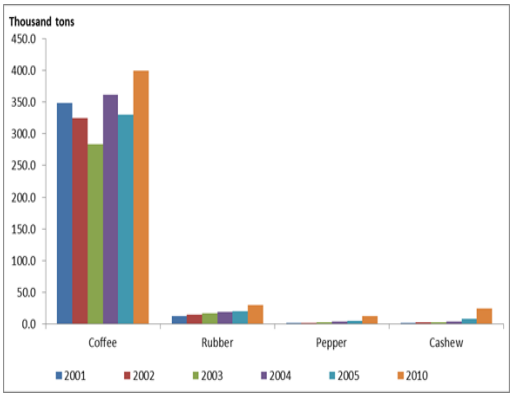


Figure 5.11: The productivity of perennial crops in 2000s

Source: (Dak Lak DARD, 2015; Dak Lak PSO, 2005)

In order to balance the land use, enabling economic benefits and limiting uncontrolled land exploitation, the national Socio-economic Development Program for 2001–2010

promulgated a focused plan of reforestation. The main crops were recommended to be integrated by diversification with cotton, sugarcane, and semi-culture.

In conjunction with this, coffee was encouraged to be converted into cacao, pepper, rubber, cashew and fruit crops to supplement households' income. Consequently, some indigenous farmers replaced their coffee plantations with annual crops such as maize and beans, while Kinh people began intercropping with annual crops, pepper or fruits to cope with the financial challenges.

Interestingly, mixed farming systems (MFSs) comprised of perennial crops, annual crops and livestock were practiced widely. As revealed by Chau, (2007), MFSs were more sustainable than the mono-coffee system in terms of ecological, economic and social sustainability. Marsh, (2007) argued, recognising lessons from the period of fluctuating prices, that intercropping pepper or vanilla in areas of planted coffee created higher economic performance.

Picture 5.3: Mixed coffee and annual crops, and shade trees (pepper, cashew)

Source: Author adapted

5.1.5. Current practices of perennial crops (2010—2018)

- *Perennial crop production faces many challenges*

Over the past quarter-century, agriculture has achieved great successes. It developed such prowess that many countries tried to learn from Vietnamese agricultural success, in particular, the lessons from the perennial crop sector which achieved explosive growth in export earnings.

Since the 2000s, Vietnam has ranked among the top five global exporters of perennial crops, particularly coffee beans and dried black pepper (JICA, 2013; Nguyen, 2017). Perennial crop commodities in Dak Lak Province include coffee, pepper, rubber, and cashew. These have been consistently identified as the main drivers for economic growth, currently and up till 2030 (Dak Lak DARD, 2015).

Unfortunately, external and internal factors have caused perennial crop systems to undergo significant changes since 2010 and they have recently faced various challenges.

The main constraints have been drought, ageing coffee trees, pests, and diseases, and fluctuations of commodity prices (CCAFS SEA, 2016; DARD, 2018), leading to concerns about reduced yields, and negative impacts on the provincial economy.

Firstly, to illustrate the point about drought, recently about 70% of the cultivated area in Vietnam has been impacted. In Dak Lak, over 42 thousand ha (equivalent to 60 million USD) were impacted. Accordingly, coffee productivity is estimated to have been reduced by 1.7% up till 2020 due to climate change (Nguyen et al., 2017). Additionally, as drought episodes have increased so have periods of excess precipitation, about 3–5 times/year. Recently, construction of wells and boreholes of up to 120m depth, which has been necessary to get water as the groundwater level has dropped so low, has further exploited the groundwater. Consequently, perennial crop production is facing challenges and the uncertainty for livelihood of rural households is exacerbated because of unavailable alternatives for economic activities.

The second issue is the ageing of coffee trees. As previously stated, although Vietnam has become the second-largest exporter of coffee (OECD, 2015), Dak Lak's coffee yield currently ranks just in fourth position after Kon Tum, Lam Dong and Gia Lai provinces, and is about 6%, lower than the Central Highlands as a whole country. The main reason for this reduction is ageing trees. In attempting to compensate for ageing trees, farmers must use heavy applications of fertilizer (e.g. often one ton of NPK and 3–5 tons of manure per hectare) and they must over-extract the groundwater (e.g. farmers must irrigate at a rate twice normal) (Amarasinghe et al., 2015; IDH, 2013; Scherr et al., 2015). While many older trees have not been replaced in suitable areas, there has been considerable expansion of planting new trees in less suitable or unsuitable area. Over one third of the provincial coffee plantation fields are about 15–20 years old, accounting for 20% of trees in Dak Lak and Lam Dong. In terms of land, about 877,000 ha is unsuitable area for coffee growing while only 22% is highly suitable (NIAPP, 2017).

According to the Dak Lak People's Committee, the rejuvenation of the coffee areas reached 26,800 ha during 2017–2018 (equalling 64.5% of the planned amount) (Figures 5.9 and 5.10) and until 2020, over 41,000 ha needed to be replaced. However, the replanting programme faced many difficulties for different reasons. Firstly, 95% of coffee-growing areas are held by smallholders, often being the main households' income. This problematic because replacing trees requires high investment capital while smallholder households' savings are often limited. According to Phan et al., (2019a), coffee farmers need at least 40 million VND per ha for the establishment of a newly planted plantation. Consequently, many households don't want to replace their plantations, even though the coffee trees are old and the output is decreasing. Another difficulty is the nurturing of seedlings. Recently, the government has supported coffee seedlings for farmers but the quality has been questionable. Added to this is also a lack of scientific and technical training courses related to criteria for successful replanting.

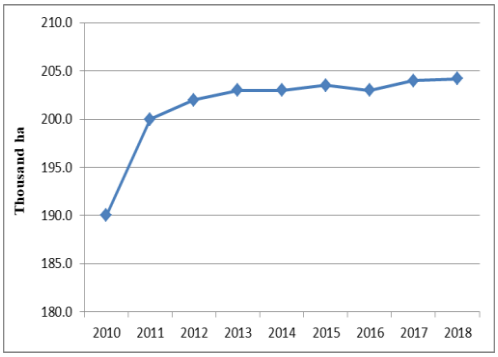


Figure 5.12: The evolution of Dak Lak's coffee area during 2010-2018

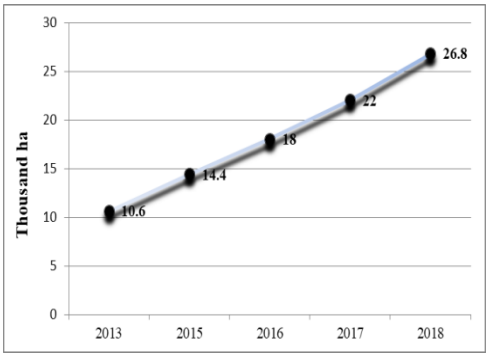


Figure 5.13: Rejuvenated coffee area from 2013-2018

Source: (Dak Lak Provincial People's Committee, 2018, 2019a)

Another current problem is diseases and pest incidence, which is exacerbated by the occurrence and intensity of droughts. Excessive application of nitrogen-based fertilizers (e.g. urea and NPK) in the absence of an optimal amount of water limits nutrient uptake of crops and facilitates the spread of infectious disease in crops (Scherr et al., 2015). This situation is serious in pepper production. The planted pepper area was over 40,000 ha in 2017, over provincial Master Plan (Figure 5.12), so vulnerability in the crop exists.

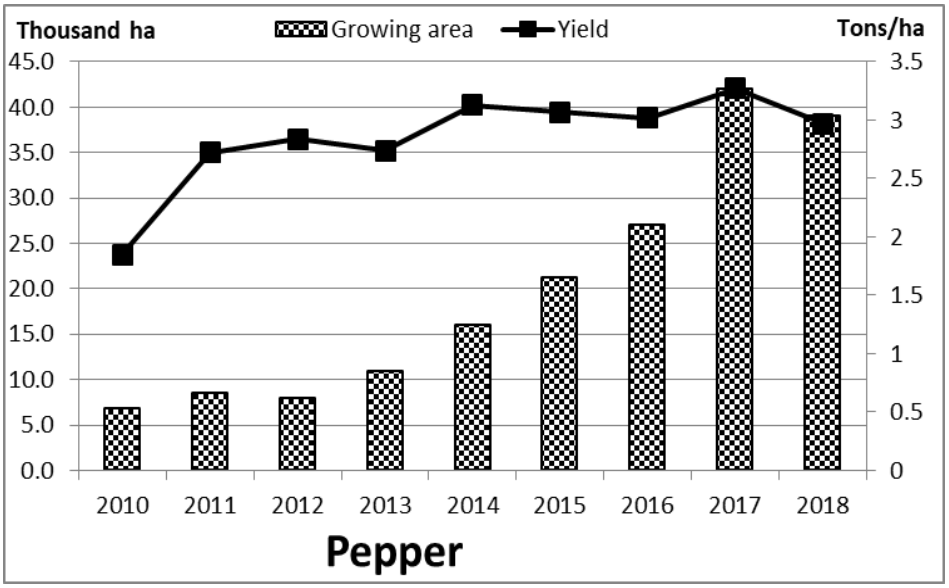


Figure 5.14: The growing area and yield of pepper sector from 2010 to 2018

Source: (Dak Lak PSO, 2014, 2019)

The limited application new technologies, agronomic practices and capital resourcesn lead to constraints and challenges. The sudden increase in prices from 2010 to 2016 encouraged intensification of production by overuse of chemical fertilizer, and unplanned

cultivation. The consequence has been that infection by pests and diseases has widely occurred and the pepper area of 2018 decreased in compassion to 2017 (Figure 5.14). According to some authors, Dak Lak had over 2,000 ha of crop losses in 2017 (Duong and Nguyen, 2019; Scherr et al., 2015; Nguyen and Bui, 2011). Furthermore, the lack of water and increasing cost of using wooden, and concrete pillars has caused increasing input costs. Beginning in 2017, the pepper price has declined strongly, being estimated at half its value as compared to mid-2016, which has brought many difficulties for growers (Quynh Lan, 2018) (Figure 5.15). Although pepper has been one of the primary products leading to economic growth, local government action has been limited in interventions for sustainable development. For instance, there has been a lack of extension services, good practice guidelines and preventive measures for infectious diseases. In the future, aid with transferring knowledge and technologies as well as to cooperation between governments, private companies, and farmers will have to be taken into account.

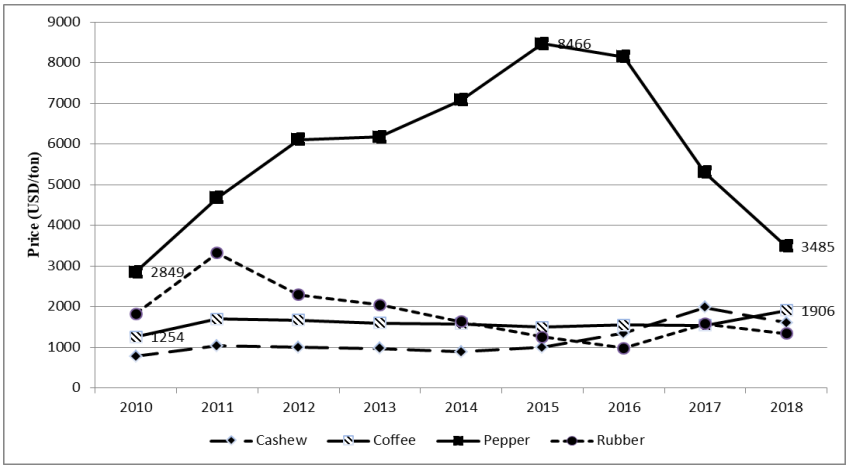


Figure 5.15: Evolution of international prices of perennial crops in Vietnam

Source: (Dak Lak PSO, 2010, 2018)

Because of their longevity, perennial crops are highly sensitive to disease and in Vietnam their success has primarily depended on the long-term behavior of the international market. In recent years, the fluctuation of price has caused challenges for the provincial economy and households' income. To cope with this, successful perennial crop practice has mainly had to have one of two decisions made regarding production strategy: the first is specialization by applying technology and meeting global standards on production to reduce environmental impacts, input costs and to enhance the quality of products; the second is to implement crop diversification, such as intercropping systems.

- *Current development of perennial crop systems*

- Specialization by application of innovation and contract for perennial crop production

Modern production techniques have gradually replaced conventional cultivation methods, creating a better market by effective farming management and higher-quality products, especially one the coffee farm (Nguyen et al., 2019). Some previous studies have demonstrated that a large percentage of the environmental pressure (50%) is reduced while the value is added and outputs are annually more stable thanks to

production certification, such as VietGAP, Global GAP. In other words, farm certifications contribute to stability when prices fluctuate and livelihoods are uncertain (Ho et al., 2018; Rueda and Lambin, 2013).

Table 5.5: Area and participants in certified coffee production

(1): Unit; (2): Area (thousand hectares); (3) Participants (thousand households)

Certificate	2013		2015			2017			2018		
	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)
UTZ	16.8	14.5	29.0	19.5	14.5	17.0	15.6	11.0	7.0	6.2	5.6
4C	36.8	23.0	-	37.1	25.4	14.0	25.2	15.5	4.0	8.7	6.7
RFA	7.4	3.2	3.0	4.3	-	3.0	2.1	-	3.0	5.1	2.8
FLO	0.2	0.4	1.0	3.0	0.5	5.0	0.6	0.3	6.0	0.7	0.5
GI	-	-	10.0	-	-	12.0	-	-	12.0	-	-

Source: (DARD, 2018)

There can be many kinds of support for the rejuvenation of farms, such as technical training, new seedlings, guidelines for land preparation, pest and disease treatments, crop rotation and loans. For example, in addition to the original planted Robusta coffee species (Coffea canephora), which has smaller seeds and lower yields, newer higher-yielding and healthier varieties have been recommended and introduced, there are better adapted to climate change, according to research, for example by the Western Highlands Agriculture and Forestry Science Institute (WASI). However, only 15% of coffee farms have applied for production certification in Dak Lak. One concern is that smallholders have found it difficult to meet strict standards criteria. Added to this are the significant problems of a lack of independence and the monopoly power of large commercial enterprises, leading to failures of smaller farms that attempt contract certification. Furthermore, certified coffee farms face difficulty when they obtain a lower yield than conventional farms, especially if they strictly follow the control of fertilizers and pesticides, if they don't have access to sufficient financial and other incentives.

Picture 5.4: Innovate perennial crop systems in Dak Lak

- *Expansion of diversified systems including agroforestry and intercropping systems*

Coffee agroforestry systems that combine coffee with shade-providing trees such as pepper, cashew and fruit, have developed in popularity because of market volatility. Many recent studies have demonstrated that coffee intercropped with the other crops (pepper, cashew, avocado and durian) generate higher profit. For instance, CPI and ICFs have proved to be more efficient than the mono-coffee systems due to the extent of the economic advantage in combinations of these crops (Phan et al., 2019a, Phan et al., 2019b). Medium intercropping models recently have reached an income of 186 million VND per ha, in half the time compared when to monoculture (Duong and Nguyen, 2019). Currently, Dak Lak province has 39,000 ha of coffee-based intercropping systems (CBIS), including coffee intercropped with pepper (20,000 ha, equivalent to over 50% of the total area of CBIS), coffee intercropped with cashew (500 ha), coffee intercropped with durian (3,200 ha), coffee intercropped with avocado (8,400 ha) and others (7,000 ha) (Figure 5.16). In particular, in terms of coffee and pepper intercropping systems, there has been a dramatical formation of these thanks to a sharp increase of pepper price. The combination of rising pepper prices along with the acceptance of decreasing coffee yields has encouraged adoption of this practice, in an effort to be "producing more from less".

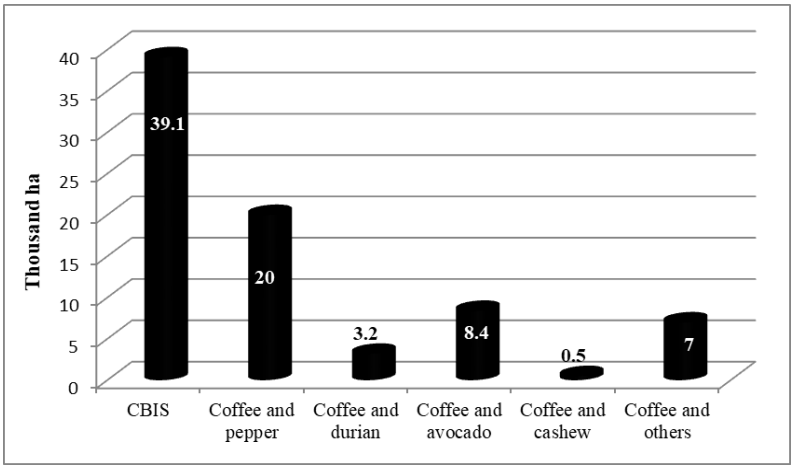


Figure 5.16: The contribution of coffee based intercropping systems (CBIS) in Dak Lak, 2018

Source: (Dak Lak Provincial People's Committee, 2019b)

To conclude, since physical expansion was unavailable in Dak Lak during 2010–2018, local farmers had to acknowledge the benefits of innovative techniques and diversification. Intercropping using shade trees or using drip irrigation were examples of practices which gained in popularly. However, the constraints included huge operation costs, highly technical requirement and cash flow problems (CCAFS SEA, 2016). Moreover, a lack of standards and the varied technical requirement from farm to farm created many difficulties or resulted in farms becoming less effective.

Picture 5.5: Coffee and pepper intercropping systems

Prior Unification 1975
Early Stage
Ecological impact
Abundant resources, ferralsols and favorable weather
Content
Perennial crop cultivation was controlled and occupied by the government
Private farmlands were non-existent
Very low population, low know-how, and simple equipment tools
Consequences for perennial cropping systems
Productivity depended on nature
Low yield and productivity
Coffee is the major crop behind the rubber
Large plantations by mono-culture popularly

1975 – 1986
State-owned farms and cooperatives
Ecological impact
Abundant surface and groundwater resources
Good conditions
Content
Resettlement campaign of population
Land allocation. Rights of property land was less common
Perennial crop production under state controll
Consequences of perennial cropping systems
Development of large-sized perennial crop plantations
Lack of intensification
Other profitable cash crops were initially introduced and expanded

1986 - 1990s
Intensified cropping systems
Ecological impact
Deforestation; Fluctuation of weather; Disease and pest appearance
Content
Economic Revolution; Land management; Good coffee price; Population explosion;
Private farms, small households and the state-owned farms
Consequences of perennial cropping systems
Coffee was greatly a expanded
Variety of cash crops intensified development

2000s
Integrated cropping system
Ecological impact
Climate variability and high deforestation
Content
Spontaneous immigration
Changes in land management
Decreased coffee market prices
Consequences of perennial cropping systems
Perennial crops were mixed with annual crops
Shade trees mixed perennial crop plantations

2010 to now
Specialized and diversified cropping systems
Ecological impact
Fluctuation of natural conditions
Low soil fertility
Aging trees and disease infections
Content
Price volatility
Long-term exploitation of perennial crops
Technology and innovation
Consequences of perennial cropping systems
Applying technology with specialized systems
Diversified products and systems
Primarily intercropping systems

Figure 5.17: Important historical milestones and consequences of perennial crop production

Source: Author's own summation

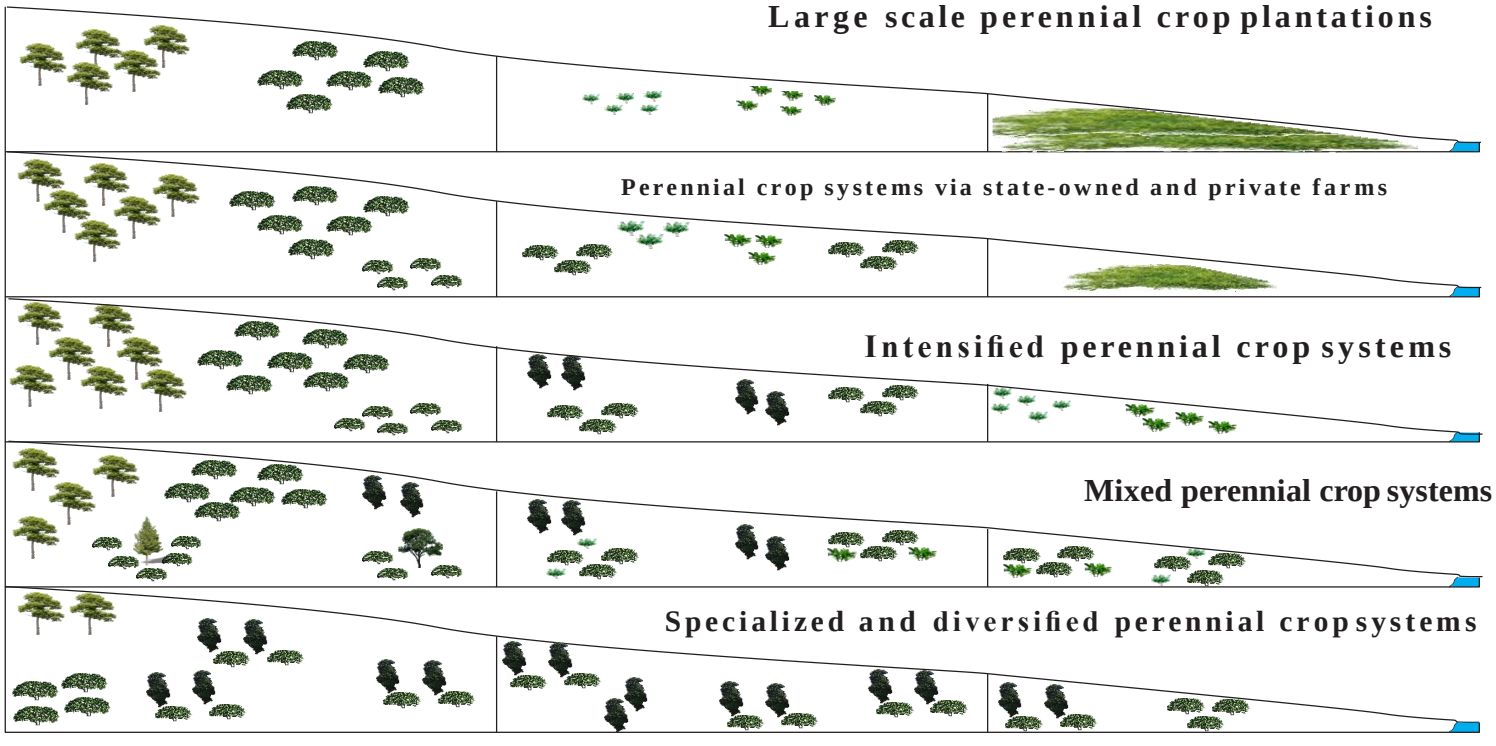


Figure 5.18: A chronological diagram of the local transect of the perennial crop systems in Dak Lak

Zone 1	Zone 2	Zone 3

Source: Author's own elaboration

5.2. The recent contribution of government to trends and the prospects for perennial crops

According to the World Bank, (2016), policies play a key role in the facilitation of adaptation by small-scale producers and their inclusion in the marketing chain. At a time, when this applies to the current situation, agriculture has recently undergone considerable structural change over time (OECD, 2017). Important to be factored into this is that Vietnam is considered as one of ten countries in the world that could be most influenced by climate change; this is expected to have significant effects on the perennial crop sector (World Bank, 2016). In other words, the perennial crop sector faces future uncertainties and risks that may lead to a reduction in the growth of productivity (OECD, 2015), especially for coffee and pepper. This is precisely why projections and perspectives on agriculture and perennial crops must be linked to the development of policies.

In recent years, the government and local authorities have underlined the significance of agroforestry systems that control perennial crop expansion and increase added value to ensure sustainable production and efficient trade. In Vietnam, production and trade of perennial crops have recently been paid more attention to and have achieved high praise and consideration, especially in terms of the coffee sector. To aid in the preservation of success, the Prime Minister recently declared in a strong statement "Vietnamese government announces the closure of over 2,253 ha of natural forest to other purposes, except as related to special defence and security. The Government does not undertake to transform low density forest to annual and perennial crops." In addition, regional policy has recently addressed perennial crop development. To illustrate this case, the Decision No. 2325/QĐ-UBND dated to 10 August 2016 and issued by Dak Lak People's Committee promulgated: "Agricultural restructuring towards raising added values and sustainable development to 2020 and with an orientation to 2030". Through the Extension Programme for Sustainable Coffee Production, the aim of the restructuring policy in agriculture was to increase the value and the sustainability, in order to achieve sustainability in Vietnamese coffee through to 2020, and then looking forward to 2030. This includes a wide range of objectives related to varieties, replanting coffee areas, and application of technology. The province has identified perennial crops such as coffee, pepper and rubber to be the main drivers of economic growth. According to the Ministry Agriculture and Rural Development, in the recent and next few years, coffee rejuvenation will be significantly concentrated, instead of being physically expanded, following the Decision 214/QĐ-UBND of "Replanting old coffee tree programmers during 2016–2020". This can be achieved by replacement of outdated processing technologies. Correspondingly, the provincial Master Plan shifts the orientation of perennial crops, by increasing yields and productivity rather than increasing the area. For example, about 180,000 ha of coffee-growing area will be remain stably in production, and while producing more than 478 million tons in 2020, it is projected to produced 563 million tons of coffee beans by 2030 (Figure 5.16). Additionally, the province is trying to encourage farmers to certify their coffee production, expecting to have 30% participation in 4 C, UTZ and Rain Forest certificate applications, instead of only about 15% at the current time. Continuing their support as in previous years, the Vietnam

Cocoa and Coffee Association (VICOFA) supported farmers with over 7,000 kg coffee seedlings for Dak Lak Province. Nestle Vietnam subsidized half the price of coffee seedlings to assist farmers with the replacement of the ageing coffee trees. Additionally, banks and other social organizations continue to provide loans for households to grow new coffee plants.

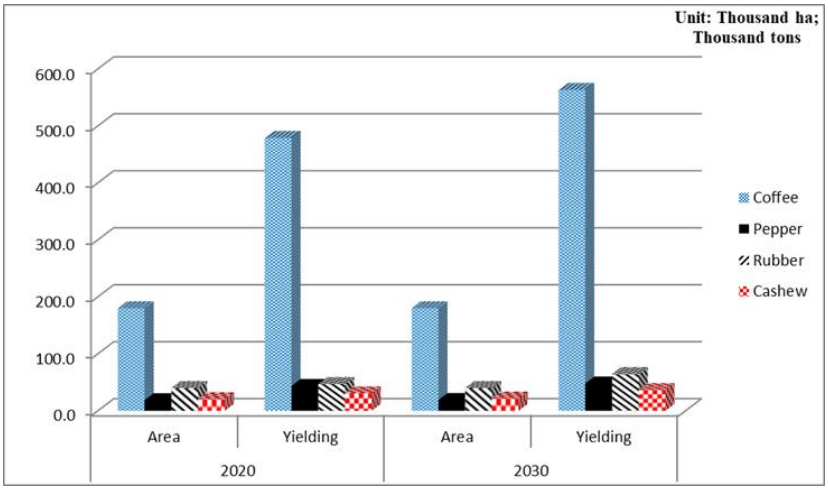


Figure 5.19: Master perennial crop Plan of Dak Lak province

Source: (Dak Lak DARD, 2015)

With respect to future promotion, the Protected Geographical Indication (PGI) and the Buon Ma Thuot coffee festival are involved in the expansion of strong international markets connections. PGI was registered in Vietnam in 2005 with 11 coffee producers in the province. Currently, the PGI has a presence in 15 countries and territories around the world, while the Coffee Festival's aim is to promote Buon Ma Thuot as a palce of origin for coffee. It's also a chance to honour coffee producers, processors and traders (Pictures 5.7 and 5.8). In terms of processing enforcement, there have been weaknesses in resources and environmental management and the government's regulation and management policies have had operational and protection difficulties that will hopefully improve.

Picture 5.6: Buon Ma Thuot PGI logo

Picture 5.7: Logo promoting Buon Ma Thuot Coffee Festival

6

Practices and socio-economic analysis of selected perennial crops

This chapter aims to provide a comprehensive study of general perennial crop practices at the small farm level in Dak Lak province and their socio-economic benefits, using comparison different systems, approaches and groups.

This analysis consists of three sections. In the first section, a principal overview of perennial crop practices and a reliable description of household characteristics is given, focusing on coffee and pepper crops. The second section provides a comparison of economic aspects of Mono-coffee systems (MCSes), Mono-pepper systems (MPSes), and coffee and pepper intercropping (CPI) with regard to costs, revenues, net farm income and profits. Finally, the social benefits of MCS, MPS and CPI in terms of employment creation, gender allocation in labor and labor productivity are discussed in the third section.

Parts of this chapter have previously been published as:

(1) *"An overview of perennial cropping system development and economic performance of perennial cropping systems in Dak Lak Province"*, Economics, Development and Sustainability, EDESUS conference proceeding 2019, VNU University of Economics and Business (UEB) in cooperation with Springer Publishing House.

(2) *"Economic analysis of perennial crop systems in Dak Lak Province".* Sustainability, 2019. Vol. 11, Issue 1. ISSN 2071-1050

(3) *"Which Perennial Crop Farm Approach Generates More Profitability? A Case Study in Dak Lak province, Vietnam"*. Asian Social Science 2019, Vol. 15. ISSN 1911-2017

(4) "*Recent evolution of perennial crop farms: evidence from Dak Lak Province"*. Agris on-line Papers in Economics and Informatics 2020, Vol. 12, No. 3, ISSN 1804-1930.

6.1. A brief introduction of perennial crop production

6.1.1. A description of perennial crop systems in research sites

A brief overview of three distinct perennial crop systems is illustrated in Table 6.1

Table 6.1: General characteristics of three selected perennial crop systems

Items	MCS	MPS	CPI
Grower[1]	Ethnic Minority group	Ethnic majority (called Kinh)	EMs and Kinh group
Nursery	Robusta	Domestic nursery (called Vinh Linh)	Robusta coffee Vinh Linh pepper
Nursery source	Self-produced	Self-produced	Self-produced
Space	3mx3m/ 3mx3.3m	2.5mx2.5m 3mx3m	Intersection Group
Wind-break trees	Needed	Not as needed	Not needed
Source of land	Owned and rented	Owned	Owned and rented

Irrigation sources	Well	Well	Well
Technical requirements	Medium	Very high	High
Risk	Low	High	Medium
Main tools	Machine, pipe, sprayer	Machine, pipe, sprayer, ladder	Machine, pipe, sprayer, ladder
Harvesting labor	Manual labor	Manual labor	Manual labor
Life expectancy	25	25	25
Rejuvenation	Popular	Less popular	-

[1]: In Vietnam, there can consider the to be three major groups including the majority ethnic group or Kinh, and others including indigenous people (called ethnic minority-EMs) and people who have migrated from elsewhere. Among the indigenous EMs, are those located primarily in Dak Lak, namely the E'de people (Thai, 2018a)

(Source: Secondary data, KIs, FGDs, Households' interview, 2018-2019)

6.1.1.1. Mono-coffee systems (MCSes)

As discussed in previous sections, the coffee sector brings many benefits to farmers such as income generation, employment creation and poverty alleviation (FAO, 2018b). In Dak Lak Province, the French initially grew coffee in the 1920s. Under colonialism, coffee farms existed as large-scale plantations. After that, the coffee-growing area expanded significantly over the subsequent decades. Currently, around 95% of coffee households owned small-scale (cited by Head of Dak Lak People's Committee, 2018).

At the time of the survey, the majority of EMs group hold MCSes. This may be because MCSes require fewer techniques and have a greater production certainty, while EMs as a group have been identified as being vulnerable, less educated, and in a situation of poverty with insufficient key assets and portfolio, as compared to Kinh people. There has a significant income gap among indigenous people and other groups (Thai, 2018b). Thus, MCSes are likely to be an appropriate form of investment. Furthermore, most MCSes are inherited from previous generations, especially among Ede people, and therefore farmers can often learn the practices involved in growing coffee by experience. Currently, MCSes are widespread in the region, which means the broad distribution allows producers to acquire knowledge and understand production. In some cases, MCS extensively become a "valuable asset" by selling coffee products from intermediaries. Farmers with limited income often sell unripe coffee cherries (*cà phê non*) for subsistence needs. Furthermore, as mentioned earlier, MCSes seem to be less risky, especially with respect to price uncertainties and crop losses compared with other perennial crops. This is one of the reasons why poorer growers are likely to choose MCSes (MCSes are characterized by lower initial and annual investment than that of CPI and MPS (Phan et al., 2019a).

Occasionally, MCSes are operated by agreement. This is because land-use rights are currently owned by cooperatives or state farms (in these circumstances the government deed, a "Green Book", states that planters cannot mortgage as assets, e.g. in the bank).

Thus, some growers are obligated to form MCSes. In recent years, some of these MCSes have been intercropped with shade trees or with annual crops for subsistence purpose, or to maintain soil fertility, under the control of cooperatives. MCSes require a considerable number of shade trees due to unique characteristics such as latency in flower buds and initiation of fruit development. In this study, other perennial crops (cashew and pepper vine); fruit trees (durian and avocado) and the others (*Leucaena and Senna*) were noted as being used as shade trees.

Various articles had demonstrated that increasing the area of shade-grown coffee reduces yearly irrigation round and maintains crop yield (Albertin and Nair, 2004; Bote and Struik, 2011; Cheesman, Son and Bennett, 2007). There is evidence that shaded coffee plots reduce light intensity over 50% as compared to unshaded coffee gardens while there are no differences in the number of flowering branches and fruit per tree (Chau et al., 2015).

Regarding the young plants, they are primarily Robusta seedlings (*Coffea canephora*), Robusta coffee reaches 30% of the total area and 40% of the total output in nationwide. Dak Lak province is the "coffee capital" (ICC, 2019). The reason for this is that Robusta coffee's characteristics are the most appropriate for Dak Lak region, with the altitude from 600 to 800m above sea level, and so Robusta grown here is able to obtain higher yields in comparison with other regions. Robusta coffee is considered to be more easy to cultivate and more has resilient features than Arabica coffee.

In terms of irrigation, according to statistical data, provincial systems such as reservoirs provide for only a part for perennial crop production, while about 25% of water requirements come from rainfall. Coffee trees need enough water to feed flower bud development and subsequent initiation of "cherry" development, which is absolutely crucial to achieving high yield. Consequently, wells become the main sources for irrigation. Data have shown that wells are now being drilled deeper to reach the aquifer. Some cases, households have to use at least 2–3 wells per plot.

Typical advice is that MCSes can utilize about 1,100 coffee trees per hectare with a space requirement of 3mx3m per tree. However in practice, current coffee gardens tend to have a lower density than recommendations due to crop losses. In some cases, planters do not replace lost trees, or they might add other crops (for example fruit trees or perennial crops) instead of filling in gaps with coffee seedlings.

Picture 6.1: A new planting system of mono-coffee

6.1.1.2. Mono-pepper systems (MPSes)

Black pepper crops (*Piper nigrum*) are mainly grown in tropical regions with a hot and humid climate. The Asian countries that cultivate pepper are India, Sri Lanka, Thai Lan, Indonesia, China, Malaysia and Vietnam. In Vietnam, the majority of pepper is cultivated in the Central Highlands, particularly in Dak Lak province.

Initially, pepper was grown at home in gardens for self-consumption as a spice. Over time, thanks to the sharp increases in prices, the cultivated area of pepper increased steadily each year, despite warnings from local authorities, with around 28,000 ha in 2018, more than suggested by the provincial plan. Recently, the mono-pepper systems have been formed by converting rubber, cashew and other the annual crops. For example, at first, pepper crops were intercropped into coffee farms, and then later shifted to mono-pepper systems entirely, and this has led to the higher areas of pepper that have recently been reported to be cultivated. Unlike MCSes, Kinh ethnic group are the main producers of MPSes (the Kinh represented 86% of the national population in 2018). Meanwhile, it may be that the differences of traditions or social inequalities between Kinh and other groups (e.g. education, awareness, assets and capital). Another reason is that Kinh people may own several plots, and so have more opportunities in choosing system types. In contrast, the capital and technical knowledge are obstacles to indigenous farmers (Thai, 2018a). Most of the pepper vineyards belong to the private property classification, having the deed known as "Cadastre (*Sổ đỏ*)".

Regarding propagation, the bulk of pepper varieties in the Central Highlands, in general, and Dak Lak, in particular, is a domestic variety called "Vinh Linh", accounting for 97.2% of cultivation. Most pepper propagation is done from a stem or terminal cuttings and rarely from seeds (NIAPP, 2017; Duong and Nguyen, 2019; Nguyen, 2010). According to farmers, the Vinh Linh variety is healthy, high yielding and well adapted in comparison to other seedlings. Pepper cultivation has fewer requirements with respect to shade trees, especially when pepper vines are trained on

pillars. The most common pillars used for pepper vines in the study site were wooden, accounting for over 70%. Additionally, wells were the commonest source of water for pepper irrigation systems. Although requiring fewer litres per application, pepper plots have to be watered more frequently compared to coffee.

Picture 6.2: A new planting pepper system

Picture 6.3: A mono-pepper system

6.1.1.3. Coffee and pepper intercropping - CPI

Intercropping systems like types of multiple cropping systems are likely be transition from monoculture, to improve income, enhance land productivity and improve the environment (Blanco-Canqui and Lal 2008; Gaba et al. 2015). The pathway that leads to intercropping systems have been applied worldwide thanks to its benefits. In terms of perennial crops, coffee has been intercropped with food crops, banana, and fruit trees (Asten et al., 2015; Coelli and Fleming, 2004; Ho et al., 2017).

In Dak Lak, CPI accounts for 20,000 hectares in 2018 (DARD, 2018), generating higher profit than mono-cropping systems (Phan et al., 2019a; Phan et al., 2019b). Initially, pepper crops were introduced into the coffee garden as shade trees or to prevent the wind in the dry season. However, because of a tremendous increase in pepper prices, more pepper was added to coffee plots which led to an increase in CPI. In the research site of this study, both coffee and pepper crops, with similar density are considered to become the main crops for households' income. Currently, CPI is practised using two main approaches including intersection (2 or 3 or 5 coffee rows with one pepper row intercropped, where pepper crop is grown at the intersection point of the coffee holes) and group (small sub-areas are designed in the plantation). Other items such as irrigation and propagation are similar to MCSes and MPSes.


Picture 6.4: CPI by interaction method and by group method

6.1.1.4. Crop calendar

A crop calendar provides information to ensure rational and efficient time management, helping farmers and agricultural extension experts in making an appropriate decision on crops (Yegbemey et al., 2014).

Figure 6.1 illustrates the calendar of coffee and pepper production in a given crop year. According to planters, they have very limited supporting the form of agricultural extension services. Thus, the practice primarily focuses on the personal experience and capability of households. According to coffee producers, as indicated earlier, the dry season is characterized by high sunlight and significant evapotranspiration. At this time irrigation is the main activity, playing a crucial role in the growth of coffee trees and maintaining yields. Coffee trees require more water from January to April to help flowers bud and assist the development of cherries. According to the advice of MARD, the coffee plots need approximately 650 litres/plant/round in three rounds (MARD, 2017). In this study, the irrigation of coffee trees was mainly done via private wells. However, due to this being "free water" (except for labor and energy costs), there is no control of the quantity used. Many farmers believe that coffee yields will increase if crops are watered more, so this had led to waste and inefficient use of irrigation.

Pruning is often done after the harvest season, and if done correctly, it can mean higher yields and higher productivity (Dufour, Kerana and Ribeyre, 2019). Both men and women perhaps participate in pruning. Sometimes, households use non-family labor hired with fixed wages (about 40 trees/day/person and 3000 VND/coffee tree).

Fertilizer application is often performed at least three times per year to provide nutrients for vegetative growth, help flower opening, and assist in fruit formation. The timing of application is from May to September and December to February. Generally, manure, compost and chemical fertilizers are used in flexible proportions, depending on farmers' capacity or cost. For instance, wealthy households may apply both organic and chemical fertilizers, while others may only apply chemical fertilizer on their farms.

Weeding is mainly controlled in the rainy season by tractors and herbicides which are more popular than hand-made furniture. Due to the wet weather, the need for weeding is due at least monthly, leading to waste of more laborers. The next essential task is harvesting, from September to December. Because of coffee and pepper characteristics of handpicking totally, hired workers (to cost 160–180 thousand VND per working day) mostly use beside family people.

In terms of pepper production, the pruning is only necessary for living pole of pepper vines. Unfortunately, in this study, a high percentage of pepper farms use dry pillars (wooden and concrete). It must be noted that pepper crops are extremely sensitive to water, and pests and diseases. In the rainy season, the water needs to be evacuated as fast as possible, to avoid the dramatical crop losses. For example, in 2016, due to bad weather such as ElNino, lack of rain or drought, pepper productivity of India, Brazil, and Indonesia decreased significantly in comparison in 2015.

Pepper vines need to be harvested on time with intense labor, from February to April (around three months). The timing of the harvest is different in other countries such as Brazil and Indonesia (July-September); Malaysia (June-September), Sri Lanka and India (April-July, November-December) (Dan, 2018; NIAPP, 2017). According to their response in interviewees, most CPI farmers implement concurrently operations to care for coffee and pepper crops such as fertilizing, irrigation and weeding. However, others separate each task to enable good crop growth. Accordingly, trees are often pruned in the rainy season, and this activity often requires a substantial number of able laborers (for trees such as *Cassia siamea* and/or *Leucaena leucocephala*). In some cases, the branches can be used as food for cows and goats. Some households decide to use other "productive" tree as pillars for pepper vines. The decision to hire labor or use the labor of family members depends on households' means.

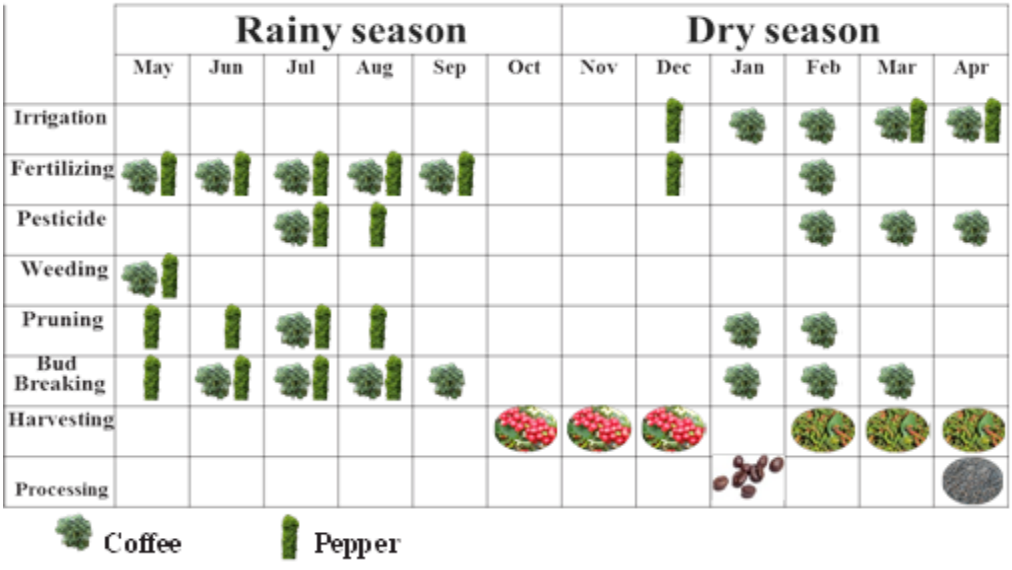


Figure 6.1: Coffee and pepper crops calendar during a cropping season

Source: Authors' own elaboration

6.1.2. General socio-economic and technical characteristics of perennial crop households

Selected households' profiles

Table 6.2: The perennial crop households' characteristics

Items	*N*	Min	Max	Mean	SD
The head of HHs (male response)	86	-	-	0.70	0.46
Kinh ethnic	86	-	-	0.68	0.47
Age (years)	86	25	72	49.42	9.84
Education (years)	86	0	13	8.07	3.61
Experience (years)	86	3	30	10.34	6.16
Training (% household (HHs))	86	-	-	0.47	0.50
Family labor work at farm (people)	86	1	8	2.23	0.96
Loan credit (% household)	86	-	-	0.49	0.50
Groundwater (% household)	86	-		0.91	0.28
Lack of water (% household)	86	-	-	0.38	0.48
Crop losses (% household)	86	-	-	0.41	0.49

Source: Authors' own calculation

Table 6.2 describes the characteristics of surveyed households in the research site.

The majority of respondents are Kinh people who are migrants from New Economic Zones (NEZs) programme or who have come due to other unregulated migration (D'haeze et al. 2005; Winkels 2008), estimated to be 68%. There are 30% female-headed households (HHs), except for the Ede households, where 38% were female. Regarding education, most had finished up to the 8th year of school in Vietnamese education, except for some Ede households. Farmers had significant experience in perennial crop production (around 10 years), which was provided by diverse sources such as parents, neighbors, social media, and agricultural experts. Interestingly, 47% of surveyed farmers affirmed that they had participated in training courses, implemented by the local authorities and companies. For instance, the sustainable trade initiative (IDH) engaged WASI, DARD, the Women's Union, and the Farmers' Union to complete a project to improve resilience to climate change in coffee production, from 2016 to 2018 (IDH 2018). In addition, for example, over 150 participants attended the workshop "farmers learning from farmers" organized by the Vietnam Coffee Coordination Board, the Global Coffee Platform, IDH, and the Sustainable Trade Initiative to enhance farmers' adoption practices and advance their knowledge (Global Coffee Platform, 2018).

Family members provided labor, with 90% working full-time, as in the case of husband and wife. The children sometimes worked on farms as part-time work. Therefore, the average family contribution to farming labor was estimated at 2.23 members. Younger laborers in a family seemed often go on to high school and maybe become workers in nearby provinces, and so most households tended to require hired employees, especially in the harvest season.

Financially, about half of the farmers borrowed money, from both formal and informal institutions. Part of loaned was often used for annual investment costs (buying fertilizer, pesticide, and hired labor), and the rest was used for ongoing costs (house construction, children's education).

Interviewees described their irrigation sources, and stated that it not only plays an important role in yields, but also decreases the risk of crop failure (FAO, 2015b). Dak Lak farmers often used groundwater as the irrigation source (91% in this study). However, many growers faced a lack of water, and 38% report that it could cause widespread damage for agriculture, in the Central Highlands and Dak Lak. 41% reported the death of some crops due to lack of water in this study and there was a drop in crop yields of more than 42,000 ha (nearly 60 million USD) in 2016 (CCAFS SEA, 2016). According to UNDP, (2017), two regions, namely the Central Highlands and South-Central Coast, are the most vulnerable to climate risk. In response to anticipated effects of climate change, at least, one well per household needs to be established. The inefficient use of irrigated water in the future may pose a problem and should be taken into consideration (Scherr et al., 2015).

- **Diversification activities**

Diversification of livelihoods is instrumental in reducing vulnerability, poverty and coping with economic and environmental problems (Gautam and Andersen, 2016). Relevant to this study, one of the most popular livelihood strategies in developing countries is crop diversification (Asfaw et al., 2017; Nguyen et al., 2017). In Vietnam, the improvement in production value and generating more household income are vital at a time when there is rapid development of the country and foreign trade. Crop farming is crucial in poverty reduction, employment creation and households' income. In the research site, diversified activities are their daily tasks and production goals. However, in these difficult times, growers admit that they are trying to look to various sources in order to generate more income and hopeful about the recovery of pepper and coffee prices in the coming years.

Table 6.3: Other income sources and diversified activities of households

	Items	Value
On farm	Income (Mil.VND/year)	15 Mil.VND/year
	Activities	
	Other perennial crops and fruits activities	80 %
	Annual crops	15 %
	Livestock and aquaculture	5 %
Off-farm	Income	18 Mil.VND/year
	Activities	
	Business	27 %
	Employees (Paid jobs)	40%
	Others (Officers and retired salaries, remittances)	33 %

Source: Author's own calculation

Table 6.3 states the other sources of income including on- and off-farm income of surveyed households, apart from MCS, MPS and CPI results.

These days, households grow other perennial crops (rubber, cashew), fruits (avocado, durian), annual crops (rice, maize, spice crops) and raise livestock (cows, chicken and goats). But the benefits of these only accounted for 15 million VND per year per household. The main income sources were from coffee and pepper plantations instead of crops and livestock like these. Often the main purpose of raising animals was for composting and to augment land fertility (e.g. the benefit of the efficient use of animal manure and coffee crop residues reduces input costs and mitigates against environmental degradation (Dadi et al., 2019; WASI, 2016b). With regard to annual crop (maize and rice) and spice crops (Turmeric), these are only grown when taking advantage of limited ground space land or in peripheral areas. Concerning fruits, many households intended to convert into fruit production, thanks to the good prices. However, these are long-term trees and require high, long-term investment. Thus, growers need to analyse a decision to change their crop carefully.

In terms of off-farm earnings, as reported by (FAO, 2015b), this area not only contributes to food security and poverty alleviation but also complements livelihood as a critical risk management tool. Especially in the case of agricultural shock, such extra-agricultural income helps to maintain the household livelihood. In this study, the off-farm earnings were about 18 million per year. Activities consisted of businesses, being drivers and other official salaries. These activities were mainly done by Kinh people, while the off-farm jobs of Ede group often involved being seasonal workers. In the future, increasing off-farm income needs to be considered as an improvement to households' strategies.

In summation, farmers seem highly specialized in perennial crops such as coffee and pepper crops, and these farms are the main contribution to main farmers' livelihood in Dak Lak province. Going forward, the local government should consider advice for their farmers or the promotion of marketing channels.

- **Farm size and land resources**

In Vietnam, the land is one of the main assets useful in maintaining a livelihood, especially for the indigenous people. In addition, land plays a crucial role as a pillar in farmers' livelihood, especially for small-scale farmers, and farm size is one of the indicators used to identify the available land resources. In the Central Highlands, approximately 67% of people live in the rural area and 64% of household's livelihoods depend on agriculture (Thai, 2018a; UNDP, 2017). Therefore, the land is a major resource of provincial households.

Table 6.4: Land situation of surveyed households

Indicators	*N*	Min	Max	Mean	SD
Number of surveyed plots	86	1	2	1.1	0.2
Average surveyed area	86	0.5	2	1.0	0.5

Source: Author's own calculation

Table 6.4 presents the situation of land of surveyed households. The number of plots of the sampled households was 1.1 pieces. Over 95% of those surveyed in the sample were smallholders with one piece, who held farms from 0.5 to 2.0 ha. Therefore, their average area for coffee and/or pepper crops was 1.0 ha (Table 6.4). In other words, most farms in Dak Lak are of relatively small size. This result seems to be similar with other countries in Asia (e.g. coffee cultivated areas are 1.6 ha in Indonesia) and in the world (with small farms of less than 2 ha operating on about 12% of the world's agricultural land) (Dak Lak Provincial People's Committee, 2017; Kaosa-ard and Rerkasem, 2000; Lowder, Skoet and Raney, 2016; World Bank, 2016). This small size means, therefore, there are difficulties in being able to afford and operate high technologies.

- **Farm management practices**

Table 6.5: Management of soil fertility in perennial crop systems

	MCS (n= 32)	MPS (n=28)	CPI (n=30)
1. Chemical fertilizer			
Major ingredient	NPK, Urea	NPK, Urea	NPK, Urea
Times/year			
Coffee	3		3
Pepper		3	1
2. Bio- fertilizer			
Major ingredient	Bio-fertilizer	Organic fertilizer	Bio and organic fertilizer
Times/year	1	1	1
3. Pesticides (Time/year)	2-3	3-4	3
4. Weeding method (%)			
Hand tools	30	25	30
Equipment	30	40	40
Herbicides	40	35	30
5. Irrigated water (Round/year)	4	5	5

Source: Author's own calculation

Farm management impacts on yields, income and production costs (Amarasinghe et al. 2015). According to the FAO, (2016b), adaptable farming has a crucial role for resiliency in crop production systems. In doing so, adoptions are needed for small-scale growers to produce more from the land while reducing environmental impacts as well as conserving natural resources.

In relation to soil conservation, activities required fertilizer application, management of pests, diseases, weed and irrigation, which not only maintain healthy soil, but also enhance crop nutrition to help crop growth, particularly during the sensitive

development stages of flower formation, cherry development and bean growth. The surveyed data shows that farmers use a relatively large number of rounds of fertilizer application. For these, mineral nutrients are NPK (N-nitrogen, P-Phosphorus, K-potassium) and urea, which are applied to replace the nutrients lost during the harvest and to encourage the growth cycle, usually three times per year. One application helps crops grow well after harvesting, another for flower development and the last is for cherry development. When asking the reasons for purchasing a specific type or brand of chemical fertilizer, the price, nutrient content, resellers, and advice from family members/neighbors were suggested. About 60% of interviewees admitted that they had insufficient knowledge to make the appropriate fertilizer choices. Besides this, recommendations concerning application intervals and nutrient status also informed their decisions. Organic fertilizers can be composed of lime, compost (coffee husks and animal manure) and bio-fertilizers (containing microorganisms) (Byrareddy et al., 2019). According to growers, although they are well aware of the benefits of manure for soil fertility, the amount used depended on output prices and the family's income. In this study, all perennial crop systems only applied bio-fertilizers once per year (Table 6.5). For MPS and CPI, farmers tend to select compost and lime, while for MCS there is a tendency to use chemical fertilizers. Some households keep cattle or goats, mainly for manure purposes (as described above).

Pesticides are chemical compounds used to kill insects using crops as their host (Kellogg et al., 2002). Brazil is the largest consumer of pesticides, and Espírito Santo State is the second largest one for coffee plantations (De Queiroz et al., 2018). In Vietnam, the poorer plantations rely largely on cheap, old and more toxic pesticides due to incorrect information and enforcement failure (Pham, Mol and Oosterveer, 2013). Thus, pesticide management is an essential consideration that needs to be addressed. In Dak Lak, pesticides are often applied to the soil or foliage by machine and MPSes seems to use more applications (3-4 times per year) than the others forms of cultivation do (Table 6.5).

With respect to weeds, during the rainy season in Dak Lak, the spread of weeds needs to be dealt with regularly. To aid and assist workers, equipment and herbicides are used. However, there are some concerns which have been raised about the short and long-term effects on soil and community health. According to farmers, cheap and convenient processing informs the decisions of producers on their choice of herbicides. The correct selection of herbicides is important because without proper information or management, crises in production may occur. Information and demonstration of proper use is advice that must be passed on to the local communities.

With respect to irrigation, as advice, coffee trees need to be provided with three rounds per year (650 litres/plant/round) (Amarasinghe et al. 2015). In practice, farmers try to add as much water as possible in the belief that to increase yields, four rounds in MCSes and five rounds in the others (Table 6.5) are required. The policymakers in water management should provide guidance and regulations for the sustainable development of perennial crops. Insufficient water management will lead to groundwater issues in the future.

- **The technical limitations of surveyed households**

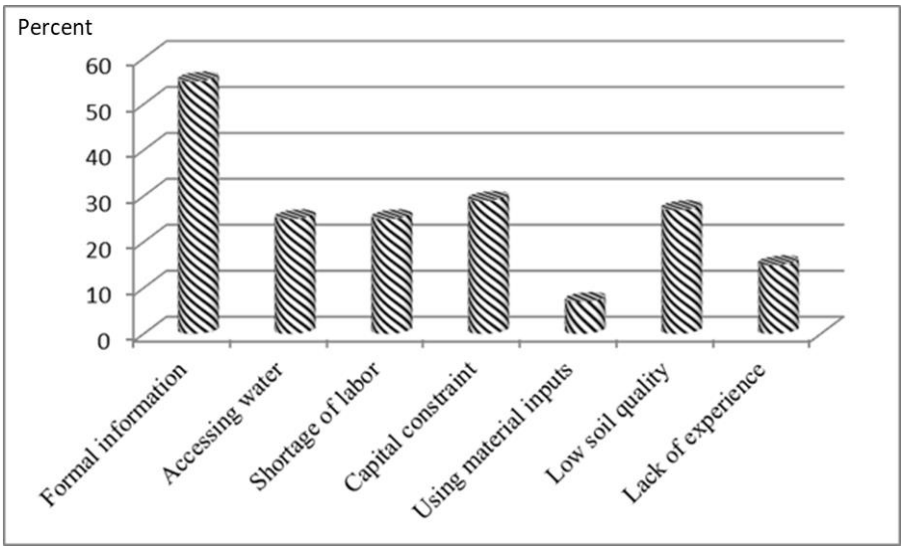


Figure 6.2: Technical limitation of households

Source: KIs, FGDs and Interviewees

As in other Vietnamese regions, Dak Lak's farmers struggle with technical limitations for their production. Over half of farmers lack official information sources. For instance, when farmers participate in training programmes, a range of consulting services recommend that growers should apply sufficient and correct amount of fertilizer and pesticide. Farmers need consistently high-quality advice on which product to use, the time of application, the number of rounds, and the quantity. This means having the precise advice and recommendations which are tailored to the specific fertilizer and pesticide. Growers also complain about the contents of training programmes that seem to pay so much more attention to introducing and promoting the sale of products rather than the sharing experiences and guidance on use. To cope, most farmers' operations often depend on experiences or learning knowledge gained through relatives or friends or neighbors rather than through extension workers and agricultural experts. A drawback is that the variety of informal sources can lead to confusion regarding pest and disease treatment and market tendencies. Obviously, in the global context, efficient production requires official reliable information such as proper pests and disease control practice, market prices, and information on management input to practise a good agriculture. Suitable knowledge for farmers needs has to be taken into account because education and knowledge will be able to help farmers with strategic behaviour to enhance their livelihood and deal with risks (Dijk, 2011; Ngo, 2018).

A) Mrs Kim, who is 58 years old, has experienced over 20 years in coffee production. She said that recently, coffee trees have an unusual disease, causing crop failure but she doesn't know what disease is and does not know who she needs to ask.

She only deals with the problem using her own experience. In the following years, she is displeased with her coffee plantation.

B) Mr Phan Van Quy, a pepper producer, said that information regarding good practices in pepper cultivation, especially in the treatment of pests and diseases, is extremely unreliable while the local authorities are an embarrassing situation. Ultimately, he used his experience to solve his problems, but he is worried about the future prospects for his farm.

Secondly, most farmers face obstacles in accessing formal credit from places like banks and social unions (e.g. Women and Youth Union). Meanwhile, nearly a third of respondents were highly dependent on informal financial sources and agencies. In recent years, due to regulation from official sources, collectors and agencies have become sponsors (*Bà đỡ*) to provide loans or fertilizers, pesticides, herbicides or food. To benefit from this, a verbal contract between farmers and agencies is agreed upon and in some cases, unfair prices are settled on (for prices lower than the current market value).

Thirdly, soil quality is a challenge for perennial crop development. For example, degradation and erratic rainfall have resulted in the appearance of some novel pests and diseases, and have resulted in poorly grown crops. In this study, roughly one quarter of farmers had soil quality problems. In order to explain this issue, farmers noted that, in addition to natural hazards, their practices were a contributing reason. For example, using excessive chemical fertilizer, irrigation, pesticides and herbicides all lead to reduction in soil quality.

Fourthly, labor constraints were estimated at 25%, and were commonly considered to be prevalent in perennial crop production, especially in the harvest period. In some cases, labor contracts for cherry picking, during harvesting season, were via verbal work agreement. Sometimes, farmers must accept ripe cherry losses when there is a labor shortage, or there must be working overtime. The local community can establish volunteers to support farmers during harvesting, but this is a limited labor force.

Fifthly, access watering is still an obstacle, affected by fluctuation in precipitation and over-exploitation of groundwater. Furthermore, the irrigation issue is related to the appearance of social problems due to the competition between producers as they compete for limited groundwater resources.

Sixthly, the lack of experience is a common constraint when perennial crops require technical skills and a deeper understanding, especially in MPSes and CPI.

Finally, in terms of material inputs, the primary onces are fertilizers, pesticides and herbicides. Specially, manure and mineral fertilizers provide the nutrients and soil maintenance. However, farmers note that, apart from what is produced in their own their farmyard, manure is expensive. Remarkably, some households have obtained fake fertilizers that have led to economic losses and crop failure. In order to avoid economic losses, farmers have a tendency to use variety of brands instead of trusting just one. Meanwhile, non-organic fertilizers and pesticides are available in so many types and brands that it has led to farmers being more confused in their choice.

- **Unsafe practices**

According to the FAO, (2018b), agriculture often deals with issues of occupational safety, and it is one of the most dangerous sectors to work in. Thus, agricultural work needs to be planned beforehand so that there will be a safe work environment, where

producers have considered and solved occupational safety and health issues. As expressed by the ILO, the contribution to occupational accidents are working with machines, vehicles, tools, slips, trips and falls from heights, exposure and organic substances (chemicals, and toxic agents) (ILO, 2011).

In this study, perennial crop growers were recorded to have suffered from occupational accidents. Specifically, spraying chemicals onto the farms seemed to directly affect on health and indirectly affect health through contamination of groundwater sources. This is significant because 100% of rural households in Dak Lak use groundwater for their living (cooking, washing, drinking) purposes. Another unsafe activity of perennial crop production is climbing accidents. With the height of pepper vines (4 - 6 m), farmers are sometimes subjected to accidents while picking ripe cherries and pruning the plants.

Picture 6.5: Some dangerous activities of pepper production

- **Farmers face economic losses by theft and agency bankruptcy**

Theft and bankruptcies are important factors that affect economic losses. Coffee and pepper theft happen frequently during the harvest season. According to farmers, thieves pick cherries or break into houses to steal coffee beans and dried black pepper. During the survey, thefts tended to occur in remote areas and in young people, who are unemployment. To prevent the theft, the local government has established patrol groups to intensify security during the prior-harvest and harvest seasons, but these groups are limited due to lack of funds and staff. At a grass-root level, farmers sometimes harvest unripe coffee and pepper to be safer or patrol in their fields. These methods reduce product quality and are costly due to added laborers. Thefts force farmers to store their products in intermediate warehouses leading to potential risks of losing their products because of an agency's bankruptcy (in Dak Lak, coffee bean and dried black pepper are stored at home to become a households' asset or sent to agencies in the local community). In recent years, Dak Lak province reports that the number of agency bankruptcies has grown. In the future, to reduce thefts, policies related to field protection is an option.

6.1.3. Characteristics of selected perennial crop systems

6.1.3.1. Profile of three selected perennial crop systems

The general characters of three selected perennial crop systems are presented in Table 6.6.

Table 6.6: General information of three selected systems

Indicators	MCS (n= 32)	MPS (n=28)	CPIs (n=30)
1. Average plot area (ha)	1.1	0.8	1.0
2. Density (trees/ha)			
Coffee	958.0	-	964.0
Pepper	-	1344.0	914.0
3. Average age of system (years)			
Coffee	17.0	-	13.0
Pepper	-	7.4	7.3
4. Yield (tons/ha)			
Coffee	2.1	-	2.3
Pepper	-	2.3	1.8
5. Crop losses	25.0	27.0	22.0
6. Distance (Kilometer)	1.8	0.5	1.7

Source: Authors' own calculations

For MCSes, the average growing area is estimated at 1.1 ha. The density reaches 958 trees per hectare, which is a lower density than the technical recommendation (1,100 trees per hectare) (ICC, 2019; Phan et al., 2015). The low density is a consequence of pest and disease infection (41%), causing many trees to die. In FGDs, farmers stated that the MCS is a relatively simple system to plant and care for, especially for Robusta coffee (e.g. over 90% of surveyed households have Robusta). However, the yield reaches only 2.1 tons per ha (Amarasinghe et al., 2015) because of the high proportion of ageing trees (in the study, MCSes are 17 years old on average) and the climatic fluctuation. According to agronomists of the Dak Lak People's Committee, a coffee farm needs to be rejuvenated if its yield is under 1.2 tons/ha (Dak Lak Provincial People's Committee, 2019a).

The MPSes have evolved from initial residential plots of very small acreage over the last few decades. In recent years, they have developed significantly due to favourable prices. However, the average pepper plot size is 0.8 ha, on the smallest scale compared to the rest of MCSes and CPIs. According to respondents from the survey, instead of renewing old coffee plantations, they often switch to pepper cultivation to take advantage of attractive prices into two ways: (1) pepper plants are planted in vacant spaces in old coffee plantations, and after that, farmers cut down individual old coffee trees to cultivate pepper; (2) whole old or unproductive coffee orchards may be removed, after that, pepper trees are planted in the area. The stepwise replacement of pepper this way leads to a lower density, as do problems like disease. This is why pepper density isn't higher, only 1,344 trees per hectare. Unfortunately, black pepper is a disease-sensitive crop. Black pepper disease affected about 2,000 ha in 2018 (equal

to 13.2% of all plant diseases in the whole country, including footrot or quick wilt disease, pollution-related disease, slow decline or slow wilt, and stunt disease). Despite its susceptibility to disease, the dramatic collapse of coffee and rubber prices and high pepper prices and encourages farmers to grow pepper. Most MPSes have been planted since 2010, which is quite recent (7.4 years) and now produce high yields estimated at 2.3 tons per hectare. Surveyed data shows that MPSes are cultivated in areas not zoned for farming, thus this is done in an unregulated manner, with more wooden and concrete pillars used rather than live plants. There has been replacement of ponds and rice fields to have more land to grow pepper. Farmers stated that they expect a rapid development of pepper cultivation and after planting expect rapid gains in quantity as well as a quick harvest.

In terms of diversified systems, CPI can obtain a high yield, more returns or mitigate environmental damage as reported in previous studies (FAO, 2019; Lin, 2011; Marsh, 2007). For instance, in Uganda, smallholder farming systems get benefits from coffee-banana intercropping (Asten et al., 2011) while in Thailand, rubber-based intercropping systems (other perennial crops or fruits) attract more participants due to various benefits (Romyen, Sausue and Charenjiratragul, 2018). In Indonesia, coconut intercropping systems obtain more profits than mono-cropping (Godoy and Bennett, 1991). In Dak Lak, farmers are motivated to diversify by growing coffee with other perennial crops such as pepper, and cashew. In this manner, CPI is undergoing widespread development. Over time, these models have been expanded widely and have been enthusiastically adopted by farmers for their plantations. According to the surveyed data, CPI is quite recent (7.3 years for pepper, 13 years for coffee, and with 1.0 ha of plot size). The density estimates were at 964 coffee trees and 914 pepper trees per hectare, including two intercropping methods of groups and intersections. In this case, a group is defined as each small sub-area of coffee and pepper in the orchard, while for intersections two, three or five coffee rows are grown with one pepper row, where pepper is grown at the intersection point of coffee holes. CPI is estimated to produce 2.3 tons of coffee and 1.8 tons of pepper/ha (Table 6.6). According to interviewees, having too high pepper density leads to decreased yield due to the competition for space and light. Furthermore, the techniques that are involved cause some production difficulties (e.g. in irrigation and harvesting).

6.1.3.2. The profile of perennial crop by type of approach

Table 6.7: Characteristics of different farm approaches

	Items	MCFs (N=32)	ICFs (N=30)	MPFs (N=28)	IPFs (N=30)
1.	Average farm area (ha)	1.1	1.0	0.8	1.0
2.	Density (trees/ha)				
	Coffee	1,092.0	830.0	-	-
	Pepper	-	-	1,163.0	900.0
3.	Age of trees (years)	18.0	14.0	8.0	7.0
4.	Yield (tons/ha)	2.0	1.9	2.2	1.7
5.	Average crop losses (trees/ha)	28.0	21.0	32.0	23.0

Source: Authors' own calculations

For a detailed description, the approach of a coffee and pepper farm is provided, which includes mono-approach and intercropped approach (Table 6.7).

In this section, the study revealed general information of coffee and pepper farms' profiles, according to farm types. In sizes, apart from the mono-pepper farms in residential gardens, the plots are similar at around one-hectare. The MCFs and MPFs had a higher number of trees, quite dense with1,092 coffee and 1,163 pepper trees per ha. The density of coffee and pepper was at 830 and 900 trees, respectively for ICFs and IPFs. This also implies that the densities of MCFs and MPFs are lower than as advised by technical services (e.g. lower than 1,100 for coffee and 1,700 for pepper trees) while pepper intercropped farms are higher than the recommendation (MARD, 2017, 2018). The number of crop losses for intercropped farms seems to be lower than that of mono-crop plots, up to 28 coffee and 32 pepper trees per ha. When trees are lost, farmers tend to replace these crops. However, in 2018, the pepper price decreased significantly by 50% which discouraged planting by farmers compared to mid-2016 (Quynh Lan, 2018). The yields for MCFs and MPFs were found to be higher than for intercropped plots, at 2.0 tons for coffee and 2.15 tons per ha for pepper (Table 6.7).

6.1.3.3. The information of perennial crop by coffee and pepper producing groups

Another classification of coffee and pepper farms is the group classification, which includes group producing coffee (GpC) and group producing pepper (GpP).

Table 6.8: Profiles of group producing coffee (GpC) and group producing pepper (GpP)

Items	GpC (n = 62)		GpP (n = 58)	
	Mean	SD	Mean	SD
1. Sample size (hectare)	0.9	0.6	0.9	0.4
2. Density (trees/hectare)	936.0	125.0	1,197.0	213.0
3. Age of farm (years)	16.0	8.0	7.5	4.0
4. Yield (tons/hectare)	2.0	0.8	1.9	0.9
5. No. of crop losses (trees/hectare)	24.0	56.0	32.0	60.0

Source: Authors' own calculations

Generally, the average cultivated areas of GpC and GpP are similar, estimated at about 0.9 ha per farm group. This means that perennial crop farms are characterized mainly as smallholders in accord with the (World Bank, 2016). In addition, the densities reached 936 crops in GpC and 1,197 crops per ha in GpP, respectively, which were lower than the technical recommendations (1,100 coffee trees and 1,700 pepper trees per hectare). Moreover, the yields among GpC and GpP are 2.0 tons for coffee bean and 1.9 tons per ha for dried black pepper, which are smaller than that of the nation as a whole, and smaller than for other countries such as Indonesia and India (NIAPP, 2017; GSO, 2018).

For these systems, crop losses have a major negative effect on the wellbeing of rural households. More importantly, among the two groups, the numbers of crop losses are 24 for coffee crops and 32 for pepper crops per ha for the 2017/2018 season, respectively (Table 6.8). This represents a significant threat against yields and economic benefits. Previous reports have shown that major food and cash crops like rice, wheat, maize, coffee and pepper are quite readily attacked by pests and diseases, at a rate of 20 to 40 % at national and regional levels (Oerke et al., 2012). For instance,

yield losses are estimated at 5% for apples in the Netherlands, and coffee yield losses reach up to 45% in Brazil (Barbosa et al., 2004; Leeuwen et al., 2000). In Vietnam, according to Ton and Buu, (2011), pepper foot rot or yellow leaf disease causes crop losses of from 9%–95%. To explain crop losses, we need to take into account the considerable expansion of perennial crops into less suitable or unsuitable land (equivalent to 20% in Dak Lak and Lam Dong) as well as the age of the coffee tree stocks (e.g. over one-third of the provincial coffee growing area has an age of 15–20 years). In addition, in terms of GpP, in recent years, due to the very high price, excessive fertilizer has been used in an effort to increase yields, leading to soil acidification and susceptibility to a greater number of crop diseases. Thus, farmers and government agencies should implement guidelines on how to allocate resources for better control of pests and diseases to avoid crop losses.

6.2. Economic results of the selected perennial crop systems

6.2.1. Economic performance of selected perennial crop systems

6.2.1.1. The cost analysis of three selected perennial crop systems

An analysis of costs can assess the investment costs requirements of each cropping system, which may result in barriers to farming systems. With respect to perennial crops, it is not easy to shift to other crops due to long economic lifespans and high establishment costs compared to annual crops (Gunathilaka et al. 2018).

To access the costs, identification of both the start-up and the annual costs are needed, as these play an important role in influencing the growth and productivity of the perennial crop systems.

- **Start-up cost**

Table 6.9: The start-up cost of selected perennial crop systems in the 2016/2017 crop year

Unit[1]: Million VND per ha

Items	Farming system					
	MCS		MPS		CPI	
	Mean (n = 12)	SD	Mean (n = 14)	SD	Mean ((n = 11)	SD
Start-up cost[2]	**38.5[a,c]**	**22.0**	**147.5[a,b]**	**102.0**	**65.3**	**31.5**
Land preparation	**4.0**	**2.8**	**4.9**	**7.5**	**3.3**	**5.7**
Materials costs	**19.5[a,c]**	**11.3**	**130.5[a,b]**	**98.0**	**42.3[c,b]**	**28.8**
Pillars***	-	-	87.8	78.5	15.3	30.0
Holes	2.8	2.3	6.5	8.3	2.5	3.0
Nursery	12.0	8.3	9.4[b,c]	20.5	3.6[c,a]	3.0
Fertilizer	3.0[a,c]	3.9	23.0[a,b]	24.0	19.0	11.0
Pesticide	0.4	0.6	0.1[b,a]	0.4	0.2[c,a]	0.4
Others	1.2	0.8	3.5	4.2	1.4	1.3
Labor	**15.0[a,c]**	**10.0**	**12.3[b,c]**	**4.2**	**19.7**	**7.0**
Hired labor	3.0	3.3	3.2	4.2	1.3[c,a]	2.8
Family labor	12.0[a,c]	7.0	9.0[b,c]	4.7	18.4	5.0

Note: [1] Exchange rate: 1 USD = 23,000 VND. [2] The costs include family labor. Mann-Whitney U Test *** Significant at 1% level. Different superscripts (a, b, c) denote a significant difference between means within rows ($p<0.10$).

Source: Authors' own calculation

Firstly, the detailed upfront capital cost are presented in Table 6.9. This startup cost is estimated at 38.5 million for MCSes, 147.5 million for MPSes, and 65.3 million VND per hectare for CPI. It includes various costs such as land preparation, materials, and labor. The surveyed results show that most plantations which were renewed replaced old and unproductive coffee trees. For the detailed analysis of startup costs, land preparation, cutting trees, ploughing, and cleaning operations to grow new crops were considered. Normally, MCSes and MPSes farmers hire contractors to do those activities instead of doing it themselves, especially ploughing and (growers responded that ploughing was important because new cultivation is a rejuvenation that decides how well new crops will grow). MCS and MPS farmers holding a few plots prefer to have a more's scientifically planned operation. In contrast, CPI seems to be taken advantage of more family labor for farm practices. Therefore, these costs amount to 4 million for MCSes, 4.9 million for MPSes and 3.3 million VND per ha for CPI (Table 6.9).

Materials expenditures were the highest of the startup costs, and these included pillars, digging holes, nursery costs, fertilizer, and pesticide costs. The study shows that MPSes had higher material costs than MCSes and CPIs, at 130.5 million VND per hectare, in which the pillar cost (either concrete or wooden) was the dominant factor in the materials costs, making up to about 90 million VND per ha. According to farmers, pepper plants cultivated using pillars (wooden and concrete) produce a faster harvest that farmers can take advantage of to respond more quickly to high pepper price, so this increases their use.

In contrast, CPI had lower pillar costs than MPSes since they use live plants as support propagated by the farmer or purchased at a low cost, estimated at 15.3 million VND per ha. By comparison, the concrete and wooden pillar price was around 160,000 VND/pillar, whereas plant support amounted to only about 7,000 VND/pillar. Therefore, a recommendation will reduce the establishment costs in MPS is the use of living trees for support instead of wooden or concrete pillars.

Another material cost is nursery cost. For these, plants can either be propagated by the farm family or certified plants purchased. According to local authorities, propagated coffee plants are provided for farmers by government to replace old coffee trees, but there is no policy for new pepper plants. As a result, the nursery cost for pepper is the highest compared to CPI and MCSes, at 9.6 million VND per ha.

The next cost is fertilizer including manure and chemical fertilizers. MPSes and CPI had high levels of fertilizers uses (23 million and 19 million VND per ha, respectively), whereas MCSes only used 3 million VND per ha (Table 6.9). Coffee farmers used less manure or compost in the startup process, which influences the growth quality of the crop and productivity (Amlinger et al., 2001). The study found that most farmers applied more manure or compost than chemical fertilizers. Manure (created from pigs, cows and chickens, and from coffee raw materials) was applied in the first week after

planting, and included farmer-produced (30%) and purchased (70%), given at rate of 10-20 kg/tree.

Regarding labor costs, this included costs for cleaning, preparing plantations, digging holes, planting nursery plants, and setting pillars. MPSes had the highest hired labor cost, at 3.2 million VND per ha. MPSes were recorded as using more male workers to set the wooden and concrete pillars (Table 6.9). Probably because setting wooden and concrete pillars requires labor involving heavy lifting. In contrast, CPIs had higher family labor and lower hired labor costs than MCSes and MPSes, accounting for 18.4 million and 1.3 million VND/ha. This means that CPIs took better advantage of family labor (both men and women) for the care and planting instead of being used to set pillars, thus saving on hired labor costs.

- **Annual cost**

In this section, the question of how much money farmers spend for their cropping systems in Dak Lak Province during a year is addressed.

Table 6.10: Production cost of three selected perennial crop systems in 2016/2017 crop year

(Unit[1]: Million VND per ha)

Items	Farming System					
	MCS (n = 32)		MPS (n = 28)		CPI (n = 30)	
	Mean	SD	Mean	SD	Mean	SD
Annual cost (AC)	**43.6** [a,b]	**11.1**	**87.6**	**39.3**	**86.3** [a,c]	**23.3**
1. Intermediate cost (IC)	18.5 [a,c]	6.8	38.7 [a,b]	25.4	28.5	12.2
Fertilizer	13.0 [a,b]	5.8	24.6	18.0	20.9 [a,c]	9.5
Manure	2.6 [a,c]	5.3	11.0 [a,b]	13.2	6.1	7.0
Agro-chemical use	10.3 [a,b]	4.1	13.5	6.6	14.8 [a,c]	6.0
Pesticide, stimulants	2.4	2.2	10.4	10.6	4.2	4.1
Fuel irrigation	1.4	0.6	1.3	0.7	1.6	0.9
Others	1.0 [a,b]	0.8	1.8	1.1	1.0 [c,b]	0.6
Transporting	0.5	0.3	0.4	0.3	0.4	0.3
Packaging	0.2 [a,c]	0.1	0.3 [b,c]	0.3	0.3	0.2
2. Labor cost	21.5 [a,b]	4.7	39.2	13.7	45.8 [a,c]	13.6
Hired labor cost	3.3 [a,b]	3.2	7.6	5.1	11.7 [a,c]	7.9
Family labor cost	18.0 [a,b]	4.6	31.6	12.0	34.0 [a,c]	14.0
3. Loan interest[2]	1.9	3.0	2.6	4.0	2.9	4.3
4. Depreciation	1.8 [a,b]	0.9	7.0	2.4	5.5 [a,c]	4.0

Note: [1] Exchange rate: 1 USD = 23,000 VND. [2]Interest rate = 10%. Different superscripts (a, b, c) denote a significant difference between means within rows ($p<0.10$).

Source: Authors' own calculations

The annual cost of MCSes was 43.6 million, the cost of MPSes was 87.6 million, and the cost of CPI was 86.3 million VND per ha. These costs had higher intermediate and labor costs, which were the two main components.

With respect to intermediate costs (IC), MPSes had the highest, at 38.7 million VND per ha, with MCSes at 18.5 million and CPI at 28.5 million VND per ha (Table 6.10). Fertilizers, pesticides and stimulants tended to be overused during annual production. The survey data indicate that fertilizers represented 70% of intermediate costs for MCSes, 64% for MPSes and 73% for CPI. Specifically, inorganic fertilizer was applied as a key input in coffee and other industrial crops in the three systems. For instance, coffee farmers used agrochemical fertilizer making up 56% of total the intermediate costs, whereas fewer farmers said they use organic fertilizer in this model, accounting for only 14% of intermediate costs. A smaller number of farmers used manure, with the reasons being: (1) manure is more expensive than chemical fertilizer, and (2) a large number of old coffee trees need to be replanted (after about 15 years), which discourages farmers from investing in manure. For poor farmers, the cost of tree renewal is a serious threat to their livelihoods, so using manure exceeds their investment capabilities (Hurri and Ngoc 2015). In addition, pesticides, and growth stimulants for MPSes are costly, at 10.4 million VND per hectare (26.8% of intermediate costs (IC)), higher when compared to the others (Table 6.10). This is explained by (1) pepper plantations having a higher incidence of disease (Nguyen, 2010); (2) most plantations had to deal with a high incidence of infectious diseases (e.g. 90% of the surveyed households had at least ten crops lost to diseases); and (3) the results of FGDs show that pepper crops using wooden and concrete pillars had the worst diseases. Because households expect pepper to grow quickly and able to reap rewards from a good market, this often leads to a higher rate of stimulant use. However, if the pepper price continues to drop, as coffee did some years ago, farmers in FGDs revealed they would have to reduce fertilizers and other inputs. According to Ho, Yanagida, and Illukpitiya (2014), the ratio of output to pesticide only reached 0.13%. In 2017, pepper cultivated area overshot provincial master plans, amounting to a growth of 150%. This led to an over abundance on the market and reduced pepper prices by half to just VND 110,000 (4.8 USD) per kilogram compared to the previous year.

Regarding labor, perennial crop systems require high inputs in this area. Most labor costs are for harvest, with MPSes at 39.2 million VND per hectare (45.5% of annual costs) and CPI at 45.8 million VND per hectare (58% of annual costs), with both being more labor-intensive than MCSes (Table 6.10). This is because black pepper requires more labor (e.g. only 40 kg fresh of pepper/day can be harvested, compared to 100 kg fresh coffee/day for the same amount of labor). This creates labor pressures, especially during the pepper harvest season, and especially since the harvest time isn't expandable due to pepper growth characteristics. With respect to the CPI system, since coffee has a harvest period from September to December, and pepper from February to April, the use of family labor is facilitated. This system has the greatest number of family labor days compared to the other systems, making up about 213 days over the year (Table 6.10). In summary, the available evidence shows that MCSes incurred the lowest production costs, whereas MPSes had the highest. This has implication for sustainability (e.g. health and

environmental risks), as well as for the creation of problems accessing export markets in the future due to high chemical residues in products.

6.2.1.2. A profitability assessment of three selected perennial crop systems

Assessment of profitability of perennial crop systems is a means to understand the production incentive and a means to address the dynamics of production.

Table 6.11: Net return of MCSes, MPSes and CPI in 2016/2017 crop year

(Unit[1]: Millions VND per ha and million VND per ton)

Items	Farming System					
	MCS (n = 32)		MPS (n = 28)		CPI (n = 30)	
	Mean	SD	Mean	SD	Mean	SD
1. Gross Output (GO)	80.8[a,b]	19.0	253.5	89.0	285.4[a,c]	82.7
2. Selling price						
Coffee	*37.0*	-	-		*37.0*	-
Pepper	-	-	*110.0*		*110.0*	-
3. Value added (VA)	62.4[a,b]	15.7	214.7	71.5	256.8[a,c]	81.9
4. Net farm income (NFI)	54.5[a,b]	15.7	197.0	68.0	235.4[a,c]	79.0
5. Profit	37.0[a,b]	13.3	165.0	59.0	201.0[a,c]	76.0

Note: Note: [1] Exchange rate: 1 USD = 23,000 VND. Different superscripts (a, b, c) denote a significant difference between means within rows ($p<0.10$).

Source: Authors' own calculations

Economic efficiency in the three perennial crop systems can be differentiated by considering the total output, value-added, net farm income, and profit.

The output of MCSes, MPSes, and CPI reached about 81 million, 254 million, and 286 million VND per ha respectively (where total output equals the coffee and/or pepper yield multiplied by the coffee and/or pepper price) (Table 6.11). Net farm income was about 54.5 million for MCSes, 197 million for MPSes, and 235 for CPI, whereas profit figures were 37 million, 165 million, and 201 million VND per ha, respectively (Table 6.11). This is explained by coffee price declines in recent years, being today about one-third of pepper prices. Furthermore, the ageing tree stock has been leading to declining productivity. The mono-cropping inefficiency level of synchronization and segregation is around 18% (Ho et al., 2017). This means that CPI had the best performance for the above indicators among the three systems due to the presence of scope economies of coffee and pepper.

6.2.2. Cost and return analysis of perennial crop production by the approach type

In order to facilitate understanding of the contribution of coffee and pepper to the development of perennial crop production systems, a cost-benefit analysis by type approaches was undertaken and detailed in Table 6.12.

Table 6.12: Cost-benefit analysis of different approaches of perennial crop farms in 2017/2018 crop year

(Million VND per ha)

Items	MCFs (N=32)		ICFs (N=30)		Sig	MPFs (N=28)		IPFs (N=30)		Sig
	Mean	SD	Mean	SD		Mean	SD	Mean	SD	
1. GO	70.2	31.3	68.2	22.7	NS	120.0	51.0	93.0	42.0	0.04**
2. AC[2]	30.5	9.6	24.3	8.1	0.00***	50.0	25.0	28.0	10.0	0.00***
IC	22.6	8.9	12.8	4.7	0.00***	30.3	19.6	15.0	6.5	0.00***
Fertilizer	*18.4*	*7.7*	*10.0*	*4.3*	*0.00****	*18.2*	*10.4*	*10.8*	*4.4*	*0.00****
Pesticides herbicides	*1.9*	*1.8*	*1.2*	*0.8*	*NS*	*9.6*	*11.4*	*2.8*	*2.9*	*0.01****
Watering	*1.4*	*1.1*	*0.7*	*0.4*	*0.04***	*0.9*	*0.8*	*0.6*	*0.4*	*NS*
3. NFI	39.6	30.2	46.4	23.0	NS	70.0	55.0	66.0	41.0	NS
4.Laborers	132	42	110	28	0.02**	220	20	164	64	0.03**
5. Profit	18.8	29.7	30.5	21.6	0.05**	35.0	62.0	44.0	40.0	NS
6. GO/IC	3.4	1.7	6.0	3.0	0.04**	8.6	4.8	15.5	10.0	0.03**

Note: [1] Exchange rate: 1 USD = 23,000 VND. [2] The cost is not included the family labor. Excluding family labor cost. Mann-Whitney U Test ***,**,N/S Significance level at 99%, 95% and Non-significance

Source: Author's calculation

An analysis of variable cost components is shown in Table 6.12. Generally, total expenses for intercropped farms were found to be less than for mono-crop farms.

In coffee farms, MCFs had higher annual cost (AC) (30.5 million) than ICFs (24.3 million VND per ha). This cost included intermediate costs, labor costs, interest, and depreciation expenses. With respect to intermediate costs (IC), they were 22.6 million per ha for MCFs and 12.8 million VND per ha for ICFs (Table 6.12). Other specific costs included chemical fertilizers, pesticides and herbicides, and watering. These were lower in ICFs compared to MCFs by 45%, 37%, and 50%, respectively. This can be explained by the intercropped approaches (when coffee is grown under shade trees). This helps to preserve soil fertility due to leaf litter, aids in moisture retention and reduces weed growth.

This decreases costs for such inputs as herbicide (over 40% of surveyed farmers used herbicides), labor costs such as weed, fertilizers cost, and irrigation cost. It is known that planting with the shade-trees provides leaf litter or a mulch which reduces the need for weeding and application of manure and fertilizers. In addition, when cultivating a large shade-grown coffee area instead of growing coffee under full sun, annual irrigation needs are reduced and high crop yields are maintained (Albertin and Nair, 2004; Bote and Struik, 2011; Cheesman and Bennett, 2005; Godoy and Bennett, 1991; Romyen, Sausue and Charenjiratragul, 2018).

At a time, when the coffee sector faces enormous challenges, and bearing in mind recent excessive use of fertilizers and irrigation, ICFs seem to be a perfect and sustainable choice for farmers. With coffee being the main crop in Dak Lak Province, it

is suggested that the local government should encourage coffee cultivation involving intercropping with other crops such as pepper, cacao. As (Scherr et al., 2015) have noted, mono-cropping is associated with high water demand and evaporation rate.

Similarly, with respect to pepper farms, MPFs had higher expenses. For example, annual cost (AC) amounted to 50 million VND per hectare and IC reached 30.3 million VND per hectare, which were both more than those of IPFs (Table 6.12). On the other hand, for IPFs, there is a lower rate of material expenditures including chemical fertilizers and pesticides-herbicides by 41% and 71% when compared with MPFs. In addition, IPFs used living plant supports (e.g. 90% for surveyed intercropped farm types while this figure was only about 50% for MPFs). In earlier studies, pepper pillars using Cassia siamea and/or Leucaena leucocephala trees assisted not only with microclimate balance, heat, soil moisture and light, but were also shown to diminish pest and disease infection (WASI, 2016a).

The next component is labor costs. Coffee and pepper production are labor intensive with over 50% of the total variable cost in Vietnam and 70% in Colombia (IDH, 2014; Phan et al., 2019a). As mention earlier, perennial crops need more short-term manual workers for harvesting fruit (e.g. a large number of laborers hired for picking ripe fruit at the optimum harvest time). Compared to mono-crop, intercropped farms call for fewer laborers (including family members and hired laborers). The number of workers on MCFs and MPFs were 132 and 220 person days while these figures on intercropped farms were at 110 and 164 people days per hectare, respectively.

These figures make sense in view of the fact that intercropped plots that incur fewer labor costs in irrigation and/or weeding have high density that mono-crop plots don't. This means that intercropped farms seem to decrease evaporation and areas that require weeding. The survey reveals that workers in intercropped farms are less necessary in securing the survival the second crops than those mono-crop ones. On the other hand, the mono-crop farms are often more easy to establish than the others are. A reasonable solution is to intercrop with farmers applying a reasonable density to improve the efficiency of labor instead of overreliance on the potential yields of the main crops, thereby possibly suffering loss (e.g. farmers should follow technical advice). Perhaps an added desirable feature of intercropped farms is that since they involve more labor opportunities than mono farms, the labor is likely to be more stable.

Undoubtedly, the reduction of IC not only improves effectiveness but also seems to be appropriate for a sustainable orientation (low commodity prices) as per the FAO guidelines for perennial crop farming and agricultural systems at small-scale producers (FAO 2013). As a whole, intercropped approaches seem to have lower costs than mono-crop ones. Significantly, in case of limited funds, intercropped coffee approaches reduce expenditures by 23.7% and are likely to be the most applicable for rural households.

- **The economic viability of perennial crop farms**

The economic performance of monoculture and intercropped plots is illustrated in Table 6.12 in terms of gross output (GO), net farm income (NFI), profit, and the ratio of GO to IC and the ratio of NFI to family labor.

For coffee farms, although ICFs obtained less GO value at 68.2 million VND per ha) than MCFs (at 70.2 million VND per ha), the other indicators including NFI and profit at 6.8 million (17%) and 11.7 million (62%), respectively were higher than MCFs (Table 6.12). Interestingly, the ratio of GO to IC for ICFs wasn't significant in comparison with MCFs. The ratio was 6.0 for ICFs (meaning that an increase of 1 Viet Nam Dong (VND)

in IC leads to an increase of 6.0 VND per ha in GO) while this proportion was only 3.4 for MCFs (Table 6.12). Clearly, in a severe situation like low coffee price, ICFs seem to be a good alternative for farmers to spend less and have more profit. Thus, ICFs' farmers should apply cultivation with a suitable density of coffee plots and second crops. The aim should be to avoid the depletion of resources as well as to create efficient production.

To conclude, the analysis reveals that intercropped farms are a suitable alternative for perennial crop production, whereas lower variable costs and higher return rates were observed with mono-crop approaches. This is in concord with previous studies that showed that mono-cropping has lower farm income than diversified cropping (Scherr et al. 2015; Phan et al. 2019a). It should be seen as preferable to operate, ICFs and IPFs, considering that they are financially and economically profitable. In particular, as Dak Lak Province has experienced significant issues related to irrigation and prices for coffee and other industrial crops, intercropped farms have been likely more convenient, especially ICFs. The author recommends that farmers and local authorities should pay more attention to the economic performance of intercropped farms, especially coffee farms. It is still the case that, many farmers consider that they could maximize their earnings via monoculture without shade trees. As a result, training programs that help to change farmers' perception should be scheduled for the coming years.

6.2.3. Comparison of economic efficiency of perennial crop production according to group in two crop seasons

The economic performance of perennial crop production by coffee and pepper groups was analyzed during two cropping years to determine the dynamic processes of each perennial crop scenario.

6.2.3.1. The change of input costs between two farm groups

Table 6.13 shows the input cost items among the two groups and the variances in each group during the period of 2016/2017–2017/2018.

Table 6.13: The variance of input cost of the two farm groups during the period of 2016/2017–2017/2018

(Unit[1]: *Million VND/ha*)

Items	GpC (n = 62)			GpP (n = 58)		
	2016/2017 Mean	2017/2018 Mean	Sig	2016/2017 Mean	2017/2018 Mean	Sig
Variable cost[2]	**23.2**	**26.2**	**0.04****	**42.0**	**38.4**	**NS**
I. Intermediate cost (IC)	***15.6***	***18.0***	***NS***	***26.7***	***22.3***	***NS***
1. Fertilizer	11.3	14.5	0.01***	17.7	14.5	NS
Manure	*2.3*	*3.2*	*NS*	*7.1*	*4.4*	*NS*
Chemical	*8.7*	*11.3*	*0.03***	*10.6*	*10.0*	*NS*
2. Pesticides, herbicides, stimulants	1.8	1.6	NS	6.5	6.0	NS
3. Watering	1.2	1.0	NS	1.0	0.7	0.06*
4. Transporting	0.2	0.2	0.00***	0.2	0.2	NS
5. Packaging	0.2	0.5	0.00***	0.2	0.2	0.00***
6. Others	0.7	0.2	0.00***	1.0	0.7	0.02**
II. Hired labor cost	***3.5***	***3.2***	***NS***	***8.5***	***7.8***	***NS***
III. Interest cost	***1.0***	***1.6***	***NS***	***1.4***	***3.0***	***NS***
IV. Depreciation	***3.2***	***3.2***	***NS***	***5.3***	***5.3***	***NS***

Note: [1] Exchange rate: 1 USD = 23,000 VND. [2] Family labor is not included in the cost. Mann-Whitney U Test $^{***,**,N/S}$ Significance level at 99%, 95% and Non-significance.

Source: Author's own calculations

The results indicated that GpC demonstrated lower variable costs, which are estimated at 23 million VND in 2016/2017 and 26 million VND in 2017/2018 than GpP, whereas GpP had variable costs of 42 million VND and 38 million VND per ha, respectively. GpC is therefore considered to be preferable for smallholders who rarely have available savings and face considerable difficulties in accessing credit. Unfortunately, the average cost of pesticides, herbicides, and stimulants for GpP is several times higher than that of GpC, which is estimated at 6.25 million VND per ha (Table 6.13). One of the reasons for this might be that farmers tend to boost the number of pesticides and stimulants in response to a higher occurrence of pests and diseases on black pepper plants, which influence plant growth and yields (Trinh, 2010). At the same time, a higher pepper price may also encourage farmers to overuse pesticides and stimulants. Thus it seems that pepper farms are likely to increase dependency on inorganic and toxic inputs, which could have negative impacts on production and sustainable development (Susmita, 2007; World Bank, 2016).

In addition, the findings show that the GpP puts greater demand on the labor force. This means this group requires more working days and more hired labor during the crop season than GpC, especially to ensure a timely harvest that avoids ripe cherries being lost and also to help plant growth for the next season. Because of a lack of manpower during the black pepper harvest season, the wages paid to labor in the local regions rises. Some households must even work overtime, causing health problems or resulting in the use of less efficient laborers such as children or elderly people. Another reason that pepper production needs more laborers than that of coffee is field management and protection (Theft is a widespread problem in the pepper harvest season, which increases the need for laborers. This can be a problem in ethnic communities, where there is high unemployment in the 15-20 years old age group).

Fortunately, compared to the past, irrigation costs have been reduced in both groups due to the application of three-phase electricity as well as the use of advanced irrigation technologies (drip and spray irrigation), instead of using diesel machines. This has been become a helpful development for local farmers, especially at a time when perennial crop production is experiencing the effects of climate change, such as an increasing number of hot days and nights, as well as an increase in the occurrence of intense droughts (Haggar and Schepp, 2012). In the coming years, training programs on irrigation management should be improved and continuously offered, which can increase the efficient water use. According to one report, for example, trained farmers tend to use fewer liters per plant than do those without training (Amarasinghe et al., 2015).

Taking everything into consideration, GpP is likely to require more input items and labor for farmers, as opposed to GpC. Labor resources should be taken into account when choosing a suitable crop farming system, to ensure an adequate supply of labor, especially during the harvest season. At a government level, volunteers or the involvement of the broader social community might be organized to help rural farmers to collect black pepper cherries in urgent cases. Moreover, officials should consider careful regulation of chemical fertilizers and pesticides in pepper production, especially with respect to the future because of ecological effects and export regulations.

The annual costs increased by 13% per ha for GpC but declined for GpP by 8% per ha during two crop seasons that were surveyed. In terms of GpC, the intermediate cost jumped significantly by 3 million VND per ha (about 30%) which is mainly a result of

chemical fertilizers use (an average of about 52%). The first reason is the older age of the coffee crops. This changes the revenue and increases inputs which are required. In addition, farmers often do not apply the optimum nutrient ratio of fertilizer, or do not apply it at the optimal times. Farmers also follow the erroneous advice of retailers or acquaintances, which can lead to a large amount of fertilizer wasted and ending up in groundwater and streams, not to mention the increases in input costs (World Bank, 2016). On the whole, there is some confusion about the best way to use these inputs.

Obviously, the growth rate of costs for GpC creates vulnerabilities for the farm groups, especially because coffee prices have been lower than in previous years. Increased fertilizers (urea and generic NPK fertilizer) leads to polluted surface water, excessive irrigation and soil acidification, affecting sustainable production. The researcher suggests that rather than having greater inputs and costs, farmers should implement better agricultural practices (e.g. apply agro-chemical fertilizers in optimal proportion, in accord with need and technicians' recommendations). For example, according to a Technoserve study, optimizing fertilizer leads to reductions in the use that could improve yield and income, by 10% and 30%, respectively (IDH, 2013). Similarly, considerable coffee rejuvenation should be implemented to build a more sustainable coffee sector, assisted by provincial and national levels.

On the other hand, with respect to GpP, the intermediate cost declines by 4.4 million VND per ha (16.5%). The reasons for this included the following (1) the density was lower than the previous year due to losses crops; (2) farmers decreased their use of manure or bio-fertilizer, which is an expensive fertilizer (e.g. the price of bio-fertilizer was recently 24 million VND per ton). Although surveyed farmers were aware of the important role of organic-fertilizer in increasing yields and maintaining the soil, only 30 % of households produced their own bioorganic fertilizers, the others had to buy it from the sales representative.

Although GpP shows a decline in intermediate and hired labor costs during the two crop years, GpP had higher input costs, such as intermediate costs (e.g. labor cost) and interest costs, than GpC over the two years, which likely creates barriers for the households if they don't have a lot savings and available labor resources. Furthermore, applying high levels of pesticides, herbicides and stimulants is harmful to farmers' health, and has raised concerns about pesticide residues and effects on the marketing of products, especially internationally.

Interest costs continued to rise over the two years for both groups. In this study, the interest payment costs were 1 million VND per hectare for GpC and 1.4 million VND per ha for GpP in 2016/2017, sharps increases of 60% and 130% respectively in 2017/2018 (Table 6.12). Meanwhile, it is to be expected that farmers must still invest input costs, especially considering how the low prices of produce has been. They must borrow larger amounts of money from intermediaries and collectors, or mortgage the Land Use Certificate to maintain production, hoping that produce prices will recover to the level they were. In light of this, the author suggests that the government should implement more monetary policies to assist farmers, and to offer a variety of financial sources. This will be also avoid the spontaneous expansion of informal, more expensive financial channels.

Generally, coffee and pepper farms not only are costly but also face struggles, leading to various challenges in livelihood strategies. The researcher suggests that

perennial crop farms should undertake more diverse practices. Specifically, the application of modern cultivation and technology and intercropping farms (e.g. coffee and pepper, coffee and cashew and fruits) should be considered. These will not only generate more income by taking advantage of space, but they also reduce input costs due to water, and fertilizers, as well as help environmental sustainability. In addition, traditional practices that use animal manure and legumes to boost nitrogen into the soils and assist in the control the pests and diseases should be undertaken, as is done in many developed countries and central Asian countries (Stillitano et al., 2019; Salazar, 2006; Ho et al., 2017; Romyen et al., 2018; Kunnal and Basavaraj, 2006). Integrating perennial crops and livestock can sustain smallholder's livelihood. Going forward, it is likely that changing behavior in perennial practices at the farm level is bound to involve more than just direct financial support. Finally, developing "specialty products and bioproducts", like those that have been promoted successfully in Brazil, Indonesia, and Africa, should be considered to be a new orientation for farmers (Dak Lak People's Committee, 2019)

6.2.3.2. The variance of profit between two groups

Profitability is an indicator of production incentive, which provides a reference for farmers and local governments in the decision-making process.

Table 6.14 displays a comparison of output for the entire sample set over the two crop years in the two farm groups that were surveyed. The findings show that GpC yielded lower economic performance for various indicators than GpP did. Specifically, the profitability of GpC accounted for 41 million VND per ha in 2016/2017 and 25 million VND per ha in 2017/2018, whereas these figures were 158 and 40 million VND per ha for GpP, for these two respective years (Table 6.14).

Table 6.14: The change of economic efficiency of the GpC and the GpP over two crop years of 2016/2017 and 2017/2018

(Unit 1:Million VND/ha and Million VND/ton)

Items	GpC (n = 62)			GpP (n = 58)		
	2016/2017	2017/2018	Sig	2016/2017	2017/2018	Sig
	Mean	Mean		Mean	Mean	
1. Gross output (GO)	80.7	69.2	0.00*	224.7	106.5	0.00*
2. Price selling	37.0	34.5	-	110.0	56.0	-
3. Value Added	65.0	51.0	0.00*	198.0	84.0	0.00*
4. Net farm income (NFI)	57.0	43.0	0.00*	183.0	68.0	0.00*
5. Profit	40.7	24.6	0.00*	157.6	39.8	0.00*
6. Labor Productivity	0.7	0.5	0.00*	1.4	0.7	0.00*
7. GO/IC	6.0	4.6	NS	11.3	6.0	0.00*
8. NFI per Family labor	0.7	0.5	0.00*	1.4	0.5	0.00*

Note: [1]Exchange rate: 1 USD = 23,000 VND. All comparisons are statistically significant (les than 5%) in the Mann–Whitney U Test, except the GO/IC

Source: Author's own calculations

Additionally, there was a significant decrease in economic performance for each farm group over the two crop years with the GpP rate of reduction being larger than that for GpC. The rate of decline for GpP is estimated to be 21% for gross output, 46% for the ratio of GO to IC, and over 50% for value added, NFI, profit, labor productivity, and ratio of NFI to family labor, respectively. The rates of decline for GpC for the same indicators were 14%, 21%, 23%, 24.5%, 40%, 28% and 33%, respectively (Table 6.14). It can be surmised that less suitable market condition at the time was a factor of the decrease in economic returns of the GpC and GpP, in particular, the lower pepper market price. For instance, in mid-2017, the selling price of pepper had fallen by nearly one half, from 110 VND per ton in 2016/2017 to 56 million VND per ton in 2017/2018. Generally, economic performance can be achieved by cost reduction, improved input-output performance, increasing revenue and better crop prices. It implies that reductions in productivity and rising costs need to be taken into consideration when the market prices are an important factor at the farm level. Climate change and resulting crop losses can additionally reduce output and so should be considered (e.g. the proportion crop loss for pepper in 2018 was 7.18%) (Duong and Nguyen, 2019).

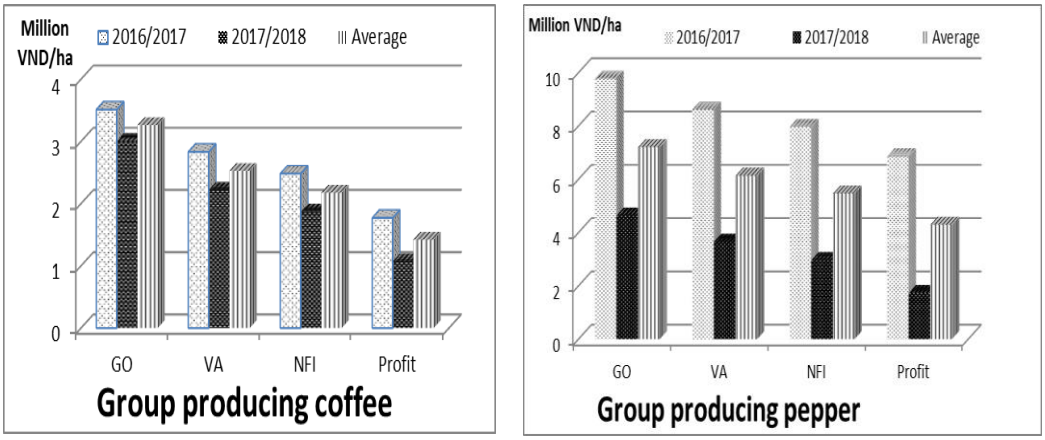


Figure 6.3: The average economic indicators between two groups in two crop seasons

Notes: The prices of coffee and pepper were 37 and 110 thousand VND per kilogram in 2017/2018 while 35.5 and 56 thousand VND per kilogram in 2018/2019, respectively

Source: Author's own calculation

Although GpP shows higher indicators than GpC in both crop years, the amount of decrease greater for GpP than that of GpC. Labor productivity and NFI for family labor for the two farm groups decreased from the 2016/2017 to 2017/2018 season. This contributed to serious challenges to production, and increased difficulties faced in farmers' lives. Given such problematic circumstances, the author suggests that local farmers and the community should alterations to the method of growing coffee and pepper, in order to mitigate risks and maintain production.

For instance, the authorities should promote certification of farmers suitable to the subregion. In addition, programs can be implemented which improve the use of shade trees for plantations in the whole province, which can lead to reductions in environmental impacts and production costs (e.g. irrigated cost), and at the same time

enhance households' income from by-products (timber, fruits) (Jezeer et al., 2018; Ho et al., 2018). In Mexico, Peru and Ethiopia, certification of coffee has been shown to create sustainability (Barham and Weber, 2012; Villa, Adenso-Díaz and Lozano, 2019). For example, in Spain, diversification has been seen as a crop planning strategy which allows correlation with geographic area and products In Dak Lak, it is suggested that the government should focus on quality certification of farms rather than an emphasis on quantity. In addition, the authorities should implement a program of land consolidation, which through consolidation of efforts among land plots can result in among households to obtain functionally larger fields *(cánh đồng mẫu lớn)*, which can be more appropriate for the application of technology or in hi-tech zones and can improve marketing channels. The local government needs to address the current situation of pests and diseases as a serious emerging threat. Marge plants losses should be addressed by the improving the producer's awareness, and growing conditions as well as by encouraging cultivation of other crops. Improvements in technical training, and guidance on safe product application are recommended. The use of live plants as pepper supports instead of concrete and wooden supports needs encouragement. Lastly, national and local governments should assist in the provision of a wide range of package insurance for specific stages, such as immature and mature stages.

6.2.3.2. A sensitivity analysis of MCS, MPS and CPI with respect to profit under scenarios prices

Table 6.15: The profits of three systems under different scenarios of prices

(Million VND/ha)

Scenarios		Farming systems		
		MCS (n = 32)	MPS (n = 28)	CPI (n = 30)
(1) Good scenario: coffee and pepper price increase	Coffee price increase			
	10%	45 [a,b]	165	211 [a,c]
	20%	53 [a,b]	165 [b,c]	219 [a,c]
	30%	62 [a,b]	165 [b,c]	228 [a,c]
	Pepper price increase			
	10%	37 [a,b]	192	222 [a,c]
	20%	37 [a,b]	217	242 [a,c]
	30%	37 [a,b]	243	262 [a,c]
(2) Moderate scenario: coffee and pepper prices are current prices		37 [a,b]	165	201 [a,c]
(3) Bad scenario: coffee and pepper price decrease	(3.1) Coffee price decrease			
	10%	29 [a,b]	165	194 [a,c]
	20%	21 [a,b]	165	185 [a,c]
	30%	13 [a,b]	165	177 [a,c]
	(3.2) Pepper price decrease			
	10%	37 [a,b]	141	182 [a,c]
	20%	37 [a,b]	116	162 [a,c]
	30%	37 [a,b]	91 [b,c]	142 [a,c]

Source: Author's own calculation

Note: Different superscripts (a, b, c) denote a significant difference between means within rows ($p<0.10$).

The sensitivity analysis can help farmers to determine how vulnerable PCSes are, and is very useful for insight into farm management information when making decisions.

The results show that profits for MCSes, MPSes and CPI are relatively sensitive to price. In particular, we can consider variations of up to 10% and 20% in the coffee selling price. Because of this, profits increase and decrease 22 and 43% for MCSes and 5 and 9% per ha for CPI. Similarly, for an increase and decrease of 10 and 20% in pepper selling price, profits are predicted to rise and fall 16.5 and 31.5% for MPSes and 10 and 20% per ha for CPI (Table 6.15). Modelling with these variables shows that large effect of profits and its vulnerability with respect to the selling prices for MCSes, MPSes and CPI. With a change in the coffee and pepper selling prices under different scenarios, CPI is shown to have higher profit compared with MCSes and MPSes.

For example, a 30% reduction in the coffee price results in a 65% reduction in profit for MCSes and 12 % for CPI. Similarly, a 30% decrease in the pepper price leads to a 45% lowering of profit for MPSes and 30% for CPI (Figure 6.4). While, MCSes, MPSes and CPI might survive a decreasing coffee and pepper price of 30%, CPI is likely to be less sensitive to these coffee and pepper price fluctuation than MCSes and MPSes. In terms of this model, these results which are predicted with 30% coffee and pepper piece decreases seem to be similar with the current prices in the previous section (6.2.1.2.). Both for the model and surveyed data, CPI has higher economic benefits and lower sensitivity to market risk in comparison to the other systems.

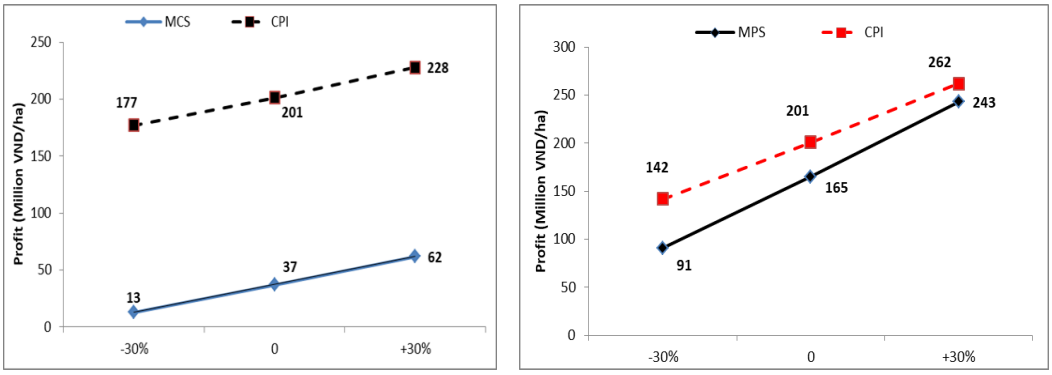


Figure 6.4: Sensitivity analysis of profits considering variation between -30% and +30% in the cofee and pepper selling prices

6.3. Social benefits among three selected systems

6.3.1. Job creation

An understanding of the employment and labor requirements helps farmers to decide the appropriate choice of cropping system and provide information for policy and policymakers in determining applicable development strategies (Ngeleza et al., 2011). Generating employment is a key aspect which is related to socio-economic change and poverty alleviation (World Bank, 2011). In practical terms, job demand can indicate the worker constraints of growers and identifies the creation of employment opportunity in research sites. In 2017, Vietnamese labor force in the agriculture was comprised of

people ages 15 and older, about 40% of the total population, and they contributed to less than 20% of the GDP of the national economy (Nguyen et al. 2019). Nowadays, many countries like Vietnam have adopted mechanization for agriculture in order to decrease labor cost.

Table 6.16: Labor allocation by activity in three selected systems

Unit: days/hectare/crop season

Workdays	MCS (n= 32)	MPS (n=28)	CPI (n=30)
Weeding	13.0	17.0	12.0
Fertilizer	7.0[a,c]	14.0 [a,b]	12.0
Pruning, bud breaking	20.5	24.0	30.0
Irrigation	12.0	11.5	15.0
Pesticides	6.0 [a,b]	11.0	6.0 [c,b]
Harvesting	69.0 [a,b]	158.0	198.0 [a,c]
Post-harvest	3.0 [a,b]	3.5	7.0 [a,c]
Others	3.5 [a,b]	6.0	5.0
Total	134.0 [a,b]	245.0	286.0 [a,c]

Note: Different superscripts (a, b, c) denote a significant difference between means within rows ($p<0.10$).

Source: Author's own calculation

This part evaluates the different workforce requirement among and between selected cropping systems throughout the labor calendar of activities. The labor calendar establishes the number of labor-hour involved in given crop year, which is an important tool to measure the labor situation and improve its efficient use. Table 6.15 illustrates how many person-days are needed for different activities between cropping systems.

Between three systems, total working people varied significantly between cropping systems, with $p < 0.10$. Specifically, CPI needed more laborers than MCSes and MPSes, estimated to be 286 workdays (Table 6.15). Next, MPSes ranked second in average employment demand, accounting for 245 working days. MCSes had the least needs for workers as compared to the others, totalling 134 laborers. This implies that CPI is perhaps likely to attract more people per ha to move into that area than the others are. Consequently, when a majority of the rural households depends on perennial crop systems in Dak Lak, CPI should be considered to be an appropriate system which will enable high employment in comparison with the other systems.

Looking across operations, the largest proportion of workers was involved in harvesting, as well as in pruning and budding. These activities occupied 51 and 15%, for MCSes, 64 and 10% for MPSes, 69 and 10% respectively for CPI (Figure 6.5). Because of this, these activities should be recognized as labor intensive, and therefore they should be carefully considered in order to avoid labor shortages, especially during the harvesting time. Additionally, there was a significant employee difference among fertilizers, pesticides and management use between the three systems (all $p < 0.05$).

Interestingly, CPI required the least proportion of agricultural workers for weeding, accounting for 12 working days. CPI is therefore considered to have benefits in terms of weed management, which relieves the reliance on herbicides which are harmful to the local community (Bajwa, Walsh, and Chauhan, 2017). It also needs to be taken into account that there cannot be too much competition for growth, and the secure harvesting of other crops needs to be taken into account.

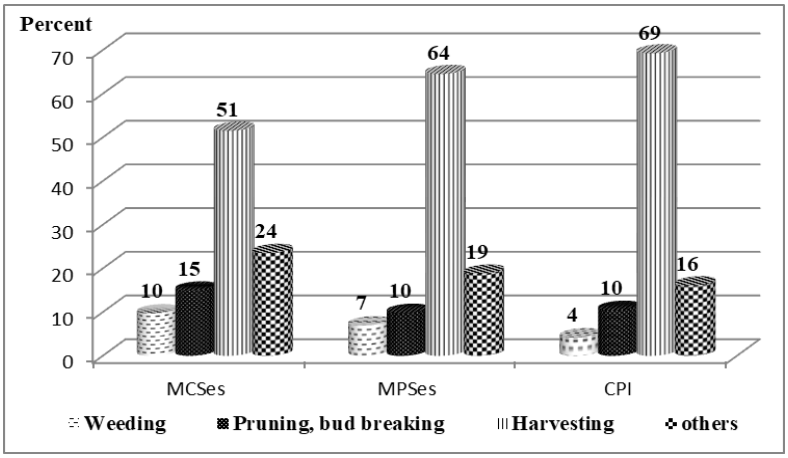


Figure 6.5: Labor requirement among three selected systems

Source: Author's own calculation

6.3.2. Gender labor division

As reported by the FAO, (2018c), women provided approximately 25% of global employment in agriculture and reached about 43% of the labor force in developing countries. In Asia, agriculture has been the most essential sector for female employment. In South Asia, for example, more women work in the agricultural sector than men do. In South Asia, women are considerably more empowered in comparison to other developing regions of Southeast Asia (Mason and Smith 2003). Moreover, the closing gender gap can improve agricultural productivity, raise women's employment and increase households' output (Nelson et al., 2012).

In addition, many donor agencies, local governments and NGOs are trying to increase women's participation by reducing inequality between gender as a long term goal. This is related to the Sustainable Development Goals (SDGs), formed during the United Nations Conference on Sustainable Development held in Rio de Janeiro in 2012 (United Nations General Assembly, 2015; World Bank, 2011b).

Figure 6.5 determines the level of women's labor participation in three cropping systems. Generally, men and women both perfectly engage in perennial crop production. However, the proportion of men and women varies considerably among activities and between systems. Men have a relatively high percentage for some activities, whereas women are higher for others. Men are especially responsible for some technical and heavy tasks such as pruning, weed control, disease treatment (herbicide and insecticide spraying) and irrigation, as well as are responsible for management. On the other hand, women tend to take part in fertilizer application, harvesting and post-harvesting activities. For example, during the harvest, there are

primarily more women involved in the picking up of ripe cherries.

From the results, it can be seen that MCSes and CPI create more opportunities for women than MPSes do. For instance, while activities pruning, irrigation and management involved 40%, 30% and 30% of women's labor respectively for MCSes; these figures were 30%, 35% an

d 20% for CPI, but only reached 10%, 20% and 5% for MPSes (Figure 6.6).

Perhaps it is possible that the specific cultivation requirements that attract females, with the exception of some more common, established activities. In other words, for these labor activities, there was a higher gap between genders for MPSes compared to the other systems.

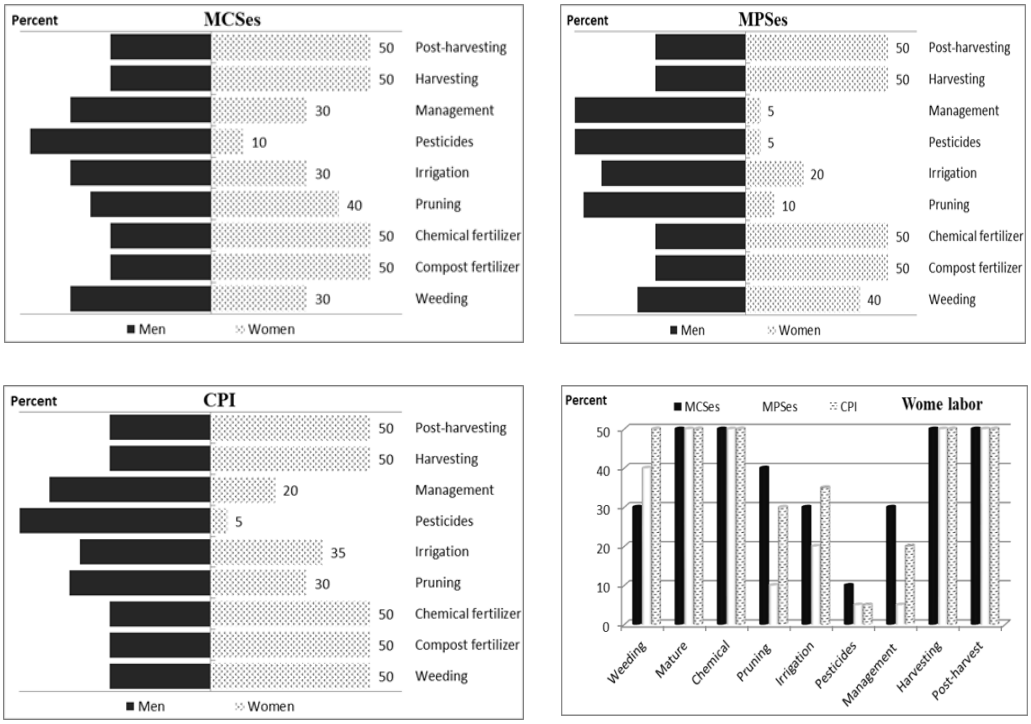


Figure 6.6: Gender allocation of each task on perennial crop production

Source: FGDs and surveyed data, 2019

FGDs in MCSes

FGDs in MPSes

FGDs in CPI

Picture 6.6: FGDs with the difference of women's participation between three systems

6.3.3. Extended employment for farm workers year-round

Labor shortages result from variation in workers' willingness, ability and availability to work and the number of workers desired by growers, given the market wage (Cassey et al., 2018). A lack of labor is one of the more serious resources problems for commercial tree crops, which are planted by the mainly smallholders in Vietnam. Labor resources affect farmers' decision – making processes in perennial crop production.

Coffee and pepper production and other perennial crops are especially in need of workers for pre-harvest and harvest processes. Historically, apart from family labor, smallholders have extensively used non-paid labor, and these are often friends and neighbors, who are often employed through some sort of exchange (*Đổi công*), for example, food and drink. There were some households which hired one or two workers by annual contract. In recent years, hired labor has been increasingly used on harvesting and/or other tasks, such as weeding, and irrigation. For this, non-family labor, it is often paid by daily wages which include food and drink (one day's labor = 160,000 VND) or on a quota basis (e.g. 3,000 VND per coffee tree for

pruning or 200,000 VND per 100 kg of fresh coffee harvested). Wages depend on the current product price or level of labor shortage in the region.

The empirical results in Table 6.16 show that most of the perennial crop systems experienced a labor shortage. That implies that labor availability in the local region is an element in decisions when considering the application of technological solutions (such as weed control by tractor or drip irrigation). In reality, the micro-irrigation isn't widespread due to high establishment cost and security (loss due to theft).

With respect to harvesting, this operation required the highest percentage of total employment among the three selected systems, representing more than 70% (Table 6.16). This is because coffee and pepper ripe cherries must be handpicked, which is time and labor intensive (detailed crop calendar on section 6.1). Seasonal workers are often required to pick during the harvest season. Unfortunately, since 2017, the shortage of temporary, casual labor has steadily increased. This can be explained by considering that available workers in Dak Lak include two components, residents and migrants. In recent years, due to the development of industrial and service park, most migrant workers have moved near these, instead of staying or moving to areas of Dak Lak province which require seasonal employment as they did before. In response, some households collected only 20%-50% of ripe pepper fruits, and only 50–70% of ripe coffee, which has quality and price impacts.

Although the local government encouraged harvest levels of ripe cherries at least over 80%, to achieve this most farmers often have to begin harvest early because of the labor shortages, which creates quality problems. Compared to MCSes and MPSes, CPI had the highest proportion of workers hired. While CPI used 25% of hired labor, the figures for MCSes and MPSes only reached 15 and 20%, respectively. Furthermore, the ratio of hired labor to family labor was 34% while the need for paid laborers of MCSes and MPSes were 18 and 24% respectively (Table 6.16).

At the farm level, the lack of seasonal labor produces increases in the daily wage. When workers are needed in perennial crop systems, unfilled employment opportunities must have increased salary benefits to attract workers. The author recommends that for perennial crop development strategies involving labor, there should be help for farmers to use machines or technology to reduce labor requirements, or encouragement to form labor cooperation between households.

Table 6.17: External labor of three systems by daily wage

Items	MCS (n= 30)	MPS (n=26)	CPI (n=30)
Harvesting (People)	16.0 [a,b]	37.0	57.0 [a,b]
Others (People)	5.0	11.0	16.0
Total hired labor (People)	21.0 [a,b]	48.0	73.0 [a,c]
Hired harvesting/total hired labor	0.7	0.8	0.8
Hired labor/total labor	0.2	0.2	0.3 [a,c]
Hired labor/family labor	0.2	0.2	0.3 [a,c]

Note: Different superscripts (a, b, c) denote a significant difference between means within rows ($p<0.10$).

Source: Author's own calculation

6.3.4. Labor use efficiency

Table 6.18: Labor use efficiency of MCS, MPS and CPI

Items	MCS (n= 30)	MPS (n=26)	CPI (n=30)	Sig
Labor-use efficiency (Million VND/person)				
Labor productivity	0.5 [a,c]	0.9 [a,b]	0.9	0.00*
Return to family labor	0.3 [a,c]	0.8 [a,b]	0.9	0.00*

Note: Different superscripts (a, b, c) denote a significant difference between means within rows ($p<0.10$).

Source: Author's own calculation

Productivity of the agricultural workers, for example in the perennial crop sector, is calculated as the total value-added divided by the number of people who work in that sector. The standard deviation of the economic result per worker is essential assessment.

According to research, the highest rates of agricultural benefit per worker are in developed countries and in Europe, North America and New Zealand this was about 70,000 USD/person in 2017. For example, most countries across South Asia attained less benefit, around 1,000 USD per worker in 2017. In Vietnam, there were differences in agricultural labor productivity, and there was large variation by location and farming systems. In 2017, agricultural productivity was approximately 1,126 USD per worker (World Bank 2016). Higher returns per day on labor that exceeds the average daily wage rate encourages the employer to prefer a particular system. In other words, the labor productivity and return on labor demonstrate how attractive a particular perennial crop system is for farmers and labor. This reasoning assists in answering the question whether a perennial crop system can attract more people to move there, compared to other agricultural sectors in the region. It can be established which cropping system generates more wages for labor.

As mentioned labor productivity, varies greatly between three cropping systems. MCSes have the smallest labor productivity, with 0.5 million VND while MPSes and CPI had 0.9 million VND per worker.

Looking at family labor return for CPI, it was measured to have the highest wage rate, about 0.9 million VND while the lowest ratio of return to labor was found in MCSes (0.3 million VND per person). These findings were produced from many reasons, but as per the information in this research, higher output, profitability, and women's participation in CPI are indicative.

6.3.5. Potential employment opportunity

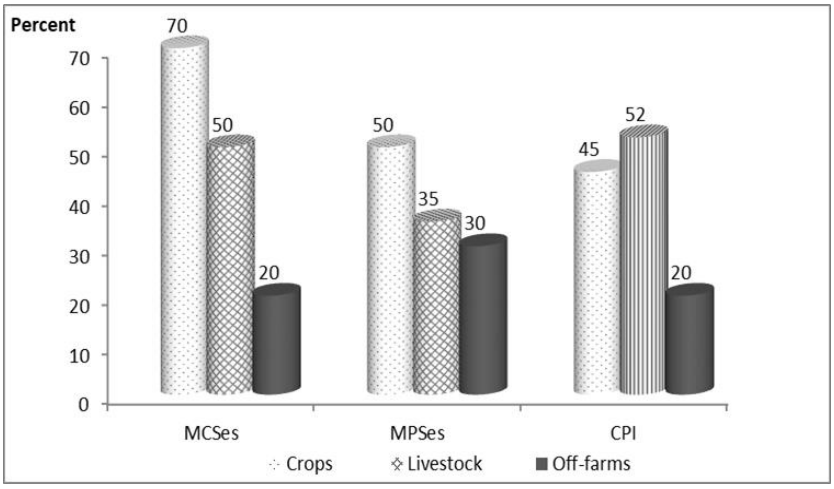


Figure 6.7: The potential creation of employment

Source: Author's own calculation

In terms of employment opportunity, besides perennial crop production, farms often engage in a variety of jobs in order to increase households' income. The strategic objectives of the FAO are to create employment opportunities for the rural poor, and improve of employment access on farms and off-farms (FAO, 2018c).

Figure 6.6 indicates that MCSes created the largest contribution of occupation in the field and in relation to off farm activity while CPI had the highest potential for raising livestock. This is explained by considering that MCSes use as a unit space the area of 3m x3m, and so farmers are able to take advantage of planting other crops such as permanent crops, annual crops, fruit crops or shade trees as a second crop, which give farmers more output and jobs on their fields. In addition, as reported by farmers, MCSes often allocate more of their workforce to specific activities such as pruning. While, MPSes may be less busy, except at harvesting time. MPSes also require labor for use of wooden and concrete pillars. Consequently, farmers can have chances to find part-time jobs there. Unfortunately, the research revealed that such part-time employment at sites was not usually available. Most of the CPI assessed in this study (about 90%) used *Leucaena leucocephala* (tamarind trees) as support for pepper vines, which can also be used to provide animal feed for goats and cows. Thus, CPI planters also have a tendency to raise animals, which creates female employment, provides manure for plantations and enhances income by selling animals and their products. In other words, CPI had a higher proportion of diversified livelihoods than the other systems, which is consistent with (Sneessens et al. 2019). The author contends that crop diversification is a strategy which helps to cope with risks, and a strategy of mixed crop-livestock is considered to have less market dependency and more flexibility. In other words, CPI is a powerful option that has socio-economic benefits.

7

Determinants of perennial crop farms' decisions on adoption in Dak Lak province

This chapter is designed to investigate the impact of various factors which impact upon on a farm's decision of adoption. The chapter is laid out two parts. In the first part, the descriptive statistics of the driving factors of a farm's decision in adopting a perennial crop are identified. These include socio-demographic characteristics, farm endowment and the crop profile. Moreover, a determinant rate between two distinct approaches and among each adoption approach is given. The second part presents the important factors which influence a farm's decision on perennial crop adoption. Specifically, these factors included ethnicity, training, crop failure and profit, and these significantly alter the probabilities of farms' decisions in adopting. The findings provide an interpretation and information for farmers to have a better understanding of their decisions and give a platform for policymarkers to advise on perennial crop development strategy. The chapter is laid out in two parts.

Parts of this chapter have previously been published as:

(1) *"Economic analysis of perennial crop systems in Dak Lak Province".* Sustainability 2019, 11, 2071. https://www.mdpi.com/2071-1050/11/1/81

(2) *"Which Perennial Crop Farm Approach Generates More Profitability? A Case Study in Dak Lak province, Vietnam"*. Asian Social Science 2019, 15. http://www.ccsenet.org/journal/index.php/ass/article/view/0/40528

(3) "*Recent evolution of perennial crop farms: evidence from Dak Lak Province".* Agris on-line Papers in Economics and Informatics 2020, Vol. 12, No. 3, pp. . ISSN 1804-1930.

7.1. Descriptive statistics of variables in the regression models

7.1.1. Variables description of adoption

Table 7.1: The general information of explanatory variables

Explanatory variables		General adoption (N=90)		Specific adoption (N=79)	
		Mean	SD	Mean	SD
Households characteristics	AGE (Years)	49.0	10.0	49.5	9.0
	GEND (1=Male)	0.7	0.5	0.7	0.5
	ETH (1=Kinh)	0.6	0.5	0.7	0.5
	EDUC (Years)	8.0	4.0	8.0	3.4
	TRAI (1=Yes)	0.4	0.5	0.4	0.5
	OINC (1=Yes)	0.5	0.5	0.4	0.5
	EXPER (Years)	2.0	7.0	10.0	6.0
Farm endowment	PRO (Million VND)	47.0	55.0	63.5	56.0
	FWORK (People)	2.3	1.0	2.4	1.2
	LURC (1=Yes)	0.9	0.2	0.3	0.7
	CAP (1=Yes)	0.6	0.3	0.5	0.2
Crop profiles	PETDIS (1=Yes)	0.4	0.5	0.23	0.4
	AGETREE (0<=20 years)	0.3	0.4	0.3	0.5
	CRFAI(1=Yes)	0.4	0.8	0.8	0.6

Source: Author's own calculation

Table 7.1 summarizes the series of variables selected to describe a farm's decision of adoption. The descriptive statistics are based on data from the farm structure survey in 2018-2019. 100% of samples were used (90 plots) to indicate general

adoption. Among these, 79 farms were decided upon for analysis regarding specific adoptions (see section 4 and Table 7.1).

The definitions of fourteen explanatory variables were provided in section 4, and these include household profile, farm characteristics and information on crops. With respect to households' profile, there aren't many differences between the two distinct adoption approaches. On the one hand, in terms of farm endowment, the average means in a specific group from profits, experience level and LURC factors were higher than that of the general adoption group, while the family workforce was similar. Meanwhile, the means of crop failure, pests and diseases were about twice as high that of general adoption group (Table 7.1).

For qualitative variables, a change from 0 to 1, leaving all other variables constant at their mean is reported. Specifically, with respect to a farmer's profile, GEND is a dummy variable that presents the gender of the farmer; it has a value of 1 for men and 0 for women; ETH is also a dummy variable to measure the ethnicity of households. It takes the value 1, if it is the majority group (Kinh people); 0, if a minority group (indigenous and other ethnic people). It is expected that the majority group has a higher probability of adoption than the rest; TRAI measures the trained farmers or not. It takes the value of 1 if the farmer takes part in training programmes, and 0 otherwise. It is hypothesized that training programme influences the farm's decision of adoption; OINC displays the other sources of income besides the main income from MCS, MPS and/or CPI. It has a value of 1 for having other income and 0 for having no other income. Other income is expected to affect the farm's decision in adopting. Regarding endowment of the farm, (LURC) is the land use rights certificate used to be the representative (in this study, it is Cadastre). It takes on the value of 1 if farms have LURC (Cadastre) and 0, unless Cadastre. Similarly, CAP measures farmers who have capital or not. It takes the value of 1 if the farmer's respond could have captial and 0 if otherwise. It is hypothesized that capital influences the adoption decision of perennial crop farms; PETDIS is a dummy variable, which indexes whether the farm is affected by pests and diseases or not. It is expected that pest and disease infection affected farmers' decision on adoption of perennial crop system; AGETREE is a qualitative factor to identify the age of the farm. It takes the value of 1 if age is over 20 years; 0, if age is under 20 years. The last qualitative factor is CROPF (Crop failure). It has a value of 1 for having crop failure and 0 for no having crop failure. On the other hand, quantitative variables include AGE (age), EDU (Education), PRO (Profit), FWORK (Family workforce); and EXPER (Experience).

7.1.2. Adoption rates

Table 7.2: Share of farms under different adoptions

	Farm'decision	Proportion (%)	Number (Plot)
General adoption	Adoption	88	79
	Non-adoption	12	11
	Total	**100**	**90**
Specific adoption	Basis adoption group (Group 0)	52	41
	Perennial crop adoption group (Group 1)	35	28
	Diversified adoption group (Group 2)	13	10
	Total	**100**	**79**

Source: Author's own calculation

Firstly, a farm's general decisions are grouped in terms of adoption and non-adoption. Specifically, around 88% of the farms underwent changes. Only an estimated 12% of farms were found not to have adoption decision (e.g. without changes on the farms). However, several farmers responded that their farms would adopt a decision to change in the coming years.

As previously stated, the share of farms' decisions varies across different categories. From 79 farms, about 52 % of farm approaches were of the basic group (to remove or add some crops). Furthermore, 35% of perennial crop plots were entirely shifted to new perennial crops such as coffee, pepper, rubber and cashew. Only 13% of plots applied changes of the diversified group by transferring into new systems by plenty of crops (Table 7.2).

7.2. Factors affecting perennial crop farms' adoption

7.2.1. General adoption

The binary regression model examines the probability of a farm's decision on adoption based on crop profile, household characteristics, and farm endowment (Table 7.3In this section, we can explain why many farms are responded positively to convert new systems, while others did not undertake such a decision.

Table 7.3: Econometric model results of significant factors of farm's adoption

Variables	*Coefficient*	Standard error
Constant	2.230	2.873
ETH	3.672*	1.231
EDUC	-.482*	.173
TRAI	2.783*	.995
CROPF	4.278*	1.079
PROFIT	-1.273*	.460

*, **, *** Significant level at 1%, 5% and 10%, -2 log likelihood = 60.254; omnibus test of model coefficients (χ2, df, sig) = 64.5, 16, 0.000; Cox and Snell (R^2) = 0.512; Nagelkerke R^2 = 0.682; percentage of correct predictions = 86.7%

Source: Authors' own calculations

The formula of logistic regression is as follows:

FDD (Farm's decision adoption) = 2.230+3.672*ETH-0.482*EDUC+2.783*TRAI+4.278*CROPF-1.273*PROFIT

The results include five variables of ETH; EDUC, TRAI, CROPF and PROFIT and these have a significant impact on the general adoption of farms, which can be explained as follows:

- **Household characteristics (socio-demographic characteristics)**

As indicated earlier, household characteristics play an important role in the farm's decision of adoption. In this study, household characteristics include ethnic, education and training, which all have a significant effect on a farm's decision in adopting (Table 7.3). Specifically, ethnicity and training factors were found to have

a positive influence on the farm's decision. The interpretation of this is that the Kinh group and acquisition of training (the contents of training programs including technical guidance, new crops and varieties for introduction, or expanding marketing practices) were factors which allowed farmers to prefer to adopt, rather than their absence.

Picture 7.1: A non-adoption of an indigenous farm

In more detail, the results of the Mann-Whitney test showed the significant relationship between these factors and the farm's decision on adoption. With respect to adopters, these were over 87 % of Kinh people and about 70 % of those with training while these figures in the non-adoption group only reached 42% and 35%, respectively (Table 7.4).

Table 7.4: Major characteristics of two groups on general adoption

Items	Non adoption (N= 11)		Adoption (N=79)		Sig
	Mean	SD	Mean	SD	
Kinh people	0.42	0.53	0.87	0.20	0.01***
Training farmers	0.35	0.49	0.68	0.52	0.00***

All comparisons are statistically significant (les than 5%) in the Mann–Whitney U Test.

Source: Author's own calculation

Perhaps opposite to expectation, education (years of schooling) was found to have a negative correlation with farms' decision in adopting. In other words, the probability of farm's decision to convert is likely to decrease when the education level is higher. In this research site, higher educational producers were young people (people who were under 35 years old), who were separated from their parents and typically held less land

(including less area and fewer plots), and this likely caused a constraint to adopt. The finding is consistent with explanations that find land shortages are less likely to produce adoption decisions on tree planting. This thinking includes the belief that the adoption of new trees will result in comparion with other crops and reduce their current limited income (Kakuru, Doreen and Wilson 2014). In addition, there were some cases revealed from the in-depth interviews in which, younger growers lacked the workforce and capital (compared with older, established growers), which are important resources which impact on the farm's adoption. As a result, the younger growers often find solutions by taking advantage of family workers for their farms to save input costs, as well as seeking part-time employment to create other income. Figure 7.1 is an illustration of the negative correlation between education and adoption.

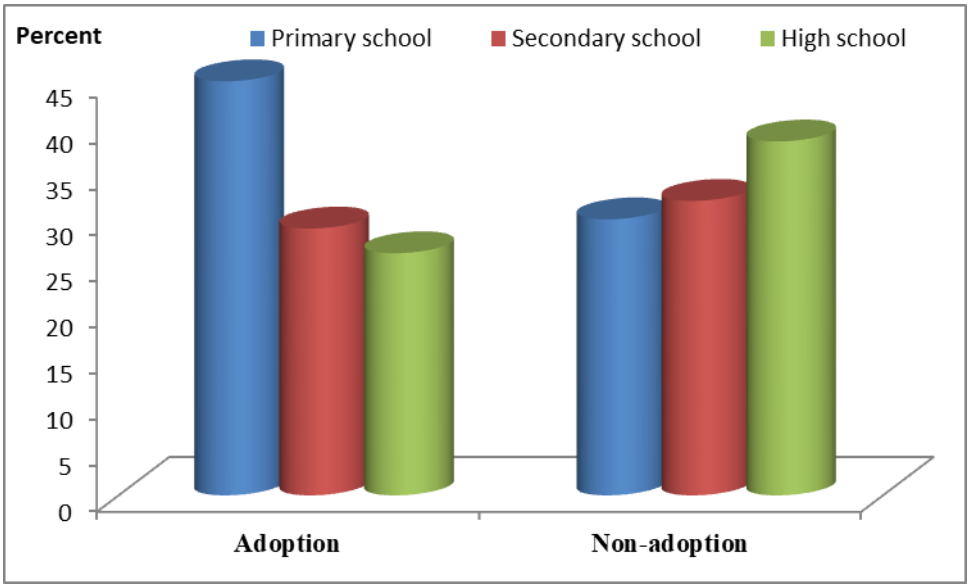


Figure 7.1. The education level of adopters and non-adopters

Source: Author's own calculation

Mr Trieu Tai Dung, CuMgar district, is 32 years old. His farm is 0.8 hectares, different from his parents' land, but without LURC (Cadastral certificate). The family is comprised of him, his wife and two children (the first is 3 years and the other is one year old). He is the main source of labor, while his wife spends more time on caring for the children. Although he graduated from high school (grade 12), it isn't easy to make adoption decisions on the farm because his family has only one piece with limited ability to gain income. Moreover, the lack of capital is a constraint due to having few relationships with agencies and without a LURC which is necessary to borrow money. More importantly, he is concerned about decreasing crop yield if he makes an adoption decision for the farm. Consequently, he decides to maintain the current farm.

Source: In-depth interview in 2018

- **Farm characteristics (Profits):**

Profit was found to be a statistically significant factor among the farm characteristics. There is a negative relationship between profits and a farm's decision (–1.273). This means that low-profit farms are more likely to have a higher probability to undergo a farm's decision on adoption.

Specifically, Table 7.5 shows the significant difference in farm profits between adoption and non-adoption groups. Accordingly, the more likely a farms' decision on adoption is, the more likely it is to have lower profits. This finding is consistent with (Verburg et al. 2004) that economic factors influence crop choice decisions.

Table 7.5: Farm profits of two groups

	Non-adoption (N= 11)	Adoption (N= 79)	Sig
Profit (Million VND/ha)	51	46	0.05**
Standard deviation	30	33	

The comparison is statistically significant (less than 10%) in the Mann–Whitney U Test.

Source: Author's own calculation

In literature, many factors have been found to be significant in explaining the farm's decision when profitability is considered. Among these are management and financial capacity, farm resource quality and operations, farm and financial management and skills (Tey and Brindal 2012). Moreover, when identifying the determinants of farm profitability of perennial crops in the same research sites, another study also found that experience, training, other income and gross output had statistical significance with respect to profit changes in perennial crop farm groups (Phan et al., 2020). Specifically, the results of the discriminant analysis found factors affecting profitability in two categories of successful farms (53 farms) and unsuccessful farms (37 farms), using data from 90 plots. The regression analysis showed that the determinants of farm profitability included experience, other income, training, and output. Each of these individually had positive influences on successful farms (Table 7.6).

Table 7.6: Discriminant analysis test on the impact of factors on the profits

Tests of Equality of Group Means				
	Wilks' Lambda	F	df1	df2
Experience	0.834	11.558***	1	58
Other income	0.929	4.446**	1	58
Training	0.661	29.696***	1	58
GO	0.939	3.797*	1	58
Eigenvalue = 1.639 (>1)				
Canonical correlation = 0.788				
Wilks Lamda = 0.384, p value = 0.02 (<0.05)				

All comparisons are statistically significant (les than 10%) in the Mann–Whitney U Test.

Source: (Phan et al., 2020)

With respect to household characteristics, it was found that experience and training skills were likely to influence the profitability of farms. This seems to be logical and is consistent with other findings (Jezeer et al., 2018). Training and experience are greatly

beneficial when cultivating perennial crops because they have a long lifespan and survive through multiple harvest seasons, and require higher levels of attention. When such extended production is faced with difficulties, experience and training skills related to good agricultural practices reduces risk, saving costs, and generate higher income. According to local authorities, training programs can guide farmers to adopt technical innovations, prevent diseases, and assist in pruning and shaping techniques as well as provide guidance in diversification of farm systems. In other words, farmers need to have an increased amount of agricultural knowledge on which to draw upon, to help decide what to grow and how to grow it, as well as attain a better understanding of their own resources, weather conditions, and price dynamics. Sustainability-certified farms, which are cost-efficient systems that are less susceptible to environmental influences, develop better economic efficiency than do conventional farms, as reported by (Ho et al., 2018). Another positive factor is other income. Other income helps farmers to increase capital endowment for their plantation, which reduces borrowing finances from informal channels. This finding is in good agreement with the literature (Warren, 2002; Turner and Annamalai, 2012; Ho and Ha, 2017). Additionally, other income activities such as agricultural and non-agricultural activities, have been shown to generate added value for farmers.

Perennial crop cultivation is faced with many difficulties. In order to maintain output and growth, solutions involving intensified and diversified strategies which save costs in activities such as labor, water, pesticides, fertilizers should be provided by governments. In addition, training skills, which put farmers in a better position to compete in production and marketing, should be improved. For instance, the government can use available funds to train farmers and leaders, instead of supplying only cash payments. This is essential in order to spread information and ensure the longevity of new behaviors that are socially and ethically sound.

Picture 7.2: A mono coffee system is adopting pepper crops due to low coffee yield

- **Crop profile**

Crop losses cause reduced crop yields and outputs, resulting in a major threat hardship for rural families, affecting things like food security and wellbeing. Pests and diseases are estimated to affect from 20 to 40% of cash crops in countries and regions. In this study, ageing trees, especially coffee trees, were a major problem. Over one-third of the provincial coffee growing area is aged 15–20 years and for over 50 % of the surveyed farms, the age was over 15 years. As reported by Dak Lak province, the total coffee growing area that needed to be replaced was over 41 thousand ha up to 2020,. The replacement coffee reached around 65 % in 2018 (DARD, 2018). Most aged trees have low yields, high production costs, less efficiency and have higher incidences of pest and disease infection. This study examined the relationship between the crop failure status and farms' decisions (Table 7.7). The regression analysis indicates that crop failure has a positive correlation with adoption decision. This means that increasing incidences of crop failure tend to boost the probability of adoption by farms.

Table 7.7: The correlation among the ageing trees, pests and diseases and crop failure to farm adoption

	Adoption (N=79)	Non adoption (N=11)	Sig
Crop failure status	0.42	0.34	0.08*
Standard deviation	0.86	0.67	

The comparison is statistically significant (les than 10%) in the Mann–Whitney U Test.

Source: Author's own calculation

Picture 7.3: Pepper crops died on a mono-pepper system

Although the local government has identified that coffee is the key crop for provincial economic growth, due to recent fluctuation of coffee prices, instead of coffee tree rejuvenation, farmers tend to follow the real market by shifting to other crops such as avocado or durian or cashew. In other words, farms seem to respond to unfolding consumer demand to maximize profits.

7.2.2. Specific adoption

This paper uses the multinomial logistic regression (MLR) to estimate how marginal changes affect three major classes of adoption, including basis adoption (Group 0), perennial crop adoption (Group 1) and diversified crops adoption (Group 2) (these were defined in section 4). In other words, the multinomial logistic model is used to identify how explanatory variables influence the farm's decision regarding the probability of adoption according to Group 0, Group 1 and Group 2.

Table 7.8: Determinants of farm crop choice for major categories

Group	Determinant	B	Std. Error
Perennial crop adoption (Group 1)	Intercept	4.992	6.055
	FWORK	3.035***	1.291
	PROFIT	-.046***	.018
	AGETREE (=1)	-4.863**	2.245
	PETDISE (=1)	-4.071***	2.274
	TRAI (=1)	5.656**	3.062
	ETHN (=0)	-4.017**	2.149
Diversified adoption (Group 2)	Intercept	-15.120	8.642
	PROFIT	-.065***	.027

AGETREE (=0)	-8.331***	3.001
PETDISE (=0)	-5.349**	2.723
TRAI (=1)	8.515***	3.780
ETHN (=1)	-9.571***	3.545

Observations: 79; Log likelihood= 83.298; Wald χ^2: 102.016. Sig χ^2 =0.00<0.05

***,**,* Significance at the 1%, 5% and 10%

The reference category is Group 0

Observed	Predicted			
	Basis adoption	Perennial crop adoption	Diversified adoption	Percent Correct
Basis adoption	29	3	1	87.9%
Perennial crop adoption	3	28	2	84.8%
Diversified adoption	2	4	7	53.8%
Overall Percentage	43.0%	44.3%	12.7%	81.0%

Source: Authors' calculation

Table 7.8 indicates that the value of the likelihood ratio is 83.298, reaching a 1% significance probability level. This means that there is a best fit model in this case. As well, the pseudo R2 value of 0.48 confirms that the explanatory variables are significant in explaining farms' choice according to type of intercropped farms, and the confidence of the associated logistics.

The result of MLR indicates that there is the relationship between the factors and the farms' choice on adopting a type of intercropped farms, and this is illustrated by the coefficients in the model (B). MLR analysis confirms that the factors explaining a farm's specific decision include farm profiles (pest and disease status; the age of trees), farmers' characteristics (training) and economic factors (profits), in accord with the findings of Ketteler, (2018). Furthermore, the prediction for Group 0 had the highest percentage with 87.9 % while Groups 1 and 2 were 84.8% and 53.8%, respectively. Overall, MLR reveals that this model attained 81% accuracy for the prediction. The results of the MLR model are presented in Table 7.8.

- **A comparison between Perennial crop adoption (Group 1) and Basis adoption (Group 0)**

In terms of farmer characteristics, the econometric analysis found that the family workforce, ethnicity and training factors play statistically significance roles when deciding between Basis adoption (Group 0) and Perennial crop adoption (Group 1) (Table 7.8).

With regard to family labor, we also found that this factor has a positive and statistically significant effect on adopting perennial crops compared to basis adoption. In other words, the increasing number of adult workers raise the probability of the farm's decision on adoption of the perennial crop group. This finding might be explained in that farms tend to transfer to perennial crop adoption if more family labor works on them, the perception being that they are labor intensive. The result is

consistent with other authors who have found that the decision on tree planting is influenced by the availability and use of shared (Dinh et al., 2017; Holden, Deininger and Ghebru, 2009; Nguyen, Bauer and Uibrig, 2010). For instance, Phan et al., (2019a) found that, in order to establish a new MCS, MPS and CPI, the required labor for all activities was about 93, 77 and 123 man-days, respectively. As a result, the presence of laborers plays great importance on crop choice decisions, especially when the availability of many family laborers can relieve the production costs in the context of capital shortages. Table 7.9 displays the statistical differences of labor-related farms between Group 0 and 1, where Group 1 has about 3.0 laborers.

Mr Hai lives in CuMgar district. His family has 4 children. But two of them work at a company in Ho Chi Minh city. Sometimes, he receives allowances from his children which help him to meet daily costs. He spends a part of the money on investing in his farm. He earns more money being a hired laborer in his hometown. Although the farm is old with ageing trees, labor is the main constraint. He said that his wife is, now, a full-time laborer in the MCS. Consequently, this MCS is kept in its current state of low yield. As he admits, the replacement of coffee trees requires extensive man-power days and financial capabilities beyond which, his family can provide.

Source: In-depth interview in 2018

The exploration of training and ethnicity produced interesting results on perennial crop adoption groups. Specifically, when compared to trained people and Kinh people, those people lacking training and ethnic people are likely less choose Group 1 (Table 7.8). For instance, the Coefficient (B) of trained people was 5.656, and therefore, log (odds) increases 5.656 units when the number of trained people is increased by one unit. It implies that as the amount of trained people is raised, the probability of conversion into Group 1 increases. In Dak Lak province, the local authority trains farmers on perennial crop practices. In addition to this, companies combine their promotional programs of fertilizers, pesticides and new seedlings with opportunities to share experiences and/or provide guidance on application practices. However, there is often a limited number of participants in these activities by farmers due to many reasons, such as farmers not being able to afford to follow the advice or growers having strong belief in their own experience. Table 7.9 adds support to demonstrate that there are 76 % of trained people in Group 1 while those lacking training amount to only 24%. At the same time, in terms of ethnicity, ethnic minority people are also less likely to adopt Group 1. This might also imply that transformation is costly (ethnic minorities are often pooer). Instead of shifting completely, these farmers often choose to change only a part of their farms, in order to maintain the income. This makes sense when we remember that ethnic minority group less financially endowed in comparison to Kinh people.

Table 7.9: The households' characteristics of basis adoption and perennial crop adoption groups

Items	Group 1		Group 0		
	Mean	SD	Mean	SD	Sig
Labor related farms (people)	3.0	1.5	2.1	0.7	0.01***
Non-training (%)	0.2	0.4	0.7	0.5	0.00***
Kinh Ethnicity (%)	0.6	0.5	0.4	0.4	NS

All comparisons are statistically significant (less than 5%) in the Mann–Whitney U Test.

Source: Author's own calculation

Mr Y Do Ron is 48 years old, a member of the Ede ethnic group, in Cu Kuin district. He has four children over aged 15 years, and of these two of them moved to Ho Chi Minh city to be workers. He farms one hectare of mono coffee system cultivation, which is owned by a coffee company in Cu Kuin district. He has participated in some training courses on coffee production, but lack training in pepper cultivation. Due to the low performance of the coffee farm, his family income is totally dependent on fining enough employment. Due to lack of the capital and other resources and knowledge on the adoption of other systems, he can only plan to maintain the farm and find paid-jobs in the coming years.

Source: In-depth interview in 2018

With respect to economic size, farm profits were found to have a negative correlation in relation to farms' profit) is choice. B (-0.46, meaning that the lower farm profits, the more the tendency towards perennial crop adoption group, as opposed to the basis adoption group (Table 7.8). Additionally, the Mann-Whitney test result showed a significant difference between the two groups, in which the farm profits for the Basis adoption group were more profitable than the rest. Correspondingly, profits for farms of Group 1 are less by several times than profits for that of group 0 (Table 7.10).

Table 7.10: The profits of farms between two groups

Profits (Million VND/ha)	Group 1		Group 0		Sig
	Mean	SD	Mean	SD	
	38	10	100	63	0.00***

The comparison is statistically significant (less than 1%) in the Mann–Whitney U Test.

Source: Author's own calculation

For crop profiles, we find that a higher age of trees on farms, and the incidence of pests and diseases boosts the likelihood of perennial crop adoption (Table 7.8). In other words, the finding of regression analysis indicates that a high age of trees and high incidence of pests and diseases has a positive effect across different adoptions. Looking at the assessed data, Table 7.11 indicates that there were 27% of farms with ages trees and 33 % of farms with pests and diseases belonging Group 1, which was higher than those belonging to Group 0.

Table 7.11: The crop status of farms between two groups

Items	Group 1		Group 0		Sig
	Mean	SD	Mean	SD	
AGETREE (=1if Yes)	0.27	0.45	0.12	0.33	NS
PETDES (=1if Yes)	0.33	0.48	0.12	0.33	0.04**

The comparison is statistically significant (less than 5%) in the Mann–Whitney U Test.

Source: Author's own calculation

Picture 7.4: Mono-coffee systems are over 25 years old with low yield

Picture 7.5: Farms are being prepared to adopt new cropping systems

- **A comparison between Group 0 and Group 2**

In addition, other, factors have statistical correspondence between Group 2 and Group 0. These factors include ethnicity, training, profits, trees age, and pest and disease status.

In terms of the presence of training as compared to the lack of training, having training meant farms were more likely to adopt Group 2 than Group 0. In as B (training) is 8.515,

therefore, log (odds) increases 8.515 units when the number of trained farmers steps up a unit (Table 7.8). According to the statistics, only 20% of untrained adopters were in Group 2 while the adoption rate for this group for Group 0 is 60% (Table 7.12). This corresponds with an explanation that households without training are limited in their ability to adopt new farming methods, as well as even limited in their ability to apply new technologies. In some cases, they seem to have no information about the new farm approaches. In modern perennial crop production, to solve difficulties and maintain profit levels, applying new technologies (such as in irrigation and, fertilizer use) and taking care of plantations) are very important, especially given the current emphasis on sustainable development. A lack of technical training affects the ability to make changes in farming technique. That is a major reason why those farms which lack training continue to maintain their current farms. This is in line with (Truong and Ryuichi, 2002).

In addition, belonging to the Kinh ethnic group increases the probability of adopting Group 2 rather than Group 0. On the other hand, members of other ethnicities are less likely to make a decision on adoption. Table 7.12 provides a statistical data that shows that constituents of Groups 2 are 90% belonging to the Kinh group, whereas Kinh adoptees within Group 0 are only 60%.

Table 7.12: The description of farms between Group 0 and 2

Items	Group 2		Group 0		Sig
	Mean	SD	Mean	SD	
Profits (Million VND/ha)	34.4	32	100	63.3	0.00***
Ethnicity (=1 if Kinh)	0.9	0.3	0.6	0.5	0.05**
Training (=1 if Yes)	0.2	0.4	0.6	0.5	0.00***
Age of tree (=1 if over 20 years)	0.4	0.5	0.1	0.3	0.04**
Pests and diseases (=1 if Yes)	0.6	0.5	0.2	0.3	0.00***

All comparisons are statistically significant (less than 10%) in the Mann–Whitney U Test.

Source: Author's own calculation

Vis-a-vis pests and diseases, and ageing tree stocks, there is a negative association with respect to adoption of Group 2 (if the age of trees is under 20 years and without the presence of pest and diseases). This finding may be explained by the fact that pests, diseases and ageing crops cause lower yields as well as high material costs for farmers, affecting sustainable livelihoods in the future. This reasoning is also consistent with previous studies such as (Hurri and Ngoc 2015; Lindskog et al., 2005). With this rationale, for example, ageing tree stocks significantly deteriorate the yields, which provides motivation to the farmers to chop down coffee plantations, and thereupon replace the previous cultivation method with other systems. In this study, the number of plantations that had crop loss due to the ageing of trees, and pests and diseases was at 41% in Dak Lak Province. In addition, the total pepper area lost in the Central Highlands in 2018 amounted to 10 thousand ha (11.4%) (Duong and Nguyen 2019). According to the Dak Lak Provincial People's Committee (2018), around 42 thousand ha of the coffee area at that time needed a rejuvenation due to ageing tree stocks. In the upcoming years, it is suggested that the government should also concentrate on pest and disease infection as an emerging problem.

Obviously, upon new farm adoptions, production risks must be managed, at the same

time that there is an evolution of farm practices. Thus, adoption decisions involve management strategies as necessary new patterns of utilization and allocation of resources are taken into consideration.

A notable finding of this study is that, farms might be expected to be more interested in the adoption of perennial crops and diversified crops, to strengthen resilience. Nonetheless, under the effects of various factors, the conversion process needs to be analyzed carefully beforehand, because perennial crop replanting is not only a call for long-term investment but it can also result in a reduction of farmers' income during the early maturation period of newly planted crops. At the time the decision is made, for success during the period the adoption of tree planting, a sustainable supply of input materials, in terms of seedlings and nursery products, is necessary. Governmental agencies should assist in offering financial support for rural households, such as via social banking or other organizations. Further, to diminish the influences of the many risk factors, in the future households need to be more cognizant of risk management in perennial crop production, for example preventing pests and infectious diseases, so that they can enhance their profitability. We advise farmers that farm adoption takes time and money, and as well is affected by many factors. Therefore, farmers and policymakers should explore the potential for adoption carefully, dependent upon their region and research, to formulate a suitable solution for their sustainable development of perennial crop farms.

8

Conclusions and Recommendations

8.1. Conclusions

This study is about practices and socio-economic analysis of perennial crop systems in Dak Lak province. The research regarding the proposed hypotheses was undertaken in three areas CuMgar district, Buon Ma Thuot city and Cu Kuin district, Dak Lak province. The research provides some noteble empirical observation including the following:

Firstly, perennial crops have undergone rapid development in Dak Lak during recent decades. Consequently, the dynamics and practices of perennial crop systems in Dak Lak province are required to be sustainably adapted to be appropriate for agro-ecological and socio-economic transformation. In doing so, the development of perennial crops can vary in a wide range of ways including types of crops, systems, production location, farm size and government support across time and space. Specific to this province, the evolution of perennial crop systems has undergone five stages involving three zones. In the early development stage (before reunification in 1975), perennial crop systems not only heavily focused on coffee and pepper on large-scale plantations but also primarily depended on natural resources. In other words, monocultures of the single crop-types were dominant, such as with coffee, cacao, tea and rubber. These were principally concentrated in the very high fertility region (Zone 1). At the time, coffee and rubber underwent the fastest expansion, while tea and cacao were only cultivated in limited areas. During the colonial era, the perennial crop plantations were most common in Zone 1 while the moderate soil fertility region (Zone 2) was used grow some annual crops like maize, beans and rice for subsistence purposes. Meanwhile, fallow land and forests covered a large area in the unsuitable region (Zone 3). In terms of the State-owned period (1975-1985), perennial crops continued to be cultivated according to large-scale production, due to maintaining the old plantations. Because of increasing population and the continued presence of state-owned farms, perennial crops gradually expanded onto Zone 2 by individuals and households, while in Zone 3 diverse culture of rice and other annual crops for subsistence was initiated. In the years of the reconstruction (1986-1990s), perennial crop systems implemented simple technology, and with the use of fertilizers, pesticides and herbicides, this facilitated the intensification of perennial crops in order to maximize yields and productivity. Also during this time, there was a trend increased coffee area and a reduction of tea and mulberry. In addition, annual crops rapidly shifted to perennial crops in the moderate region (Zone 2). Fallow and forested area were being reduced by the establishment of rice paddies and some suitable vegetables. In parallel with the physical perennial crop expansion, a growing population was also a pressure on the land. In the 2000s, the patterns of perennial cropping underwent most significant evolution, with mixed crop systems being established in Zone 1 and Zone 2. Since 2010, natural conditions and market issues have caused significant challenges to cropping structure, through physical and quantitative changes. Accordingly, perennial crops in most of these areas have shown a wide increase in their proportion, using specialized and diversified approaches, in which coffee-based intercropping systems have become, more widespread. The dynamics and variables related to perennial crops

production give a better comprehension of how the perennial crop systems are currently organized. Furthermore, such an analysis can identify and clarify evidence to guide policymakers on the suitable formulation of assistance for perennial crop development.

Secondly, the two crops coffee and pepper represent the major systems, and these include coffee and pepper monocultures and coffee and pepper intercropping systems. These practices in these systems have been described and their socio-economic performance has been examined. The practices involved in most perennial crop systems are conventional focusing on fertilizers and use few technological applications. Furthermore, they face some current challenges, such as ageing coffee trees for MCS, pest and disease infection for MPS. In addition to these constraints on perennial crop production, there is often a lack of labor during the harvesting period. Pepper farms have recently experienced a significant reduction in profitability due to infestation by pests and diseases, as well as a sharp price decrease in 2018 as compared with 2017. In terms of socio-economic benefits, intercropping systems (CPIs) demonstrate higher economic performance, thanks to the presence of economies of scope. As well, they have benefits with regard to potential employment creation, especially for women, and higher returns for labor. Going forward, CPI enhances the ability to create diversified livelihoods relating to crops and cattle. Globally, CPI is particularly suited for limited-land availability and endowed households. With classification into groups and also with respect to farm types, analyses produce informative results concerning economic performance. With respect to the analysis with farm types, the finding showed that intercropped farms (ICFs and IPFs) possess lower costs than mono-crop farms (MCFs and MPFs). In other words, the analysis revealed that intercropped farms are a suitable alternative in perennial crop production, having lower variable costs and higher return rates in relation to mono-crop approaches. In terms of group production, the results showed that during the period of two years, GpP had higher variable costs and economic efficiency than GpC. The growth profit change of GpP was higher than GpC, but GpC was more suitable for poorer and less endowed households. The assessment concerning socio-economic benefits of perennial crop systems provides critical information and perspective for farmers and local authorities on choosing and promoting and the appropriate practices. Using the results of this research, farmers have information with which to design appropriate farms systems with their specific endowments and resources.

Thirdly, socio-economic benefits explain the farm's choice and practices. In this study, a comprehensive analysis of determinants of crop choice decisions under different categories was performed. It was found that the ethnicity, education, training, crop failure and profits have a statistically significant effect on general adoption, while family workers, training, ethnicity, pests and diseases, ageing trees and profits influenced specific adoptions.

Understanding the practices, socio-economic benefits and the preferred choices of adoption helps policymakers to prioritize specific perennial crop systems and designate support for appropriate adoption options.

8.2. Recommendations

According to Vietnam's guideline, agricultural development needs to generate "more from less", meaning it must create more economic value, farmer welfare, and use fewer natural resources, human capital and less harmful intermediate inputs to decrease environmental impacts. At the present time, further growth needs to rely principally on increased efficiency, diversification and innovation to take advantage of value addition. The Vietnamese Ministry of Agriculture and Rural Development addresses economic efficiency while being concerned with sustainability and environmental conservation. Sustainable agriculture must occasionally face trade-offs with productivity, stability and equitability. To this end, the national and local governments have, in recent years, contributed in important ways to the success of perennial crop sectors by implementing various policies such as guidance on technology, providing finance and new crop varieties. In this survey, all recommendations are centred upon answering the questions: How can perennial crop systems develop in a positive manner?; How can perennial crop systems overcome difficulties?; and How can perennial crop farms be helped to increase profitability and sustainability?

- *The implication for the perennial crop sector*

With respect to the dynamics and overview of perennial crop systems, empirical data provide policymakers information to construct guidelines on cropland use, organization, management and the marketing situation. Specifically, guidelines should achieve at balance between the areas cultivated under perennial crop production and natural resource protection, by the implementation of a perennial crops Master Plan. Furthermore, national and local governments should call upon the active involvement and linkages of all concerned agencies (*liên kết sáu nhà*) such as producers, bankers, scientists, businessmen, and investors to governments as well as exchange information among a wide range of stakeholders. Subsequently, policies should be implemented that promote the formulated guidelines for perennial crop production, and promulgate this guidance between a wide range of stakeholders and farmers to integrate Vietnam's sustainable development goals. There should be exploration of the potential and promotion of agro-tourism such as coffee tourism. This can assist rural development and sustainability and needs to be taken into consideration, which has been identified in some studies (Woyesa and Kumar, 2020; Yun, 2014). It is desirable that smallholder perennial crop production in Dak Lak consider enhancing the quality and the quantity of products via smart, sustainable agriculture for smallholders with minimum effects on the environment.

- *The implications for each cropping system*

+ Mono coffee systems (MCS)

New pathways for the coffee sector should be built through reorganization and marketing activities. The authorities should carry out a Master Plan with respect to the zones of coffee cultivation, to reduce the physical expansion of coffee and enhance cost-efficient production. In Zone 3 (soil of unsuitable or low fertility), there should be encouragement and enhancement measures to rejuvenate old coffee farms or transfer to other crops. In order to facilitate this, the local government should expand access to financial services at a low-interest rate. Other than government involvement, it is

essential to enlarge the role and participation of social organizations such as women's unions, youth unions and farmers unions to create diverse financial sources.

In Zone 1 and Zone 2, the production of specialty coffee beans (*cà phê đặc sản*) should be encouraged in order to assist competitiveness and gain added value. The production of "weasel coffee" is an example. In addition, the authorities should announce encouragement for sustainably-production certified coffee in suitable subregions or/and for shade tree applications in the whole province, in order to reduce environmental impacts, decreases production costs (e.g. irrigation costs) and improve households' income from by-products (timber, fruit) (Jezeer et al., 2018; Ho et al., 2018). Additionally, coffee farms should produce under agroforestry systems rationale, because of the utility in providing the ecosystem services, especially when producing certified coffee (Pico-Mendoza et al., 2020). The government should pay more attention to quality certification for farms, rather than quantity certification. In addition, the authorities should implement programmes of land consolidation through exchanging and regrouping land parcels among households. This is likely to be appropriate for technology, hi-tech coffee zone or/and smart farming applications and marketing. Finally, in the difficult economic situations, coffee tourism could provide a potential additional market segment to maintain stability or improve livelihood and rural development.

+ Mono pepper systems (MPS)

The aims of these suggestions are to help pepper farmers cope with their current difficulties and provide a new direction for stable development in the future. Specifically, the local government should declare significant urgency with respect to dealing with the current pests and diseases situation. Significant plant losses should be well-controlled by improvements in the producer's awareness, increasing the hygiene on farms, and encouraging transferal to other crops. In particular, expansion of technical training courses, and guidance on pest and disease-free pepper production should be recommended. Moreover, there needs to be public support for using live plants for vines instead of concrete and wooden pillars. With respect to marketing, there should be cooperation and linkages established between farmers and intermediates, to find and protect legitimate rights in the market. In addition, there needs to be improvements in a farmer's ability to negotiate with respect to production marketing. With this in mind, organic pepper production can be considered to be a good path to follow in the present circumstances. Farmers, therefore, need to be able to access new technology and capital. National and local governments should have a wide range of package insurance available for distinct stages of production, such as for immature and mature stages. Lastly, the organization or coordination of volunteers or social communities needs to be considered. This would help rural farmers harvest black pepper in urgent cases, and can assist in dealing with social problem (such as theft).

+ Coffee and pepper intercropping (CPI)

Especially when land resources are under pressure, CPI and intercropped farms have been demonstrated to generate more socio-economic benefits for farmers than the other systems do. Thus, the author recommends that farmers and local authorities should pay more attention to intercropped systems, especially coffee-base intercropping. Local

authorities should encourage citizens to be interested in intercropped cultivation. Diversification is integral to CPI, as is its benefits in terms of sustainable, ecological agriculture (Conway 1993). In CPI, farmers' innovative capacity with respect to their adoptions plays a vital role in order to achieve the higher efficiency in terms of cost and benefits, sustainability, and their health protection. Thus, at the household level, farmers must always volunteer to study modern practices in order to have enough knowledge in modern production and management. By doing this, they will reap benefits in terms of saving cost, reducing environmental impacts, and identifying and treating pests and diseases. Consequently, in the coming years, farmers need to take into account technical advice, optimized density and manage costs to boost crop productivity, increase the land utilization ratio and enhance the benefits for second crops. In other words, farmers' perceptions and knowledge concerning the role of intercropping on farms needs to be reinforced in the future.

At the community level, there should be more attention paid to creating an enabling environment for small-scale farmer innovation via interventions and policies. Specifically, research should be widely publicized through practical activities such as workshops, forums and hands-on activities, along the current programmes. Financial support needs to be administered because the smallholders rarely have savings available. Moreover, there should be less emphasis on maximizing output in the coming years, but rather than to help inspire confidence in CPI and assist sustainable development, the training programmes for technical training, density, and using live trees for pillars, should be taken into consideration. The performance of intercropping systems should be evaluated on large scales (conditions, sample size and diversity in systems) in order to collect a research database. Importantly, there is a need to have correct guidance for farm practices (density, preventing pests, the amount of fertilizers and pesticides used). Successful models of intercropped systems should be promoted through the sharing experiences at different level from province to villages.

Finally, we suggest that there is a strong need to consider the influential factors on farms' adoption decisions. Household characteristics, crop profile and farm endowment should be considered the most important factors in determining the crop choice decision of perennial crop farms. It is important that the process of concersion be analyzed carefully beforehand, because perennial crop transition not only requires long-term investment, but also may result in a reduction in farmers' income during the early period while new crops are maturing.

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