RURAL LIVELIHOODS AND ECOSYSTEM SERVICES IN OIL PALM LANDSCAPES IN RIAU, SUMATRA, INDONESIA

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

GLOSSARY OF ABBREVIATIONS

ADB	Asian Development Bank
AEZ	Agro-Ecological Zones
ANOVA	Analysis of Variance
BAL	Basic Agrarian Law
BPS	*Badan Pusat Statistik* (Statistics Indonesia)
CIFOR	Center for International Forestry Research
CPO	Crude Palm Oil
DFID	Department for International Development (U.K.)
ES	Ecosystem Services
ESV	Ecosystem Services Valuation
FFB	Fresh Fruit Bunches
GDP	Gross Domestic Product
IDR	Indonesian Rupiah
KKPA	*Kredit Koperasi Primer untuk Anggota* (Credit for Primary Cooperative Members)
MEA	Millennium Ecosystem Assessment
NES (PIR)	Nucleus Estate and Smallholders (*Perkebunan Inti Rakyat*)
NGO	Non-government organisation
NTFP	Non-timber Forest Products
PTPN V	Perseroan Terbatas Perkebunan Nusantara V
RSPO	Roundtable on Sustainable Palm Oil
SPSS	Statistical Package for Social Sciences
TEV	Total Economic Value
UNESCO	United Nations Educational, Scientific and Cultural Organization
USD	United States Dollar
VIF	Variance Inflation Factor
WCED	World Commission on Environment and Development

SUMMARY

The overall aim of this research is to investigate the nexus between socio-economic and ecological sustainability of the people living in the oil palm-dominated landscapes in Riau, Sumatra, Indonesia. The rural livelihood patterns of the households living in the oil palm areas are examined. Furthermore, the study characterises the ecosystem services provided in oil palm landscapes, and estimates their total economic value. Finally, the research analyses the impact oil palm production has on rural livelihoods and ecosystem services in oil palm landscapes.

Riau Province in Sumatra was selected for the research as it is the province with the largest share of the oil palm estate in Indonesia. The participants in the study were divided into two groups: households and industry, government and conservation stakeholders. The combination of the frameworks of sustainable livelihoods and ecosystem services provided an integrated research framework. Primary data were collected using a household survey and interviews. Seventy-three households were involved along a topographic gradient that extended from the foothills of the Barisan Mountain Range to the peat swamps near the Malacca Strait. It was stratified into four landscapes: foothills, plains, lower foothills and peat swamps. One village was sampled in each landscape. Secondary data were obtained from reports from provincial government, government ministries, NGOs and the Indonesian Central Statistics Agency (BPS). Household survey data were analysed using descriptive analysis and inferential statistics. Models that predict household incomes were developed using multiple linear regression.

The study revealed new information in relation to socio-economic and ecological aspects of rural livelihoods and ecosystem services in the context of oil palm-dominated landscapes. It has provided evidence related to livelihoods patterns and diversification of income for households in the oil palm-dominated landscapes. It showed that oil palm has improved the livelihoods of the people in rural areas. It has helped them to escape poverty, enabled them to accumulate capital which they have been able to reinvest in oil palm, or other on-farm and off-farm activities.

Thirteen main ecosystem services were identified in the oil palm landscapes: nine

marketed and four non-marketed. Using direct market valuation, the total economic value of ecosystem services associated with oil palm landscapes was estimated to be US$ 6,520 ha/year (range = US$2,970 – US$7,729 ha/year). Approximately a third - 33.6% (range = 23.8 – 52.1%) - was generated by non-marketed ecosystem services. In total oil palm landscapes in Riau Province have an economic value that exceeds US$ 15 billion annually.

The study will contribute to the theory and practice of using sustainable livelihood and ecosystem services frameworks to investigate the links between ecosystem service characteristics and their benefits to the livelihoods of people in the oil palm landscapes. Integrating these frameworks allowed the significance of the benefits and values provided in oil palm landscapes to be illuminated clearly. The framework used could be useful for future research related to other social and economic dimensions in natural resources management.

DECLARATION

I certify that this thesis does not incorporate without acknowledgement any material previously submitted for a degree or diploma in any university; and that to the best of my knowledge and belief it does not contain any material previously published or written by another person except where due reference is made in the text.

Signed: ______________________ Date: 16 June 2017

(Ando Fahda Aulia)

ACKNOWLEDGEMENTS

First and foremost, all my praise is due to the Almighty Allah, for looking after me and granting me the capability to complete this thesis. I strongly believe that Allah always guides me to overcome all the challenges I face in life and achieve success.

This thesis reflects three years and four months of work at Flinders University's School of the Environment. I am truly privileged to have been surrounded, again and again, by people who were able to believe in me, and point me in the right direction. My path was not traditional and was only possible through the support of many colleagues, family, and friends. The path on which I now find myself is greater than any I ever imagined.

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Fieldwork formed a significant component of the work and I would like to thank everyone who helped make the field campaigns so successful, especially the communities of Ujung Batu, Tapung, Kerinci Kanan, and Bunga Raya that welcomed and received me with open arms. There are hardly enough words to express my gratitude to the farming families I interviewed, and who painstakingly made time to respond to my questions. I also want to express my thanks to people from organisations that I interviewed in Pekanbaru, Jakarta and Bogor.

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Again, words are not adequate to express my appreciation of my 'family' group for your constant support; all of you were more than a family to me. I will always be thankful to MIIAS and the other Indonesia communities that cheered me up and illuminated my family during our stay in Adelaide.

My parents sparked in me the intellectual curiosity that brought me on this journey. Mama and Mak, thank you for viewing my creativity as a virtue, and for your unwavering support and encouragement, even when it was unwarranted. Papa, thank you for the unseen force on visioning my future and the most powerful lesson of all: the importance of courage in the face of adversity. I express my heartfelt gratitude to all my brothers and sisters in Jakarta and Pekanbaru, for their generous support and care during my studies.

Completing a PhD while having three school age children and a wife, who also did a PhD at the same time with me, was a huge challenge. Their support was really needed on every occasion. I reserve my deepest thanks to my wife for her love and support, and for her editing skills. Your perseverance is paramount, you are the source of the confidence that has allowed me to continue this work with hope. You have accompanied me on this adventure and this is just a pit stop in our life.

To my children Azka, Fatih and Hanif, a very special thank you for your tolerance of my time away, both physically and mentally, and giving me the space to complete this endeavour. Occasionally, I missed the time to see three of you grow up. Words cannot express my gratitude; my accomplishment would not have been possible without your support. I hope that I have made all of you proud. I present this piece of writing for all of you.

Ando Fahda Aulia
Seacombe Gardens
August 2015

DEDICATION

To my wife (Dewi), daughter (Azka) and two sons (Fatih and Hanif)

Read in the name of your Lord Who created.
(Al-Alaq 96: 1)

O assembly of the jinn and the men! If you are able to pass through the regions of the heavens and the earth, then pass through; you cannot pass through but with authority.
(Ar-Rahman 55:33)

CHAPTER 1:
INTRODUCTION

1.1 Contexts

Sumatra, the world's sixth largest island, is on the frontline of a battle between the need to preserve tropical forest and the motivation to convert land to feed the world's voracious appetite for oil palm. This battle, part of a global assault on tropical forests by agriculture in its many forms, is complex, and leads to the question of whether there can be winners, among the many losers. Following one set of rhetorical threads leads to the impression that biodiversity will be the 'big loser': the iconic orang-utan, the Sumatran elephant, rhinoceros and tiger will be all extirpated, according to the World Wildlife Fund (WWF 2015). Another set of threads argues that the world needs palm oil and palm kernel oil to meet the growing global demand for food, cosmetics and industrial lubricants. The Government of Indonesia would argue that Sumatra's natural resources are underexploited, and that the land needs to work for the people in this, the world's fourth largest nation (UN-DESA 2015), to fuel the socio-economic development that has seen GDP growth exceed 6% in recent years (World Bank 2015). In arguments where proponents label their *cause célèbres* with superlatives, rational thinking is easily obscured.

While not attempting to resolve this argument, let alone 'solve the problem', the research presented in this thesis focuses on the people living and farming oil palm in four villages in Riau Province in Sumatra. It examines their household livelihoods and the potential of the ecosystem services (ES) concept to better value the oil palm cultivation they are so dependent on. It does not attempt to show that it would be better to abandon oil palm and restore the forests, nor even if it is worth saving the remaining forests; that is for others with a biological or a stronger environmental science background to work on. It does, however, show that many households have become relatively wealthy (relative to other peasant farmers in Indonesia, let alone globally), while at the same time becoming over-dependent on global oil palm commerce. When oil palms are no longer a commodity with an enormous global demand, the environmental damage may have been wrought in vain and the peasant farmers will be the real losers.

1.2 Aim and Objectives

The previous section has alluded to the debates that have arisen around the emergence of oil palm. In this section, I specifically address these issues in terms of the aims and objectives of the present research.

The overall aim of the research is to investigate socio-economic and ecological services and dis-services of the people living in the oil palm-dominated landscapes of Riau, Sumatra, Indonesia. Its specific objectives are to:

1. Assess livelihood patterns in the oil palm-dominated regions of Riau, Indonesia;
2. Characterise the ES underpinning oil palm-dominated households in Riau, Indonesia;
3. Examine the economic value of ES in the oil palm-dominated landscapes in Riau, Indonesia; and
4. Explore the potential of integrating ES into rural livelihoods production in oil palm landscapes.

This aim and these objectives of the study have been designed to explore the following research question: *How does oil palm production affect rural livelihoods and ES in the Indonesian oil palm-dominated landscapes?* It is anticipated that the research may also yield some insights into the issue of how to integrate the ES approach in understanding and improving rural livelihoods in Indonesia's oil palm-dominated landscapes.

Based on the research question, a study brief was constructed as illustrated in the Figure 1.1.

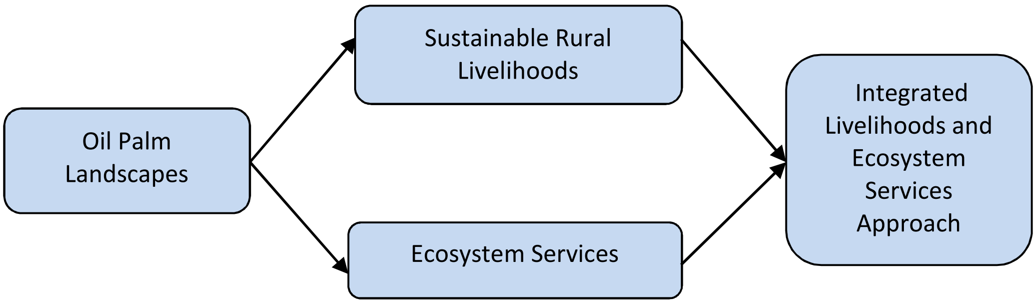


Figure 1.1. Framework of the relationship between oil palm landscapes and the integrated livelihoods and ecosystem services approach

To achieve the stated aim and objectives, the sustainable livelihoods and ES approaches are used. The research provides a significant contribution to the growing fields of sustainable livelihoods and ES, particularly in new oil palm areas. The research will also offer useful information to farmers, companies, non-governmental organisations (NGOs) and, especially, the provincial government in Riau Province. This information will provide a framework and methodology for governments to evaluate the contemporary and future impacts of oil palm landscapes on the local environment and economy. Exploring the environmental contexts of oil palm in Indonesia is a requirement for regulatory agencies, and it is anticipated that this research will be used in this milieu as well.

1.3 Thesis Structure

This thesis is organised into eight chapters. This section gives an overview of each chapter.

Chapter 1: Introduction considers the overall study context, including the background of the study; the aim, objectives and research question addressed in the study; and the structure of the thesis.

Chapter 2: Oil Palm Economy and Environment, Sustainable Rural Livelihoods, and Ecosystem Services describes and progressively interweaves the concepts used to frame the study. It provides an outline of current oil palm agriculture and trade, and introduces the concepts of sustainable rural livelihoods and ES.

Chapter 3: Riau Province describes the salient environmental and socio-economic aspects of Riau Province, and provides brief information on the case study locations.

Chapter 4: Research Design and Methods discusses the conceptual framework for the study, sampling design and the research methods used. It describes how the study was conducted, including the recruitment of participants and the necessary ethical considerations.

Chapter 5: Wealth and Dependency: Rural Livelihoods in Oil Palm-Dominated Landscapes provides an assessment and understanding of the patterns of livelihood of oil palm smallholder households, based on the people living in the communities sampled in this study from the perspective of a broad range of income sources, including oil palm. An exploration of the current literature related to sustainable rural livelihoods in the context of oil palm is also presented in the chapter. This chapter addresses research objective one.

Chapter 6: Quantifying Ecosystem Services in Oil Palm Landscapes presents the ES identified in the oil palm landscapes sampled and assesses the total economic value of ES associated with these landscapes in Riau, Indonesia using the direct current market valuation method. Research objectives two and three are addressed in this chapter.

Chapter 7: Integrating Sustainable Rural Livelihoods and the Ecosystem Services Framework in Oil Palm Landscapes discusses findings of the study in the contexts of the aims and objectives, broadly framed research questions, and the potential for use of the findings and methods in Riau and, more broadly, in Indonesia. This chapter addresses the fourth research objective.

Chapter 8: Conclusions provides the conclusions of the study, highlights its contributions and makes recommendation for future studies.

The presentation of Chapters 4, 5, 6, and 7 are written in a format that will allow them to be converted into scientific journal articles.

1.4 Summary of Chapter

This chapter has introduced the thesis by outlining the background to the study, stating the research aims and objectives, and summarising the structure of the present thesis. Chapter 2 will provide a review of literature related to oil palm agriculture and trade, ES and rural livelihoods.

CHAPTER 2:
OIL PALM ECONOMY AND ENVIRONMENT, SUSTAINABLE RURAL LIVELIHOODS AND ECOSYSTEM SERVICES

2.1 Introduction

In providing a context for the present study, it is important to consider the relevant literature. This chapter describes and connects the concepts that inform and guide the study, including its areas of focus: oil palm, the concept of sustainable rural livelihoods and ES. The first part of the chapter (Sections 2.2 and 2.3) provides background information on oil palm cultivation, its expansion and importance to the Indonesian economy, and a summary of the current status of oil palm in Indonesia and globally. The basic agronomy of oil palm is addressed to provide an understanding of oil palm growth. This is followed by a historical discussion that elaborates on the development of the palm oil trade, culminating in a review of the contemporary global palm oil markets and the status of oil palm plantations in Indonesia. This part also reviews the literature in relation to the impacts of oil palm cultivation on environment and ES. The environmental concerns raised by the expansion of oil palm plantations are also discussed.

The second half of this chapter describes the concepts of sustainable rural livelihoods and ES found in the literature that underpins this study. A conceptual understanding and framework of sustainable rural livelihoods as used in the present study is provided (Section 2.4). Section 2.5 describes ES as another framework to be used in this thesis. Major issues related to ES are provided, including some concerns about humid tropical forests, agriculture and plantations, together with their impacts to rural livelihoods.

2.2 Oil Palm: Agronomic and Economic Contexts

Since the late nineteenth century, oil palm has been developed as a cultivated tree crop, and has become an economically important crop meeting different industrial needs around the world. However, few recognise the importance and extensive use of oil palm, its history and its economic contribution to global commerce. This lack of recognition of the economic value of oil palm must be set against the fact that oil palm products are used extensively to meet a wide range of industrial and domestic needs globally. Therefore, in this section, the biology of oil palm and the historical development of oil palm production are discussed. In particular, given that the major focus of this research is on oil palm in Indonesia, a major focus is on the development of oil palm plantations in Indonesia.

2.2.1 Oil palm

Oil palm (*Elaeis guineensis* Jacq.) is a tropical perennial tree crop that is native to the humid tropical forest biome of west and central Africa (Henderson & Osborne 2000). The oil palm yields fruit in compact bunches, usually called fresh fruit bunches (FFBs), from which two kinds of oil can be extracted: palm oil, from the fleshy mesocarp, and palm kernel oil, from the seed or kernel. It is typical of palm oil production that once the FFB is harvested, it must be processed within 48 hours or it deteriorates, resulting in loss of oil content (Sheil et al. 2009). The extractable palm oil constitutes approximately 20% of the FFB's total weight, and the palm kernel oil a further 5% (Henderson & Osborne 2000).

As an equatorial plant, oil palm requires high temperatures, typically in the range of 24–28°C. Seedlings will not grow below 15°C (Corley & Tinker 2003).The crop grows well in open areas near forests and rivers, but is less practical under a closed canopy (Sheil et al. 2009). It prefers a two- to four-month dry season and a mean annual rainfall between 1780 and 2280 mm (Duke 1983), although Corley and Tinker (2003) consider it best suited to 2000–2500 mm annual rainfall.

Oil palm is an undemanding crop in terms of soil acidity and water requirements. It is tolerant of a wide variety of tropical soils, as long as it is watered adequately (Corley & Tinker 2003; Duke 1983). Oil palm plantations are recommended for tropical lowlands with slope gradients of 2–6°; slopes exceeding 20° are considered unsuitable for oil palm (Corley & Tinker 2003). In conclusion, oil palm is considered an easy crop to grow extensively in lowlands with suitable equatorial climates (Corley & Tinker 2003).

Oil palm is typically planted at spacing of 9 x 7.5 m, totalling 148 trees per ha (Sheil et al. 2009). It is not considered a productive crop until the fourth or fifth year after planting, and continues to produce fruit bunches for over 30 years. It reaches a production peak at around 13 years, yielding FFBs at a maximum of 30 tonnes/ha/year (Corley & Tinker 2003). This maximum production level is estimated to continue for about four years, then steadily decreases until its economic life as a crop ends. A typical mature oil palm in Indonesia may yield 2--4 tonnes/ha/year (Sheil et al. 2009). The differences in yields may be attributed to cultivation in less fertile lands, a large share of immature plantations, low grade seedlings and poor crop management (Casson 2000; Sheil et al. 2009).

As a commodity, palm oil and its derivatives have high commercial value, because they are versatile and multifunctional, and are currently in high demand. Palm oil can be used to produce a wide range of consumer products. Its main uses in the food industry are as a cooking oil and in the production of margarine and butter. It is also an important raw material in the oleochemical industry, producing stearine, soap, detergent, cosmetics, lubricants and biodiesel (Sheil et al. 2009). Figure 2.1 shows multiple uses of oil palm byproducts.

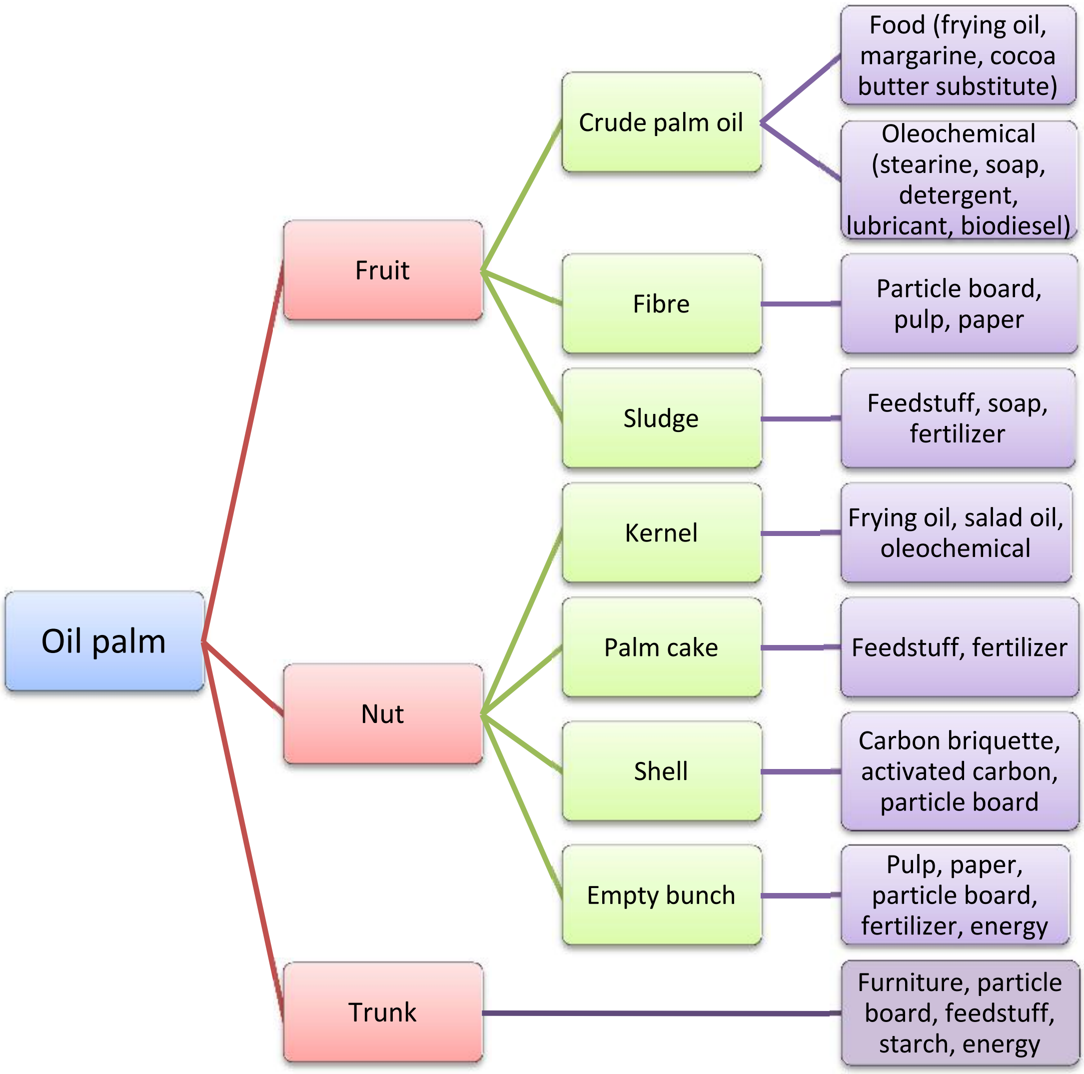


Figure 2.1. Uses of oil palm byproducts

Source: Fairhurst & Mutert (1999)

2.2.2 Oil palm history

Oil palm's historical record is mostly related to the journeys of oil palm exploration in Africa. As mentioned, oil palm originated in Africa, particularly along the continent's tropical west coast. In 1763, Nicholaus Jacquin drew one of the earliest illustrations of the oil palm tree, and therefore is considered its botanical (scientific) author (Henderson & Osborne 2000). For centuries, oil palm has remained a domesticated plant in Africa used for cooking, as an energy source, and as a medicinal plant (Berger & Martin 2000). Henderson and Osborne (2000) acknowledge a recognition of palm oil's economic value dating back to the sixteenth century, when oil was obtained from the boiled fruit in cooking. Further, the oil was burned to provide light, as a soothing ointment and to fuel fires, while its leaves were used for roofing, fencing, mats, brooms, ropes, baskets and fish traps. In 1589, an English captain and trader, James Welsh, discovered the use of palm oil in making soap, and the transport of palm oil to Great Britain was initiated (Henderson & Osborne 2000).

Commercial interest in palm oil rose after 1807, when it was recognised as an export commodity to Britain substituting for the export of slaves from Africa, which had been suppressed by the British (Henderson & Osborne 2000). The scientific advancements that drove the Industrial Revolution during the eighteenth century were a major reason for the increased demand for palm oil, particularly in non-food industries; in particular, soap was made almost exclusively from palm oil. Moreover, a palmitic acid was discovered in palm oil in 1840, which became one of the principal raw materials in candle making (Henderson & Osborne 2000). In addition, palm oil was used for greasing railway axle boxes, to prevent oxidation in the tinplate industry, and in the manufacture of dynamite. The use of oil palm in food industries began in the late 1860s, when Napoleon III encouraged the manufacture of a butter substitute, margarine, which was cheaper and had long-lasting properties. Oil palm was used to obtain a fat named oleo that was suitable as a raw material for margarine. Together with the introduction of palm oil in the manufacture of chocolate to replace cocoa butter, palm oil has proven to be a versatile commodity in both non-food and food industries.

The potential of oil palm as a global plantation crop was identified in 1848, according to Henderson and Osborne (2000), when four trees were first planted in the Dutch East Indies (now Indonesia) at the Buitenzorg Botanical Garden in West Java. However, it was not until 1909 that the first commercial oil palm plantations were established in North Sumatra and Aceh by a Franco-Belgian firm, SOCFIN (Stoler 1995). These Sumatran oil palm seeds were then taken to Malaysia in 1917 as the source stock for large-scale planting. In 1911, Lever Brothers, a British soap company, obtained concessions to establish oil palm plantations and mills in the Belgian Congo in Africa, and then opened plantations in Sumatra in the 1930s (Hartley 1988). By 1930, oil palm had become a significant input in producing margarine and was an important reason for the merger between Margarine Unie, a Dutch margarine producer, and Lever Brothers, into Unilever, one of the largest consumer goods companies in the world (Sheil et al. 2009). Soon after the Dutch recognised the profit potential in palm oil, the area under plantation and production in Sumatra increased rapidly starting in the 1930s (Potter & Lee 1998).

2.2.3 Palm oil production

In the first half of the twentieth century, Indonesia was the country with the world's largest area under oil palm production, rising from 31,600 ha in 1925 to 110,000 ha in 1940 (Corley & Tinker 2003). However, World War II and the independence struggle halted the growth in the oil palm area in Indonesia. The main producers of palm oil in 2013 are listed in Table 2.1. Although Indonesia and Malaysia accounted for over 85% of production in 2013, until the 1970s, these two countries were part of a trio that included Nigeria. Figures 2.2 and 2.3 depict the development of oil palm area and production in Indonesia, Malaysia and Nigeria from 1961 to 2013. From the early 1900s, Nigeria led palm oil production and exports globally, but lost its pre-eminent position after the civil war in the 1960s, and its remaining plantations were mostly left with limited production (Corley & Tinker 2003).

Table 2.1: The world's palm oil producing countries, 2013

Palm Oil Production	2013 (1000 tonnes)	2013 (%)
Indonesia	31,000	52.28
Malaysia	19,900	33.56
Thailand	2,150	3.63
Colombia	1,042	1.76
Nigeria	930	1.57
Others	4,276	7.21
Total	59,298	100

Source: USDA (2014)

Malaysia quickly re-established its oil palm industry after World War II with government support (Corley & Tinker 2003). The industry grew steadily, and Malaysia overtook Nigeria as the world's largest palm oil producer and exporter by the late 1960s. During this period, Nigeria had a constant oil palm area. Malaysia continued to lead palm oil production until the mid-2000s, as it had the largest number of mature age oil palm trees in the world (Corley & Tinker 2003). However, in 2006, Indonesia surpassed Malaysia to become the world leader in palm oil production; by 2013, Indonesian production comprised just over half (52.3%) of the total global palm oil production of 59.3 million tonnes (Table 2.1). Indonesia also dominated the palm oil export market, comprising 48.1% of the 42.4 million tonnes of global exports in 2013 (Table 2.2).

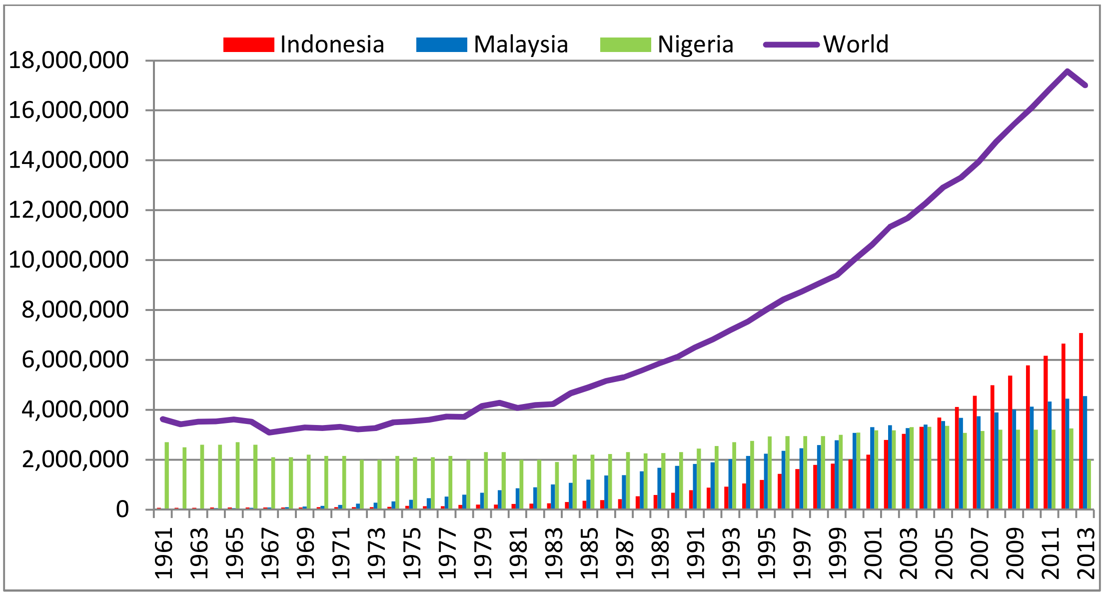


Figure 2.2. Oil palm harvested areas in the three major producing countries, 1961–2013 (ha)

Source: FAO (2014)

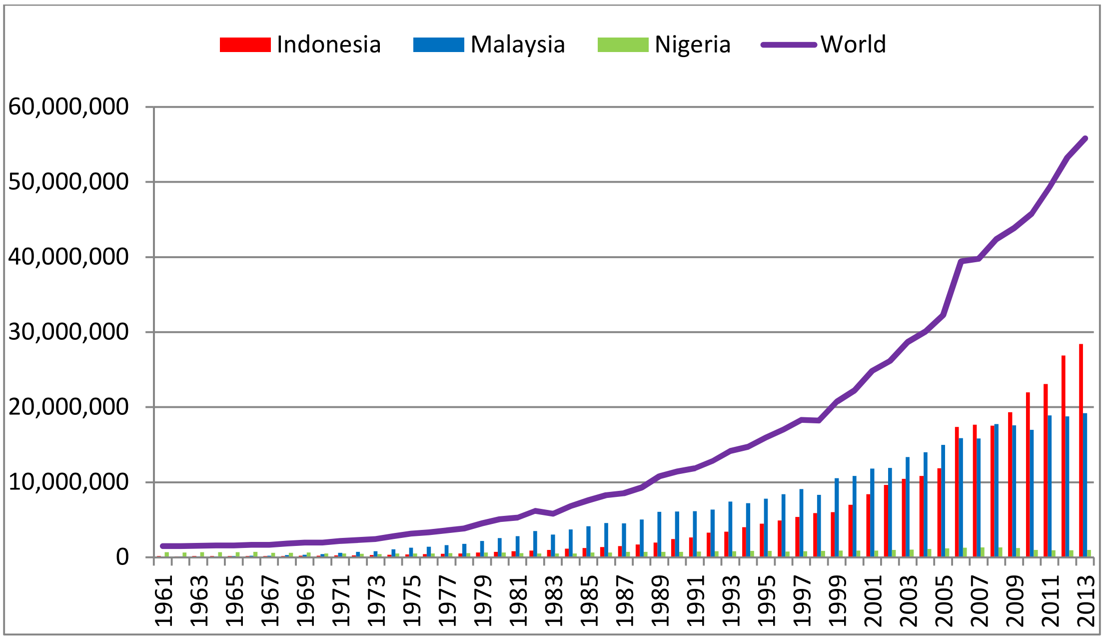


Figure 2.3. Palm oil production in the three major producing countries, 1961–2013 (tonnes)

Source: FAO (2014)

Table 2.2. The world's palm oil exporting countries, 2013

Palm Oil Exports	2013 (1000 tonnes)	2013 (%)
Indonesia	20,400	48.14
Malaysia	17,300	40.83
Papua New Guinea	640	1.51
Thailand	550	1.30
Benin	390	0.92
Other	3,093	7.30
Total	42,373	100

Source: USDA (2014)

Palm oil imports are concentrated in Asian and European regions. A little over half of global palm oil imports are to India, China and the European Union (Figure 2.4). Significant amounts are also imported by Pakistan and the United States (US). However, imports of palm oil are so extensive that approximately 40% of imports are directed to the rest of the world, which underlines palm oil's global importance as an oil crop. World demand for palm oil derives mostly from the demand for it as a cooking oil in Asian countries, particularly China, India and Pakistan; and as an ingredient in food processing, for example, in margarine, biscuits and snacks, in the European Union and the US (van Gelder 2004). The recent increase in demand for biofuels has also triggered increased demand for palm oil, as it can be used to generate biodiesel (Tan et al. 2009). Underpinning the remarkable recent growth of palm oil production has been the growing demand for its food and non-food uses, increasing populations and incomes in developing countries, health concerns, and the relationship between sustainable cultivation and productivity (Fry & Fitton 2010).

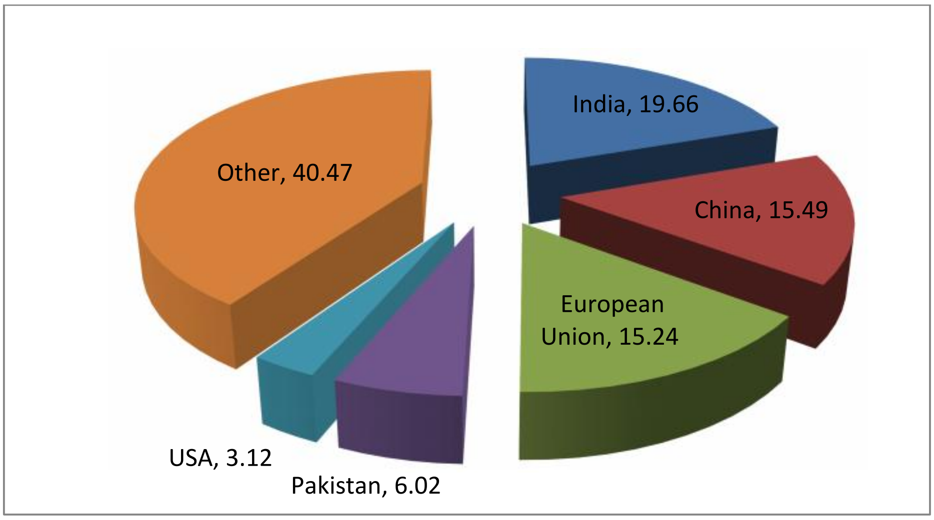


Figure 2.4. Main palm oil importing countries by percent share, 2013 (total 40.7 million tonnes)

Source: USDA (2014)

2.2.4 Vegetable oil markets

Palm oil is a vegetable oil, which, in global trade terms, is grouped in the oils and fats industry. Even though palm oil played only a small role in global oils and fats production and trade in the 1950 and 1960s, the impressive growth of palm oil in the global oils and fats market since the 1960s was not unexpected, given Mielke's (1985) prediction in 1985 that it would dominate global oils and fats production and exports by 2000. This forecast proved accurate, as the development of palm oil has shown a dramatic increase in the last two decades (Ahmad et al. 2008). During this time, palm oil's position in the global oils and fats market has gone from that of a vegetable oil perceived by some as unhealthy when consumed by humans, to one of the most nutritious edible oils in the market, and an oil that is also a feasible biofuel source (Lam et al. 2009).

Palm oil is currently the world's most important vegetable oil in terms of quantity produced (Figure 2.5), and has shown the fastest growth in production in the global oils and fats supply sector for the last four decades (Basiron, Balu & Chandramohan 2004). Since 2006, due to its rapid rise in production, palm oil has overtaken soybean oil as the oil with the largest production worldwide (Ahmad et al. 2008; Carter et al. 2007; Gunstone 2011). In 2013, together with palm kernel oil, palm oil led the world's vegetable oils, representing as much as 39% of total global vegetable oil production, totalling nearly 170 million tonnes (Figure 2.6). Similarly, palm and palm kernel oils dominated vegetable oil exports in 2013, with 66.3% of global oil exports. By comparison, for example, soybean oil only accounted for 13.9% of exports (Figure 2.7).

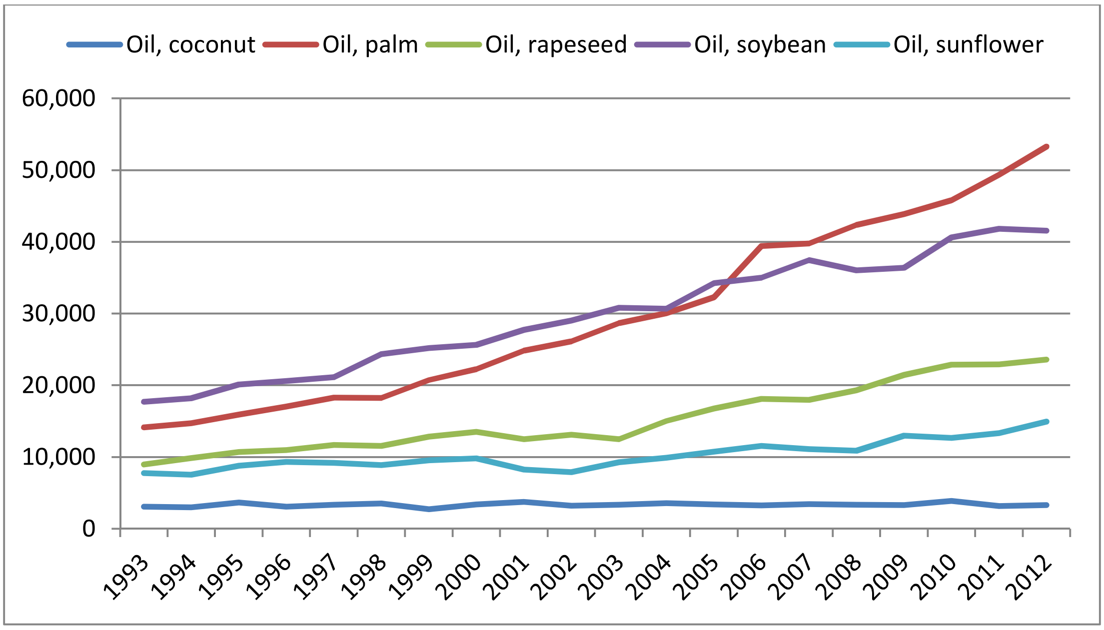


Figure 2.5. Global production of the five major vegetable oils, 1993–2012 (thousand tonnes)

Source: FAO (2014)

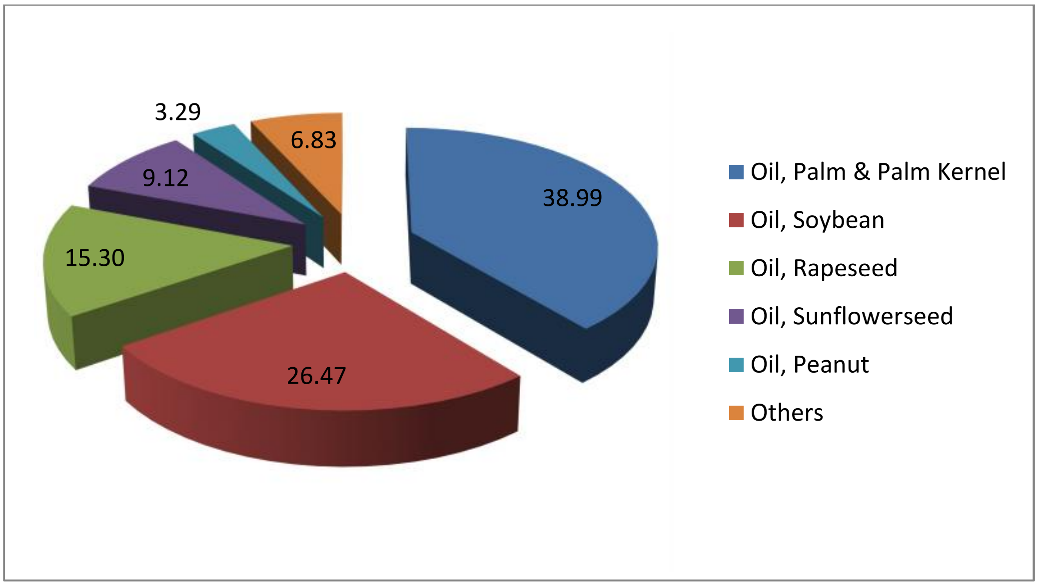


Figure 2.6. Percentage shares of the world's vegetable oil production, 2013 (Total = 169.9 million tonnes)

Source: USDA (2014)

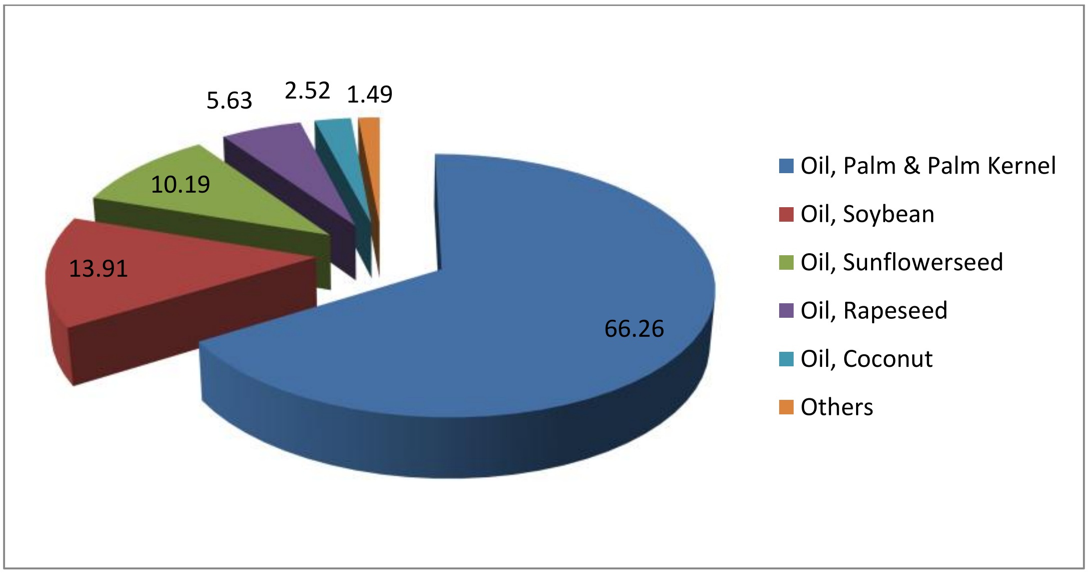


Figure 2.7. Percentage shares of the world's vegetable oil exports, 2013 (Total = 68.5 million tonnes)

Source: USDA (2014)

Oil palm is considered the most efficient and productive oil crop in terms of production costs and land utilisation. It is favoured on account of its lower production costs compared to other vegetable oils (Corley 2009). Lam et al. (2009) provide examples of these lower costs (US$ 228/tonne, in Malaysia) compared to other major vegetable oils, such as soybean oil (US$ 400/tonne, USA) or rapeseed oil (US$ 648/tonne, Canada; US$ 900/tonne, Europe). This is mainly because oil palm is a perennial crop that requires low energy inputs once established (Lam et al. 2009). The energy output: input ratio for oil palm is 9.6 GJ/ha, much higher than that of rapeseed (3 GJ/ha) and soybean oils (2.5 GJ/ha).

These efficiency arguments concerning energy input to output ratios are paralleled when applied to land use considerations. In the last two decades, oil palm has had one the lowest harvested areas among oil crops: much lower than that of soy, and lower than those of rapeseed and sunflower (Figure 2.8). Oil palm plantations covered 7.2 million ha of the world’s land surface in 1993 and increased to 17 million ha in 2013. By way of comparison, soybeans comprised 59 million ha in 1993 and 111.3 million ha in 2013.

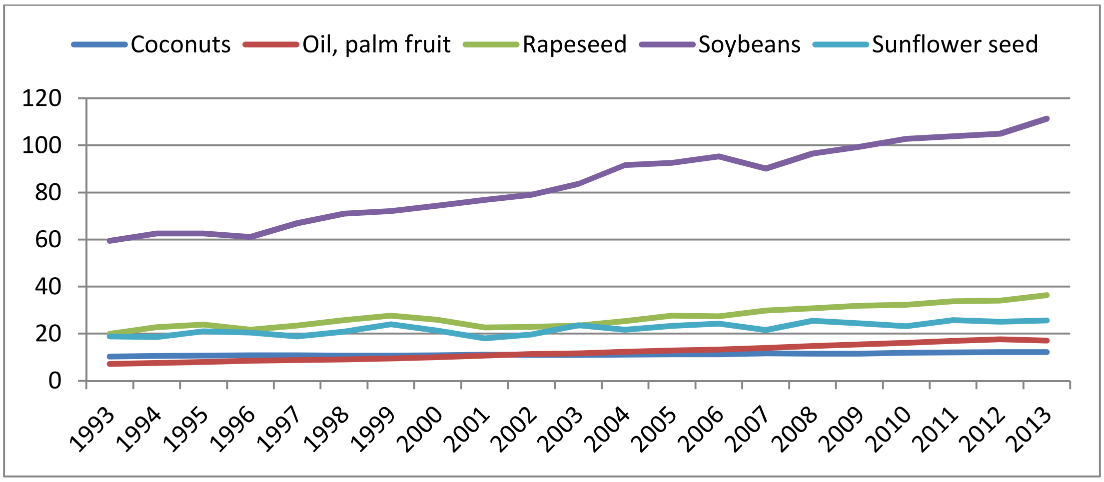


Figure 2.8. Global harvested area of the five major vegetable oils, 1993–2012 (million ha)

Source: FAO (2014)

In addition, oil palm is the highest yielding oil crop per hectare (Ahmad et al. 2008; Corley & Tinker 2003). On average between 1989 and 2012, oil palm yielded 2.33 tonnes/ha globally, and grew by 2.39% per annum (Table 3). Meanwhile in the same period, soybean oil—the vegetable oil with the second largest production globally—yielded 0.34 tonnes/ha, with growth of 1.62%.

Table 2.3: Yield of the four major vegetable oils, years 1989–2012

Year	Palm oil		Soybean oil		Sunflower oil		Rapeseed oil	
	Yield (tonnes/ha)	Yield growth (%)	Yield (tonnes/ha)	Yield growth (%)	Yield (tonnes/ha)	Yield growth (%)	Yield (tonnes/ha)	Yield growth (%)
1989	1.84	10.53	0.26	-9.07	0.51	3.93	0.46	5.64
1993	1.97	4.56	0.30	-3.76	0.41	-9.04	0.45	-0.94
1998	2.01	-3.97	0.34	8.73	0.43	-12.26	0.45	-10.54
2003	2.45	6.40	0.37	0.22	0.39	-2.12	0.53	-7.11
2008	2.87	0.66	0.37	-10.10	0.43	-16.99	0.63	4.13
2012	2.86	0.92	0.40	-1.68	0.60	14.98	0.69	1.99
Average 1989–2012	**2.33**	**2.39**	**0.34**	**1.62**	**0.47**	**1.32**	**0.55**	**2.19**

Source: FAO (2014)

Additionally, palm oil has benefitted from a relatively competitive price compared to other major vegetable oils (Figure 7). Palm oil has consistently been priced lower than soybean, sunflower and rapeseed oils since 2000. In 2013, palm oil was sold at

US$ 764/tonne, compared to soybean oil (US$ 1,011/tonne), sunflower oil (US$ 1,341/tonne) and rapeseed oil (US$ 1.081/tonne).

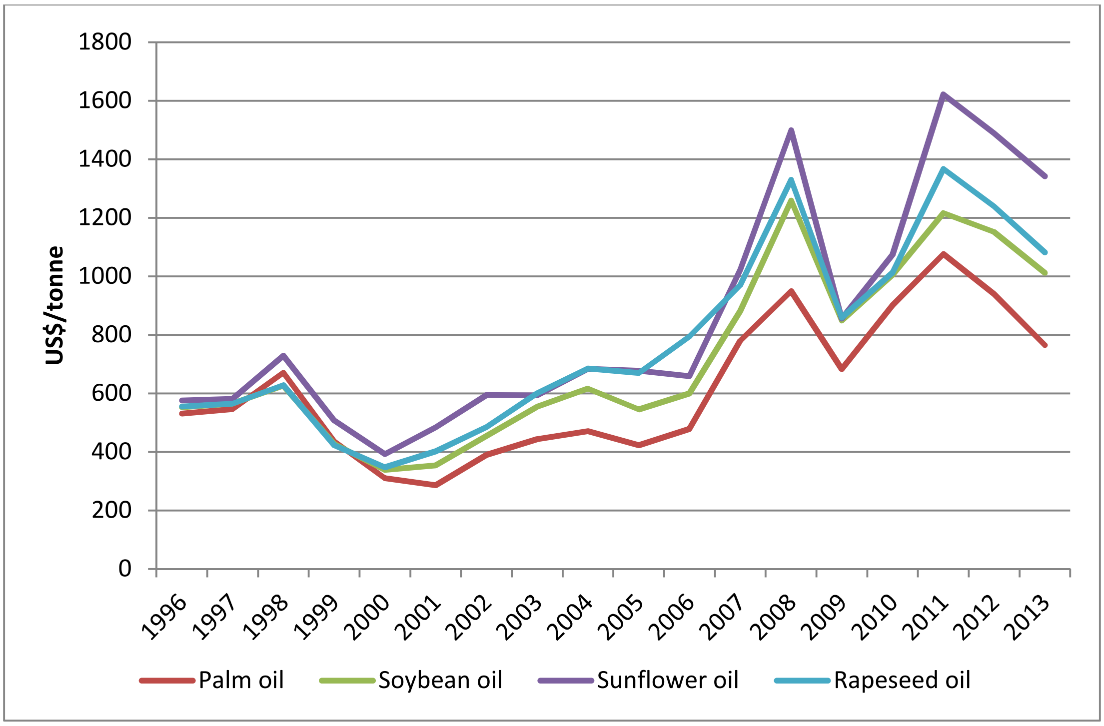


Figure 2.9. Average annual market price of the four major vegetable oils, 1996–2013

Source: 1996–2010 (ISTA Mielke 2011), 2011–2013 (IMF 2014)

At present, palm oil is one of the vegetable oils used to produce biodiesel, a source of renewable energy. However, a mere 1% of all palm oil output is used to produce biodiesel globally, compared to rapeseed (or canola) oil, which accounts for 84% of the world's biodiesel production (Tan et al. 2009; Thoenes 2006). Although an insignificant amount of biodiesel is sourced from palm oil worldwide, palm oil remains the most appealing vegetable oil because it has a high productivity in terms of yield per unit of land used (Tan et al. 2009; Thoenes 2006). In terms of cost, in 2007 the total cost of producing biodiesel and transporting it from the producing country to a petrol station in the EU was estimated at US$ 784–804/tonne for palm oil from Malaysia, compared to rapeseed oil from the EU (US$ 1,029–1046/tonne) and soybean oil from the US (US$ 831–851/tonne) (Lam et al. 2009).

Sheil et al. (2009) anticipate that the demand for palm oil will continue to increase and that it will contribute to meet increasing demand for food products and cosmetics products, rather than as a biofuel, because the price of crude palm oil is higher than that of crude petroleum oil.

2.2.5 Oil palm in Indonesia

When Indonesia proclaimed its independence in 1945, the Dutch plantations were nationalised and placed under state estate companies. However, for the first two decades, the expansion of oil palm plantations was limited (Santosa 2008). Then, from 1968 to early 2000, the Indonesian Government supported the development of oil palm plantations in three distinct phases (Zen, Barlow & Gondowarsito 2006). The first phase (1968–1988) saw direct government investment in the form of state-owned plantations. In the second (1988–1994), the government implemented a joint government and private sector development scheme called Nucleus Estates and Smallholders (NES, or *Perkebunan Inti Rakyat* [PIR]), which promoted the growth of smallholdings. In the third phase (1994–2000), investment was encouraged between the government-supported private sector and cooperatives. Under this initiative, a private sector partner would need to find a partner in the form of a cooperative, which would have been founded by a group of smallholders to achieve economies of scale and efficiency. Government-sponsored expansion had to be stopped in 2001 due to the prolonged Asian financial crisis. Since then, the government has launched an investment policy for plantations in which private companies can operate large estates in order to accelerate the development of palm oil plantations (Santosa 2008).

Palm oil producers in Indonesia consist of three distinct groups: government-owned enterprises, individual small landholders and large private companies. Of the estimated 10.5 million ha used for oil palm plantations in 2013, the shares of these three groups were 7.6%, 41.7%, and 50.7% respectively (Figure 2.10). The state enterprises comprise ten companies and have established a joint marketing office to control prices and distribution. The private companies, dominated by ten large palm oil businesses (Santosa 2008), operate plantations that totalled approximately 5.4 million ha in 2008, and sell their product to market individually. The private estates and the public enterprises collectively established the Indonesian Palm Oil Producers Association in 1981 as a government partner in enhancing the palm oil industry (Chalil 2008).

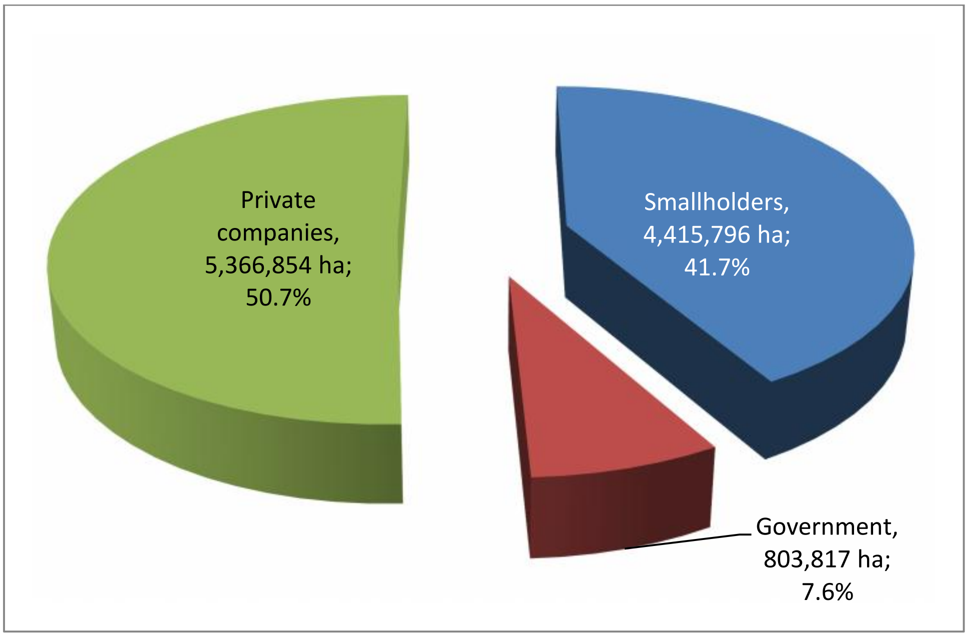


Figure 2.10. Estimated harvested area by oil palm farming category, 2013

Source: BPS—Statistics Indonesia (2014a)

In terms of geography, Sumatra is the most important island in the archipelago in terms of oil palm cultivation (Figure 2.11). In 2013, oil palm plantations that had been planted in Sumatra covered an estimated 6.6 million ha, or nearly two thirds of Indonesia's total oil palm harvested area. Kalimantan was second, with approximately 32.9% of the total area.

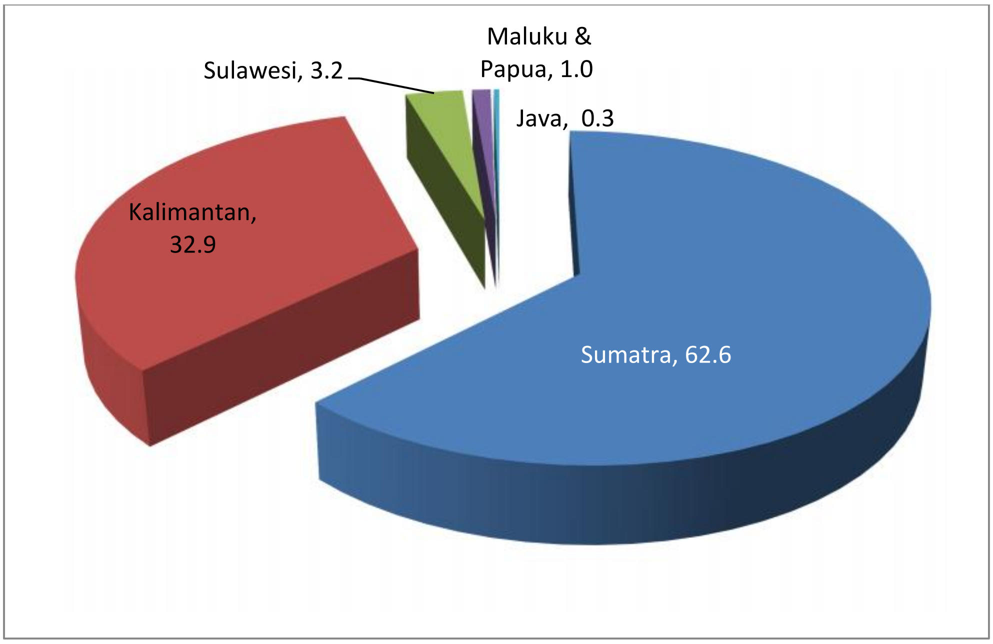


Figure 2.11. Estimated harvested area by island, Indonesia, 2013

Source: BPS—Statistics Indonesia (2014a)

In Sumatra, the expansion of oil palm plantations appeared at the expense of forests, and has also replaced rubber plantations. Rubber (*Hevea brasiliensis*), a tree native to the Brazilian Amazon, was brought to Sumatra at the beginning of the twentieth century (Feintrenie, Chong & Levang 2010). However, it was not until the early 1980s, when the government introduced its transmigration policy, that oil palm was cultivated on a massive scale. Oil palm was initially grown in Sumatra in the early 1980s in association with the transmigration policy (Feintrenie, Chong & Levang 2010). This program allowed people to move voluntarily from over-populated islands such as Java and Bali to less populous islands such as Sumatra, Kalimantan, Sulawesi and Papua (Fearnside 1997). Supported by the World Bank and the Asian Development Bank (ADB), the government established the NES scheme on government and private estates, allocating transmigrants and local people each two hectares of land for oil palm and half a hectare for housing and food crops (Zen, Barlow & Gondowarsito 2006).

The importance of palm oil to the generation of economic profit in Indonesia is considered to be due to low labour costs in Indonesia's palm oil industry compared to the other major palm oil producer, Malaysia (Basiron, Balu & Chandramohan 2004; Santosa 2008). Accordingly, the competitiveness of the Indonesian palm oil industry should have a significant role to play in the nation's economy. Rifin (2010) argues that the palm oil industry is a labour-intensive sector in Indonesia, and hence has a large effect on the economy by creating employment. It was estimated that the oil palm industry in Indonesia provided employment for over 2 million people in 1997 (Casson 2000).

Another important consideration regarding palm oil in Indonesia is that it constitutes the main raw material for producing cooking oil in the country. It supplied well over 75% of domestic cooking oil in 2006 (Munadi 2007). Due to its dominant role in food production and consumption, the government has deemed cooking oil to be an essential consumer good (Sugiyanto 2001). As a result, it is necessary for the government to exercise controls to maintain an affordable price and adequate supply of cooking oil for domestic use. Thus, palm oil is considered a strategic commodity in Indonesia.

Global palm oil production will continue to grow, as will production in Indonesia. This is evident in the fact that the Indonesian Minister of Agriculture has set a target of doubling the oil palm hectarage to 18 million ha over the next ten years 'without disturbing forest preservation efforts', and plans to increase the annual production of oil palm fruit (Koh & Ghazoul 2010).

Having illuminated the importance of oil palm globally and in Indonesia, attention must be turned to the trade-offs between the economic importance of oil palm production and the environmental damage it causes. I term this sensitive debate the 'oil palm paradox'.

2.3 The Oil Palm Paradox: Balancing Economic Gains with Losses

Like other agricultural activities, cultivation of oil palm inevitably brings about trade-offs with various aspects of the environment (Tilman et al. 2001). Oil palm is the main oil crop meeting much of the world's high demand for food and oleochemicals. Palm oil is ubiquitous as an ingredient in thousands of products used daily by consumers globally, made by multinational companies (May-Tobin & Goodman 2014). For example, palm oil is an ingredient in one in ten products sold in UK supermarkets (Friends of the Earth 2005). It has also become an economically feasible source of biodiesel (Lam et al. 2009). Economically, the argument for oil palm cultivation is compelling. However, oil palm cultivation contributes to an important issue that scientists have been quick to emphasise: that is, environmental destruction in the humid tropics. The paradox created by these two opposing arguments arises in global discourses on the loss of tropical rainforests, greenhouse gas emissions and biodiversity loss (Paoli et al. 2013).

A number of scholars and NGOs have emphasised the environmental issues that result from increased oil palm cultivation. Fitzherbert et al. (2008) argue that the expansion of oil palm plantations appears to be uncontrolled and poses a serious threat in humid tropical regions. This argument is in line with Feintrenie, Chong and Levang's (2010) claim that the fast growth of oil palm has led to a number of cautions on its consequences to both environmental and social-economic issues. NGOs have strengthened recognition of the concept of negative impacts of establishing oil palm plantations by running massive and provocative campaigns in opposition to palm oil use by pointing out the environmental impacts of oil palm cultivation: an example is Greenpeace's protests over the oil palm expansion at the expense of forests and the habitat (Greenpeace 2007, 2013).

Several environmental concerns that have been raised and discussed frequently in the literature on oil palm are identified in the sections below. These include forest conversion, biodiversity, climate change and peat swamp issues.

2.3.1 Oil palm and the forests

The first concern related to oil palm cultivation is forest conversion. It has been argued that the impact of oil palm plantations on forest conversion depends on the extent to which the expansion of plantations leads to deforestation (Fitzherbert et al. 2008). Oil palm is one of the most expansive crops in the equatorial areas. It is suited to the same areas as high-rainfall, lowland humid tropical forests, the most biodiverse terrestrial biome on Earth (Fitzherbert et al. 2008). Millington, Blumler and Schickhoff (2011) and Sodhi et al. (2004) argue that South East Asia has the greatest rate of relative deforestation in the tropics. Most oil palm is grown in the South East Asian region, where 11% of the world's tropical forests still exist more-or-less intact. It has been known to have been grown in 43 countries, which would equate to a total cultivated area comprising approximately 10% of global permanent cropland (Koh & Wilcove 2008).

However, the natural habitat of oil palm is not originally in primary forest: rather, it is grown when people clear forest, establish their own settlements, and cultivate the oil palm (Corley & Tinker 2003). Foster et al. (2011) argue that much of the forest that is converted to oil palm was not primary forest prior to the conversion: rather, large tracts of oil palm plantation have been established on land that was already logged or degraded in a variety of ways, or on land that was previously under another plantation use, such as rubber (Casson 2000; Foster et al. 2011; Koh & Wilcove 2008). Conversion to oil palm from forests takes place mainly from secondary forests, which are abandoned land from logged forests. This type of land is generally allowed to be converted for agricultural activities.

Yet there is a counter-argument, which is that oil palm cultivation deserves particular attention because over recent decades it has become a major driver of deforestation in the tropics (Butler, Koh & Ghazoul 2009; Fitzherbert et al. 2008; Koh & Wilcove 2008, 2009). In Indonesia and Malaysia, more than half of oil palm expansion since 1990 has been at the expense of forests (Butler, Koh & Ghazoul 2009; Koh & Wilcove 2008; Wicke et al. 2011).

It has been reported that a significant decrease in forested land from 130 Mha in 1975 to 91 Mha in 2005 has occurred in Indonesia, while agricultural land has increased from 38Mha in 1975 to 48 Mha in 2005 (Wicke et al. 2011). More than half (5.5 Mha in 2005) of this agricultural expansion was due to oil palm, which had further increased to 7 Mha by 2008. The other half of the expansion in agricultural land was mostly due to paddy rice cultivation. Other important direct causes of land use and cover change found in the literature are related to logging and other forms of agricultural production, and to forest fires (Hooijer et al. 2006; Sunderlin et al. 2005). These sources show that the large losses in forest cover in Indonesia are not solely due to the expansion of oil palm, though it is one of the two major types of land use on recently deforested land.

The essential causes of the changes in land use in Indonesia are various; derived from Geist and Lambin’s (2002) framework, the proximate and underlying causes are:

1. Agricultural produce and forestry markets, which generate income from illegal logging and palm oil production; and
2. Policy and institutional factors related to financing foreign debt, corruption and land tenure conflict (Prasetyo et al. 2008; Sunderlin et al. 2005).

Other drivers that contribute to the land use and land cover change in Indonesia are domestic population growth, and planned and spontaneous migration (Wicke et al. 2011).

However, oil palm’s contribution to deforestation leading to immediate environmental threats is uncertain (Basiron 2007; Carlson et al. 2013). The challenge in oil palm expansion is during the forest clearing stage, if it is not managed carefully (Basiron 2007). It is difficult to measure the extent to which oil palm has been a direct cause of deforestation, due to a lack of reliable data on land cover change in Indonesia and the complex nature of causation (Fitzherbert et al. 2008). For example, Koh et al. (2011) and Paoli et al. (2011) find that remote sensing was insufficient to detect oil palm less than ten years old or on a small scale (< 200 ha). In terms of causation, there are four possible ways that oil palm cultivation leads to deforestation, which include (Fitzherbert et al. 2008):

1. Intact forest conversion (the main reason);
2. Replacement of degraded forests;
3. As part of a wider combined forest-related business (such as timber, paper and oil palm); and
4. Indirect causes, such as through better infrastructure displacing other crops into forests.

Palm oil production has played a significant role in land use change in some areas, and this role varies with scale and between regions. Moreover, converting natural forest to oil palm plantation is also related to other issue, biodiversity loss, which is discussed further in the following section.

2.3.2 Oil palm and biodiversity

The second environmental issue related to oil palm is how its plantations affect biodiversity. Agricultural expansion is one of the major threats to global biodiversity. Conversion of natural ecosystems to agricultural landscapes has had a severe negative impact on global biodiversity (Sodhi et al. 2004; Sodhi et al. 2010), with losses of species already occurring and further regional and global extinction predicted to occur. Oil palm cultivation is among the main perpetrators, owing to its huge increase in cultivation in recent years. The rapid expansion of oil palm into forested tropical landscapes is of concern given the latter's high levels of biodiversity.

This issue has been raised and discussed by conservationists, and is found extensively in the current literature (Danielsen et al. 2009; Edwards et al. 2010; Koh & Wilcove 2008; Wilcove & Koh 2010). A growing body of research has emerged in recent years that has investigated the impact of forest conversion to oil palm on biodiversity, and it is argued that the conversion of natural habitats to oil palm has severe negative impacts on biodiversity (Fitzherbert et al. 2008; Foster et al. 2011). A systematic literature review aiming to investigate the effect of oil palm plantations on biodiversity was conducted by Savilaakso et al. (2014). After reviewing 25 studies, they concluded that oil palm is not an ecologically or biologically suitable substitute for either primary and degraded forests in terms of biodiversity. In simple terms, oil palm plantations provide habitat to fewer forest species than soybean or jatropha when grown in the tropics.

Studies have been conducted to investigate a diverse range of biodiversity losses from oil palm cultivation. These have shown that these losses are related to reductions in taxa such as insects, arthropods, mammals, birds and lizards (Edwards et al. 2014a; Gray et al. 2014; Turner et al. 2011). The main reason for such a significant loss of species is almost certainly due to the simplification of habitat that occurs when a forest is converted to oil palm (Foster et al. 2011).

Fitzherbert et al. (2008) claim that oil palm plantations are a poor substitute for native tropical forest because they support few species of conservation importance, and affect biodiversity in adjacent habitats through fragmentation, edge effects and pollution. However, Foster et al. (2011) found some evidence that oil palm can provide habitat that produces positive impacts on biodiversity, for example, for bees and butterflies; however this effect depends on the landscape and local complexity. In summary, unless governments in producer countries become better at controlling logging, protecting forests and ensuring that crops are planted only in appropriate areas, the impacts of oil palm expansion on biodiversity will be substantial (Fitzherbert et al. 2008).

2.3.3 Oil palm and carbon emissions

The third major environmental issue related to oil palm cultivation is carbon emissions. Schrier-Uijl and Anshari (2013) provide evidence that the growth of human population together with industrialisation has led to a recent increase in biomass burning, agricultural activities and land use change, resulting in enhanced emissions of greenhouse gases into the atmosphere. These emissions impact carbon and nitrogen cycles and influence atmospheric dynamics, thereby affecting temperature and precipitation patterns. Greenhouse gases reduce heat loss from the Earth's surface, and thus changes in their atmospheric concentrations have a strong impact on climate (Schrier-Uijl & Anshari 2013).

The conversion of tropical forests into areas of production of perennial crops such as oil palm has brought about large increases in greenhouse gas emissions (Murdiyarso, Hergoualc'h & Verchot 2010). A study assesing the impact of deforestation on carbon emissions in tropical regions shows that between 2000 and 2005, Indonesia's tropical deforestation was one of the largest carbon emission sources in the region, representing 105 Tg C/year (Harris et al. 2012). Germer and Sauerborn (2008) argue that estimates of emissions indicate that if tropical grassland is rehabilitated by oil palm plantations, carbon fixation in plantation biomass and soil organic matter not only neutralises emissions caused by grassland conversion, but also results in the net removal of about 135 Mg CO_2/ha from the atmosphere. In contrast, the increases in emissions resulting from forest conversion clearly exceed the potential carbon fixation of oil palm plantings.

The impact of oil palm on carbon emissions is also addressed in the work of Carlson et al. (2013), who investigate carbon emissions resulting from forest conversion to oil palm plantations in Kalimantan. They project that by 2020, oil palm expansion will contribute 18–22% (about 0.12–1.15 Gt C/year) of Indonesia's total CO_2 emissions.

The situation in Kalimantan may be worse compared to condition in 2010, as only 32% of the allocated leases for oil palm plantations have been occupied. According to Carlson et al. (2013), the government allocates lease to companies that are not required to account for forest loss or carbon emissions during development of the estates. Moreover, leases are granted without independent appraisals of land use and carbon, and are not disclosed for public evaluation. Carbon emissions from undeveloped leases have therefore remained concealed and excluded from national emissions projections. In general, the leased plantation lands represent a significant near-future source of deforestation and associated carbon emissions. It is crucial to improve transparency in oil palm development as it is needed for the efforts to include it in land management and emissions mitigation (Carlson et al. 2013).

2.3.4 Oil palm and peat swamps

The final issue related to oil palm's impact on the environment is the destruction of peat swamps. The rising demand for palm oil has caused the expansion of oil palm cultivation to enter into peatlands. Peatlands are wetland ecosystems characterised by the accumulation of organic material over a long period of time (Wahyunto & Suryadiputra 2008). The hydraulic conditions and lack of oxygen lead to slow microbial decomposition of plant remains (Tan et al. 2009). Peatlands are large stores of carbon; a very large portion of global carbon resources (> 528 Gt) is held in peatlands. This represents approximately one third of global soil carbon and 70 times the current annual global emissions from burning of fossil fuel (Hooijer et al. 2006). Carbon in peatlands can be released into the Earth's atmosphere through oxidation of peat when they are drained, and through peat fires that produce gaseous CO_2 and loss of biomass on the ground (Hooijer et al. 2006; Schrier-Uijl et al. 2013).

Globally, peatlands cover around 3% of the Earth's terrestrial area, or approximately 400–450 million ha (Hooijer et al. 2006; Wahyunto & Suryadiputra 2008). Of the world's peatlands, around 12% (54 million ha) are located in wet tropical regions (Wahyunto & Suryadiputra 2008), and it is estimated that approximately 6% of global peatlands (27.1 million ha) are in South East Asia (Hooijer et al. 2006). This represents approximately 60% of global tropical peatlands (Schrier-Uijl et al. 2013), of which 12.9 million ha has been deforested (Hooijer et al. 2010). The largest areas of tropical peatlands are in Indonesia; these are estimated at 21 million ha (Wahyunto & Suryadiputra 2008).

Sumatra has a large peatland area, between 6.7 million ha (Koh et al. 2011) and 7.2 million ha (Wahyunto & Suryadiputra 2008). Using 2010 satellite imagery, Koh et al. (2011) estimate that only 1.8 million ha of Sumatra's peatlands were still under peat swamp forests, and that 464,554 ha (around 7% of Sumatra's peatlands) had been converted to oil palm plantations. As a consequence, the conversion of peat swamps into oil palm in Sumatra has caused a biodiversity reduction of 3.4%, a biomass carbon loss of 72.2 million Mg and peat carbon loss of 2.4 million Mg (Koh et al. 2011). Murdiyarso et al. (2010) estimate that the cultivation of oil palm in forested peatlands emits carbon totalling 59.4 $\pm$ 10.2 Mg of CO_2/ha/year for the first 25 years.

Additional impacts due to the conversion of peat swamps to oil palm include human health risks due to smoke haze, and soil subsidence which leads to flooding and salt water intrusion (Schrier-Uijl et al. 2013). One way to minimise carbon emissions from peatlands is to prevent the enlargement of oil palm plantation areas onto peatlands (Schrier-Uijl et al. 2013). Moreover, Schrier-Uijl et al. (2013) suggest a practical method for reducing emissions in existing oil palm plantations on peat soils, by way of increasing the level of the water table by 40–60 cm, as recommended in the Roundtable on Sustainable Palm Oil (RSPO) manual. While this does not mean that carbon emissions will be eliminated, they can be reduced by at least 50% in comparison to situations where the water level is 70–100 cm below the surface.

2.4 Sustainable Rural Livelihoods

Sustainable rural livelihoods have been central to rural development thinking and practice in the last decade. The concept of sustainable rural livelihoods relates to a range of issues, and has become progressively more influential in debates on rural development, poverty reduction and environmental management (Scoones 1998). The concept of sustainable livelihoods is a locus for a wide range of people involved in different aspects of development policy formulation and planning. There are two broad approaches to understanding livelihoods. First, they can be viewed from an economic perspective, focusing on production, employment and household income. Second, they may undergo a holistic analysis that binds concepts of economic development, reduced vulnerability and environmental sustainability (Shackleton, Shackleton & Cousins 2000).

This concept was first proposed in a report of the Advisory Panel of the World Commission on Environment and Development (WCED) (Chambers & Conway 1991). In the process of its development, the commission proposed the concept of sustainable livelihood security as an integrating concept. Thus, the idea of sustainable livelihoods emerged as an approach to maintaining and enhancing resource productivity and the secure ownership of and access to assets, resources and income-earning activities, as well as ensuring adequate stock and flows of food and cash to meet basic needs.

Since its extensive adoption by the UK Department for International Development (DFID 1999), sustainable livelihood has become a familiar concept surrounding the concept of livelihood. Although the DFID no longer promotes it, the framework remains influential globally, and is widely applicable because of its flexibility.

2.4.1 Definitions of sustainable livelihood

The definition of sustainable livelihood has undergone adjustments since it was first introduced and developed. The first definition of sustainable livelihood was proposed in a report of the WCED in 1987. Since then, some authors have attempted to modify and adjust the WCED's definition of sustainable livelihoods. For example, in modifying the WCED panel definition, Chambers and Conway (1991) put forward the following working definition of sustainable livelihoods:

> A livelihood comprises the capabilities, assets (stores, resources, claims and access) and activities required for a means of living: a livelihood is sustainable which can cope with and recover from stress and shocks, maintain or enhance its capabilities and assets, and provide sustainable livelihood opportunity for the next generation; and which contribute net benefits to other livelihoods at the local and global levels and in the short and long term. (Chambers & Conway 1991, p. 6)

Scoones (1998), building on the work of Chambers and Conway, proposes a similar definition of livelihood, and ties it more explicitly to the notion of sustainability. Carney et al. (1999) go on to modify Chambers and Conway's well known and widely used definition as follows:

> A livelihood comprises the capabilities, assets (including both material and social resources) and activities required for means of living. A livelihood is sustainable when it can cope and recover from shocks and stresses and maintain and enhance its capabilities and assets now and in the future, whilst not undermining the natural resources base. (Carney et al. 1999, p. 4)

Another definition of livelihood is proposed by Ellis (2000b), after reviewing the prevailing concepts of livelihood, as follows:

> A livelihood comprises the assets (natural, physical, human, financial and social capital), the activities, and the access to these (mediated by institutions and social relations) that together determine the living gained by the individual or households. (Ellis 2000b, p. 10)

While different practitioners have proposed different emphases in defining livelihoods, the livelihoods framework helps researchers in a number of ways. It allows them to identify and value what people are already doing to cope with risk and uncertainty; to make connections between factors that constrain or enhance their livelihoods on the one hand, and policies and institutions in the wider environment on the other; and to identify measures that can strengthen assets, enhance capabilities and reduce vulnerability. Moreover, from the above definitions, three fundamental attributes of livelihood can be recognised (Acheampong 2003):

1. The possession of human capabilities such as education, skills, health and psychological orientation;
2. Access to tangible and intangible assets, such as land and forest; and
3. The existence of economic activities.

In addition, the livelihood concept reflects the fact that livelihood is a multifaceted phenomenon, encompassing both what people do and what they accomplish by doing it, and referring to outcomes as well as activities. In particular, the asset dimension is critical to an appreciation of the concept: assets, in this context, comprise the resources and stores (tangible assets) and claims and access (intangible assets) that a person or household commands and can use towards a livelihood (Chambers & Conway 1991). This approach has emerged as a framework known as the sustainable livelihood approach. The sustainable livelihood framework allows a wide range of influences to be brought into a single frame of analysis.

However, there have been some debates that arise within the application of sustainable livelihoods in practice. Scoones (2009) recognises four repeated failing of livelihoods approaches: lack of engagement with processes of economic globalisation with limited means of responding to major shifts in global markets and politics; lack of attention given to power and politics with the failure to link between livelihoods and governance debates within the development community;

lack of acknowledgement of the bigger environmental picture, particularly in relation to climate change; and failure to engage with long term changes in rural economies and with agrarian change.

In responding to these four perceived failings of livelihoods perspectives, Scoones (2009) identifies four areas of challenges for sustainable livelihood approaches: knowledge, politics, scale and dynamics. In terms of knowledge, Scoones urges that the framings, assumptions, and values underlying the application of a livelihoods perspective are made explicit, rather than portraying the analysis as purely rational and objective. In relation to politics, Scoones argues that this issue should not just focus on the local level but at the wider context and over time, although he does not incude political power in the set of assets. In terms of scale, Scoones argues that while livelihoods analyses have often focused on the micro-level, simultaneously they should be able to investigate networks, linkages, connections, flows, and chains across scales and keep rooted in place and context. Eventually, a dynamic perspective is needed in examining livelihoods over time, including looking into the future through examining the directions and potential impacts of long term change.

In summary, the sustainable livelihood approach presents various entry points for thinking holistically about the contribution of ES to livelihoods. Further, the flexibility of the framework means that it is highly compatible with other frameworks. The importance of the sustainable livelihood approach is reflected in its influence on others. Details of the sustainable livelihoods approach as a framework underpinning the present research is discussed below.

2.4.2 The sustainable livelihood approach

The livelihoods concept has gained ground significantly over other approaches in attempts to reduce rural poverty in developing countries. The sustainable livelihood framework encompasses the main facets that influence people’s livelihoods, and is used in various contexts, including planning new developments and assessing the contributions of different types of activities to livelihood sustainability. The sustainable livelihood approach has a number of basic elements: livelihoods assets, livelihood strategies, livelihood outcomes, institutional processes and organisational structures (Figure 2.12).

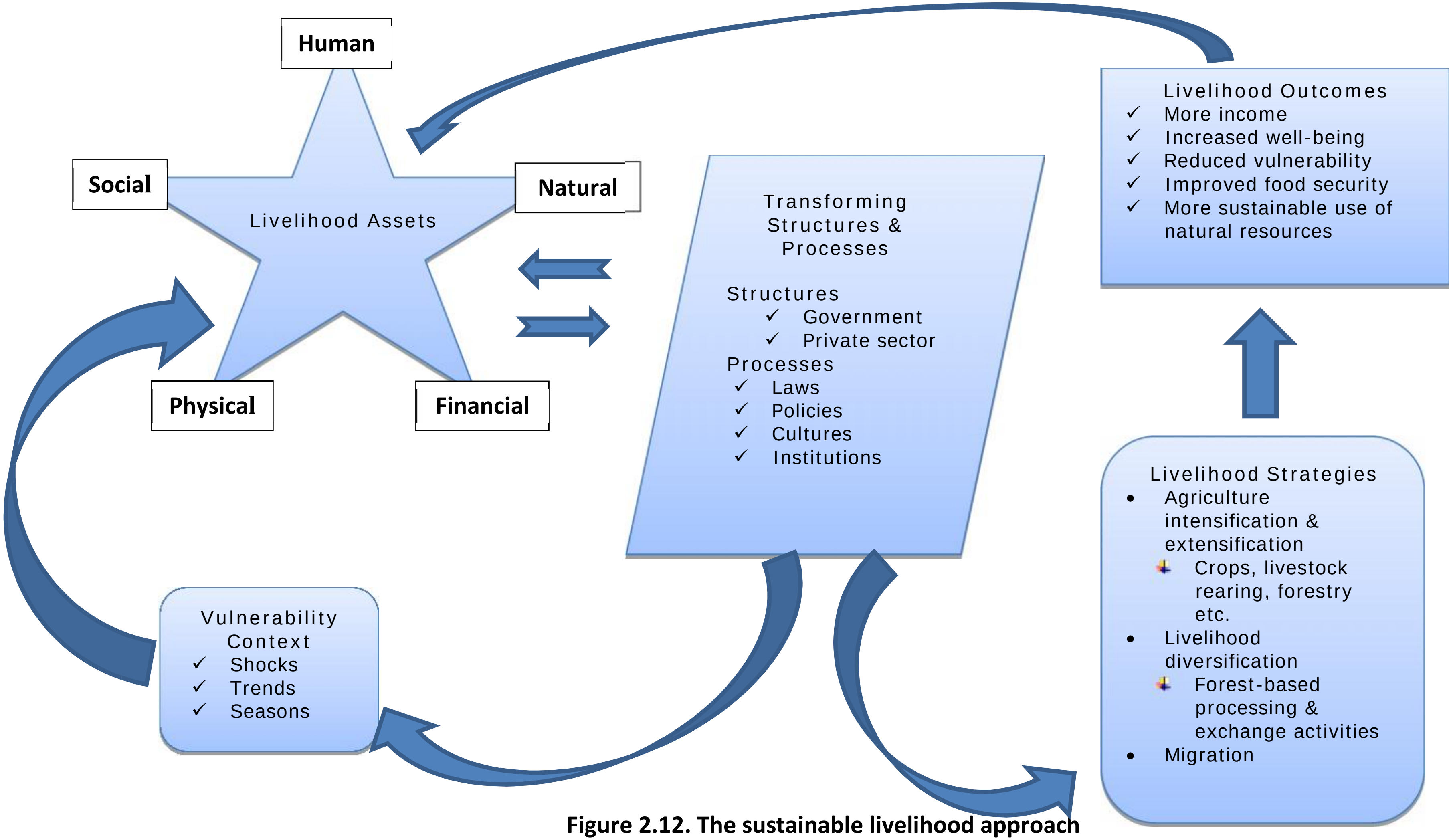


Figure 2.12. The sustainable livelihood approach

Source: Adapted from DFID (1999)

The underlying assumption of this framework is that people pursue a range of livelihood outcomes (e.g., greater income, food security, reduced vulnerability, increased wellbeing) through different activities by drawing on a range of assets. The activities they adopt and the way they reinvest in building assets is driven in part by their own preferences and priorities. However, they are also influenced by different vulnerabilities, including shocks (such as drought), overall trends (e.g., in resource stocks) and seasonal variation (Farrington et al. 1999). Their options are also influenced by structures, such as the roles of government or the private sector, and processes, such as institutional, policy and cultural factors. In aggregate, these conditions determine rural people's access to assets and livelihood opportunities, and the ways in which these can be converted into outcomes. Thus, poverty and the opportunities to escape it depend on all of the above (Farrington et al. 1999).

2.4.2.1 Livelihood assets

The ability to pursue different livelihood strategies is dependent on the basic materials and social, tangible and intangible assets that people have in their possession. The framework identifies five capital assets: [i] natural capital; [ii] human capital; [iii] financial capital; [iv] physical capital; and [v] social capital. Natural capital relates to the natural resource stocks and ecosystems from which materials and services flow that are useful for developing livelihoods. Knowledge, skills, labour and good health are important elements of human capital. Financial capital is essential for the pursuit of any livelihood strategy, and can take the forms of cash, credit, savings or remittances. Physical capital takes the form of basic infrastructure, such as transport and shelter, production equipment and technologies, all elements that are also important in supporting livelihood strategies. The final asset is social capital: this is built on social resources such as networks, social relations, affiliations and organisations that people draw on, particularly when pursuing livelihood strategies requiring co-ordinated actions.

2.4.2.2 Livelihood strategies and outcomes

In a rural context, a farming household may construct four main types of livelihood strategies (Scoones 1998):

1. Agricultural intensification, where the value of output per hectare of land or per animal is increased by the application of more labour, capital or technology;
2. Agricultural extensification, where more land or more animals are brought into production at the same levels of labour, capital or technology that exist in other parts of the household operations;
3. Diversification, where households diversify their economic activities to reduce their reliance or dependency on a primary enterprise (livestock rearing or monocultural cropping), typically by seeking a wider range of on- and off-farm sources of income, such as diversifying crops or livestock, processing and selling farm produce, gathering forest products, or off-farm employment (e.g., selling their labour to other farms, establishing small-scale enterprises and seeking salaried employment); and
4. Migration, where people move away from their initial source of livelihood (area), and seek a living, either temporarily or permanently, in another livelihood system.

In general, these strategies are seen to cover a wide range of options available to rural households. Commonly, rural people pursue multiple strategies, together or in sequence. Outcomes will not always be monetary; for example, they may include a sense of being empowered with the ability to make choices. Generic types of livelihood outcomes are provided in the right-hand box of Figure 2.12.

2.4.2.3 Transforming structures and processes

Within the sustainable livelihood framework, certain social structures and processes affect the complex and highly differentiated processes of achieving a sustainable livelihood. These structures and processes influence rural people's access to resources and livelihood strategies, and the ways in which these can be converted into outcomes. Institutional regulations play a crucial role in sustainable livelihoods, since they determine the access of individuals and households to livelihood resources or capital.

Adopted by the UK DFID in the late 1990s (DFID 1999), the sustainable livelihood approach has gained broad institutional backing from major international organisations, development agencies, NGOs and research centres. It is argued by Argawala et al. (2014) that the heart of the sustainable livelihood approach is to combine livelihood resources and strategies in an approach to poverty reduction that revolves around asset vulnerability, and that benefits from an underlying definition of what a sustainable livelihood looks like. The core assets and strategies of sustainable livelihood approach have consistently been adopted by researchers since the 1990s in many rural areas around the world.

2.4.3 Rural livelihood system

Livelihood generation refers to the bundle of activities that people undertake to provide for their basic needs (Niehof & Price 2001). The process of livelihood generation is comprised of interrelated activities and the resources and assets needed to carry out those activities as these all are geared towards the objective of securing and enhancing livelihood. Thus, livelihood generation represents the correlation of multifaceted and dynamic systems, which are collectively known as the livelihood system.

The livelihood system is embedded in a wider environment and interfaces with other systems. Ecological, economic (markets) and socio-cultural environments are all important systems for rural livelihood (Niehof & Price 2001). The livelihood system may be comprised of a variety of activities that are carried out in a structured and planned manner. Therefore, it is important for households to decide on and manage strategies for securing their livelihood. However, different patterns of operation of households influence the degree to which strategies are designed and taken. The various activities of each household will depend on the resources, assets and systems available. The household is the internal livelihood environment; household characteristics will affect the opportunities for and constraints on livelihood activities (Niehof & Price 2001). Most rural households undertake livelihoods that are directly based on agriculture or linked to agriculture; they may also be based on non-agricultural activities.

Bernstein (1992) suggested that rural household livelihood systems can have components linked to or based on agriculture as well as components not linked to or based on agriculture. These different types of livelihood activities are presented in Table 2.4 below.

Table 2.4. Means of rural livelihoods other than farming land

Livelihood systems	Wage employment by:	Self-employment in:
Agriculture	Richer farmers	Share-cropping or other Tenant-farming
Agriculturally linked	Input suppliers, contractors, crop merchants, transporters	Artisanal production, Small-scale processing
Non-agricultural	Industry, trade, other services	Handicraft production, petty trade and other services

Source: Bernstein (1992)

2.4.4 Sustainable and vulnerable livelihoods

Sustainability in the context of livelihood is described by Chambers and Conway (1991) as the ability to maintain and improve livelihoods while maintaining or enhancing the assets and capabilities on which the livelihoods depend. In contrast, vulnerability is associated with lacking sufficient assets or ability to create or maintain livelihood (Niehof 2004). When there is an insufficient base of assets and resources (including management and planning capabilities) to achieve a secure livelihood, this implies an unsustainable or vulnerable livelihood. Sustainability in livelihood also encompasses the concept of resilience: situations that are able to resist stress, avoid shocks and bounce back when affected. In contrast, when people cannot cope with stress and shocks without suffering damage, this implies or leads to vulnerable livelihood situations (Niehof 2004). When vulnerable households face problems in providing basic needs for their members, they usually are unable to create an excess, and are often involved in debt.

It is understood that a sustainable livelihood is also a secure livelihood (Niehof & Price 2001). There is a relationship between a household's level of livelihood security and its strategies used in relation to resources and assets. A lack of assets hinders the ability to design and implement effective coping strategies, pushing households into situations of extreme vulnerability. Not only do strategies require resources and assets to be implemented, but the resources and assets a household can discard also limit the scope and nature of the strategies it can develop and their effectiveness.

2.4.5 Rural livelihood in developing countries

In developing countries, rural people do not gain a full living simply from farming or herding. People in rural areas normally practice livelihood diversification to boost security and raise living standards (Sunderlin et al. 2005). The tendency for rural people to be employed in multiple occupations and activities is often noted, but few attempts have been made to link this behaviour in a systematic way to rural poverty reduction polices. This poverty should be considered a grave problem requiring justification. In the past, it has often been assumed that farm output growth will create plentiful non-farm income-earning opportunities in the rural economy via linkage effects. However, this assumption is no longer acceptable: it is becoming increasingly evident that for many unfortunate rural families, farming on its own is unable to provide sufficient means of survival (Ellis 1999).

In reality, rural livelihoods may be comprised of several activities, including cultivation, herding, hunting, gathering, wage labour and trading. These activities variously provide food, cash and other goods to meet a wide range of human needs. Some of these outputs are consumed directly, and others go into short- or long-term stores to be consumed later or invested in other assets (Chambers & Conway 1991).

In some developed countries, a single wage earner in a career occupation is largely obvious; however, for most families in developing countries, the situation is distinctly different. Livelihood structures are complex; they involve the incomes, skills and services of all members of the family in an effort to reduce the risks associated with living near subsistence (Ellis 2000a). A subsistence farmer may become a wage labourer in the off-season or during drought and could later revert to farming when it is time to cultivate the field. Another driver that may influence livelihoods in developing countries is a significant degree of dependency on natural resources, particularly natural forests (Narain, Gupta & van 't Veld 2008; Nawrotzki, Dickinson & Hunter 2012), and the recent situation of decreasing resource availability (Pyhälä, Brown & Neil Adger 2006). Among other reasons, this represents a problem because it destructively affects the livelihoods of rural people dependent on forest products and services. The main conclusion here is that there are large numbers of poor people living in rural forested areas, and there is a correlation between chronic poverty and remaining areas of natural forest. Therefore, it is important to take forest into account in improving the livelihoods of people who live in rural forested areas.

2.5 Ecosystem Services

ES can be best defined as 'the benefits people obtain from ecosystems' (MEA 2005). A seminal article by Daily (1997a, p. 3) outlines ES as 'the conditions and processes through which natural ecosystems, and the species which make them up, sustain and fulfil human life'. Another influential paper in the field of ES refers to it as a combination of ecosystem goods (such as food) and services (such as waste assimilation) that overall signifies 'the benefits human populations derive, directly or indirectly, from ecosystem functions', where 'ecosystem functions' stands for the 'habitat, biological or system properties or processes of ecosystems' (Costanza et al. 1997, p. 253).

Although ecosystem functions have long been acknowledged for their role in maintaining biodiversity and human activities (Costanza et al. 1997; Daily 1997b), the concept of ES has only been widely adopted in the field of ecological and environmental economics since the late 1990s (Brown, Bergstrom & Loomis 2007; Ferraro et al. 2012). Since then, it has been recognised as an independent discipline, while at the same time there has been a growing emphasis on integrating ES into environment-related decisions; this has been particularly the case since the Millennium Ecosystem Assessment (MEA), under the auspices of the United Nations, was undertaken to underline the value of ecosystem processes to human beings (MEA 2005). The supply of ES is directly related to the functionality of natural ecosystems, which form a backbone for ecological processes and ecosystem structure (de Groot, Wilson & Boumans 2002).

Ecosystems provide services that are believed essential to an economy's performance. In developing economies, natural capital constitutes the backbone of a country's economy, as most have reasonably low financial capital with which to produce goods and services (Ferraro et al. 2012). Two economic theories justify the connection between ES and the economy, namely those of externalities and public goods (Kline, Mazzotta & Patterson 2009). 'Externalities' refers to the effects of one person's activity on another, while public goods provide benefit to all people, whether they pay for the benefit or not.

2.5.1 The ecosystem services approach

The ES approach integrates the ecological, social and economic dimensions of natural resource management. This approach identifies and classifies the benefits that people derive from ecosystems, including marketed and non-marketed products, use and non-use elements, and tangible and non-tangible benefits (Sandhu & Wratten 2013). Importantly, the approach yields benefits in that it describes and communicates its concepts in a language that a wide range of stakeholders and the general public can understand.

The ES framework is a useful approach to better explaining the links between household activities and the maintenance of ecological functions (Tallis et al. 2008). Maintenance and access, two concepts identified in the sustainable livelihoods approach, are also essential to the ES framework (de Groot et al. 2010). ES are often categorised into four broad areas: provisioning, regulating, supporting and cultural services. The following section discusses the classification of ES.

2.5.1.1 Classification of ecosystem services

Nahlik et al. (2012) identify various definitions of ES. In general, conceptualisations of ES can be grouped into two philosophies: *ES lead to benefits*, and *ES are similar to benefits*. Some authors have proposed different typologies of ES (e.g., de Groot, Wilson and Boumans (2002), Costanza et al. (1997), Brown, Bergstrom & Loomis (2007), Fisher, Turner & Morling (2009)). Although there are a wide range of typologies, they have one framework in common, in that they all relate to human wellbeing (Kline, Mazzotta & Patterson 2009).

The most commonly used classification for ES uses the categories of provisioning services, regulating services, supporting services and cultural services (MEA 2005). Provisioning services include food, timber and other raw materials; regulating services comprise natural processes and systems that regulate climate, air and water; examples of supporting services include pollination and biological control; and cultural services involve aspects such as recreation and aesthetics.

Classification of the definitions of ES is required before estimating their values. To capture the diversity of ES, the UN Millennium Ecosystem Assessment (MEA 2005) groups them into four basic services based on their functional characteristics. This typology provides the organising principle for the assessment of ES in this work (Figure 2.13 and Appendix 2A):

1. Regulating Services: ecosystems regulate essential ecological processes and life support systems through biogeochemical cycles and other biospheric processes;
2. Provisioning Services: the provisioning function of ecosystems supplies a large variety of ecosystem goods and other services for human consumption, ranging from food in agricultural systems, raw materials and energy resources;
3. Cultural Services: ecosystems provide an essential 'reference function' and contribute to the maintenance of human health and wellbeing; and
4. Supporting Services: ecosystems also provide a range of services that are necessary for the production of the other three service categories.

The concept of ES has been used as a policy tool for the purpose of sustainable use of natural resources (Seppelt et al. 2011). The quantification of ES is an important element in assessing ES for decision making (Gómez-Baggethun et al. 2010). Several studies have suggested various classification schemes of ES for economic valuation purpose (Boyd & Banzhaf 2007; Fisher, Turner & Morling 2009). The review of valuation tools of ES is discussed in more detail in the next section.

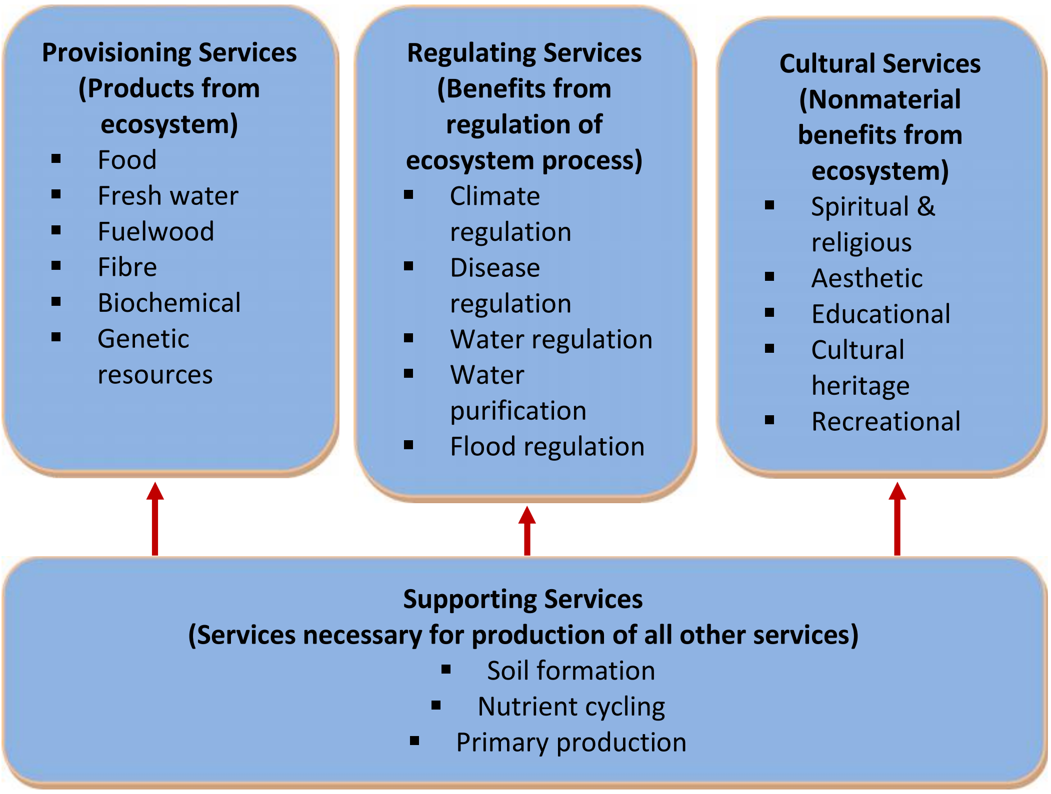


Figure 2.13. The ecosystem services approach

Source: Adapted from MEA (2005)

2.5.2 Ecosystem services valuation

A considerable amount of literature has been published on the concept of valuation of ES. Farber, Costanza and Wilson (2002) provide a background rationale for valuing ES from the economic and ecological points of view. Ecosystem services valuation (ESV) is a method used to articulate a value of ES with a scientific magnitude (Farber, Costanza & Wilson 2002). ESV is the collective term for various methods used, and is defined as the process of examining the contributions of ES to fair distribution and efficient allocation (Liu et al. 2010). However, Farber, Costanza and Wilson (2002) recognise conflicts that arise between economic and ecosystem values. de Groot, Wilson and Boumans (2002) provide an integrated framework for ESV that includes ecological, socio-cultural and economic values. ESV may be used as a means of provoking society to acknowledge the value of natural capital in light of declining ES (Liu et al. 2010). Specifically, Liu et al. (2010) assert that ESV is a tool that:

1. Provides for comparisons of natural capital to physical and human capital in

regard to their contributions to human welfare;
2. Monitors the quantity and quality of natural capital over time with respect to its contribution to human welfare; and
3. Provides for the evaluation of projects that will affect natural capital stocks.

MEA's (2005) classification of ES is considered to be an heuristic scheme. However, in a decision-making context, the MEA classification needs to be adjusted as it can lead to double counting. Hence, Fisher, Turner and Morling (2009) propose a classification scheme of ES that focuses on the final benefit of interest to achieve economic valuation purpose.

Various techniques have been developed to measure the economic valuation of ES (Seppelt et al. 2011). One of the valuation methods that commonly used to measure ES is total economic value (Gómez-Baggethun et al. 2010).

2.5.2.1 Total economic value of ecosystem services

The value people receive from ES can be measured using the various components of total economic value. Total economic value is a heuristic instrument that measures the benefits generated from ecosystems, distinguishing between use and non-use values (Barbier 2007; Christie et al. 2012). Figure 2.14 presents the components of total economic value.

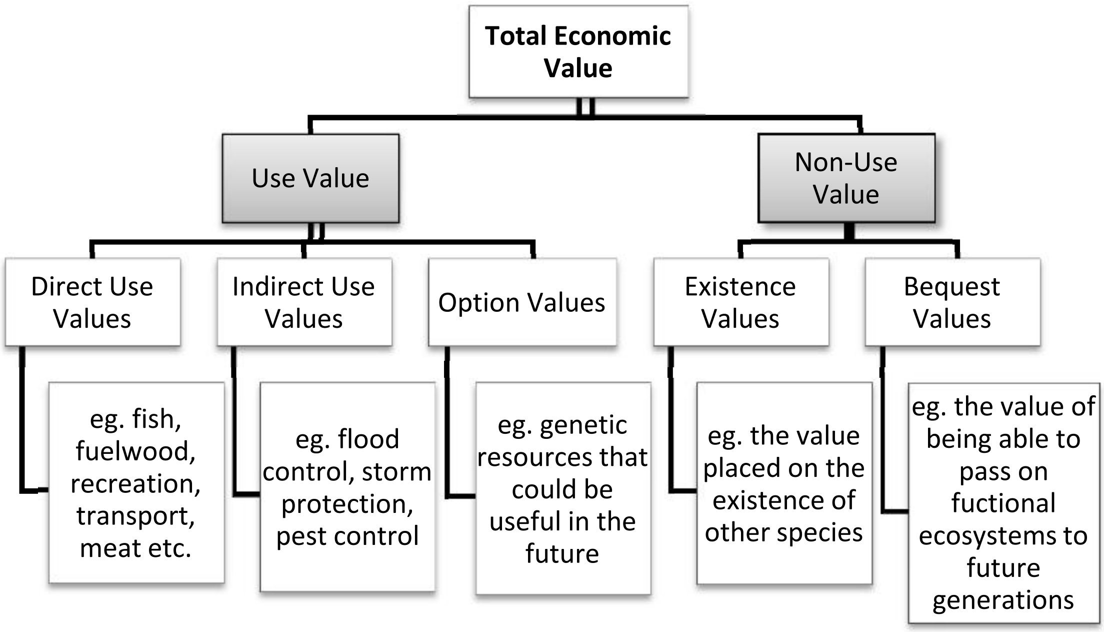


Figure 2.14. The concept of total economic value

Source: Barbier (2007); de Groot, Wilson and Boumans (2002); TEEB (2010b)

Use values involve human use (consumptive or non-consumptive) whereas non-use values do not. Use values comprise two types of benefit: direct use and indirect use benefits. Direct use values are more likely to have market value. Indirect use values, on the other hand, are difficult to quantify, and are generally ignored in management decisions. Direct use benefits come from provisioning and cultural services, while indirect values consist of benefits from regulating services. For example, production of food is a direct use value for which money is exchanged in markets, whereas the nutrient cycling performed by soil organisms indirectly supports agricultural production; however, this contribution is non-marketed and goes financially unrewarded. Another type of use values, option values, are values which are not currently used but have potential to be used in the future. These imply the satisfaction people get from the potential future uses of provisioning, regulating and cultural services.

Meanwhile, people may value natural resources without using them either directly or indirectly: this is called non-use value. These types of value rely merely on the continued existence of an environmental resource, and are unrelated to use. Existence value is the 'intrinsic' value of natural resources that arises simply due to their existence; it is the value that leads people to desire that species such as the giant panda be protected, even if the same people never see the species themselves. Bequest value is what leads people to support policies and actions that protect natural resources for future generations to use; in other words, it represents the satisfaction that future generations will glean from ecosystems.

2.5.2.2 Methods of economic valuation of ecosystem services

A variety of economic valuation methods have been developed in a range of different contexts to measure ES when market prices cannot adequately capture and integrate their social value. Based on the framework of neoclassical economics, the economic valuation of ES mainly focuses on preference-based methods (TEEB 2010b). Christie et al. (2012) provide a comparative summary of various valuation approaches, which can be divided into monetary and non-monetary methods. Monetary approaches are used to estimate the economic value of some or all components of total economic value, while non-monetary approaches are used to adduce evidence on the significance of ES to human beings.

In general, the economic valuation of ES falls into three basic approaches: (1) the direct market approach, (2) the revealed preference approach, and (3) the stated preference approach (TEEB 2010a). Each technique has its own repertoire of associated measurement issues. A summary of the relationships between the three approaches is presented in Table 2.5 below.

Table 2.5. Relationship between valuation methods and value types

Approach		Method	Value
Market Valuation	Price-based	Market prices	Direct and indirect use
	Cost-based	Avoided cost	Direct and indirect use
		Replacement cost	Direct and indirect use
		Mitigation/restoration cost	Direct and indirect use
	Production-based	Production function & factor income	Indirect use
Revealed preference		Travel cost method	Direct (indirect) use
		Hedonic pricing	Direct and indirect use
Stated preference		Contingent valuation	Use and non-use
		Choice modelling	Use and non-use
		Group valuation	Use and non-use

Source: TEEB (2010a)

The present study uses the direct market approach, because this approach uses data from actual markets, and thus reflects actual preferences or costs to individuals. Moreover, these data—such as prices, quantities and costs—exist and are relatively easy to obtain. The following section provides a brief description of the economic valuation method used in the present study, together with a discussion of its limitations.

Direct market approach

Valuation under the direct market approach calculates the exchange value that ES have in trade, and is mainly applicable to the 'goods' (i.e. production functions). Value of food produced is an example. Direct market valuation approaches are divided into three main subtypes: (a) market price-based approaches, (b) cost-based approaches, and (c) approaches based on production functions (TEEB 2010a).

Market price-based approaches are most often used to obtain the values of provisioning services, since the commodities produced by provisioning services are often sold on, such as agricultural commodities, fuel wood and non-timber forest products (NTFPs). In well-functioning markets, preferences and marginal costs of production are reflected in market price, which implies that these preferences and marginal costs can be taken as accurate information on the value of commodities. The price of a commodity multiplied by the marginal product value of the ES is an indicator of the value of the service; consequently, market prices can also be good indicators of the value of the ES that is being studied.

Cost-based approaches are based on estimations of the costs that would be incurred if ES benefits needed to be recreated through artificial means. Different techniques exist within this approach, including: (a) the avoided cost method, which relates to the costs that would have been incurred in the absence of the ES; (b) the replacement cost method, which estimates the costs incurred by replacing ES with artificial technologies; and (c) the mitigation or restoration cost method, which refers to the cost of mitigating the effects caused by the loss of the ES or the cost of having it restored.

Finally, the production function-based approach is based on the contribution of the ES to the enhancement of income or productivity. It estimates how much a given ES (e.g., a regulating service) contributes to the delivery of another service or commodity as it is traded on an existing market. Thus, any resulting 'improvements in the resource base or environmental quality' because of the enhanced ES lower costs and prices and increases the quantities of marketed goods, lead to increases in consumer and perhaps producer surpluses.

Limitations of the direct market approach

Direct market valuation approaches rely primarily on production or cost data, which are generally easier to obtain than the kinds of data needed to establish demand for ES. However, when applied to ES valuation, these approaches have important limitations. These are mainly due to the lack of a market for the ES, or markets being distorted.

The direct problems that arise are twofold. If markets do not exist either for the ES itself or for goods and services that are indirectly related to it, then the data required to undertake these approaches are not available. In cases where markets do exist but are distorted—for instance, because of a subsidy scheme or because the market is not fully competitive—prices will not be a good reflection of preferences and marginal costs. Consequently, the estimated values of the ES will be biased and will not provide reliable information on which to base policy decisions.

Some direct market valuation approaches have specific problems. Barbier (2007) illustrates that the replacement cost method should be used with caution, especially under conditions of uncertainty. The production function approach has the additional problem that adequate data on and understanding of the cause–effect relationships between the ES being valued and the marketed commodity are often lacking (Daily et al. 2000). In other words, production function of ES are rarely understood well enough to quantify how much of a service is produced, or how changes in ecosystem condition or functions will translate into changes in the ES delivered (Daily 1997b). Further, the interconnectivity and interdependencies of ES may increase the likelihood of double-counting ES, which then leads to uncertainty and poor reliability of the value estimation (Costanza & Folke 1997; Fu et al. 2011).

Given that the major focus of this study is on utilising ES in tropical regions, it is important to discuss how ES work in tropical areas. The following section discusses ES in humid tropical forests.

2.5.3 Ecosystem services in humid tropical forests

Forest ecosystems have recently faced degradation and loss due to rapid population change and economic incentives that make forest conversion appear more profitable than forest conservation. All ecological functions of forests are also economic functions (Pearce 2001): natural and managed forests are the most important providers of ES for the whole world. However, forest ecosystems are under threat, as rates of deforestation are disputed (Pearce 2001). According to the UN Food and Agriculture Organisation, annual global net rates of deforestation were at around 13 million ha in the 2000s, or 0.13% of total forest area during 2000–2010 period (FAO 2010). Moreover, Hansen et al. (2008) note an estimated forest area cleared of 27.2 million ha (SE = 2.28 million ha) in the humid tropical forest biome from 2000 to 2005, representing a 2.36% reduction in area of humid tropical forest. Forest loss in Brazil was the highest, which accounted for 47.8% of total biome clearing, nearly four times that of the next most cleared country, Indonesia, which accounted for 12.8%. Over three fifths of clearing occurs in Latin America and over one third in Asia. Although humid tropical forests represent sites of considerable economic value, it is important to manage the biodiversity of terrestrial ecosystems.

The benefits people obtain from ecosystems are essential foundations for human wellbeing. Ecosystems contribute to sustaining human life through the provision of various types of ES. In managing forests, however, ES are left outside the decision-making processes due to limited information on the economic valuation of ES from forests. Forests contribute substantially to the welfare of human society by providing valuable ES that are in high demand. Globally, the value of forest ES was estimated at US$ 4.7 trillion/year, representing the fourth largest of 16 biomes, after coastal, open ocean and wetlands (Costanza et al. 1997). Many of these ES, however, remain outside the conventional market. Many forest owners lack incentives to manage their forests in a way that ensures the sustainable and socially optimal provision of those relevant non-marketed ES, due to improper property rights and market failure. The fact that many of these ES are available for consumption almost free of charge increases the risk of overuse and overexploitation of resources.

It is well known that the world's tropical forests in Asia are disappearing at an alarming rate, and their continuing existence is threatened (Laurance 2007). Tropical forests are being cut down, causing enormous costs to local and global ES (Sachs 2005). This situation occurs due to increasing human population and consumption-driven human settlement, agricultural intensification and forest product trade into forest areas (Pearce 2001). Large populations in developing countries depend upon forests and their resources for their livelihoods. For instance, South East Asia has suffered higher rates of industrial logging than other major tropical forest regions, and could lose large amounts of its original forest cover by the end of this century due to intense forest conversion (Laurance 2007). Unsustainable activities driven by market demand severely impact the ability of forests to provide vital ES. This rapid increase in conversion of forest, especially in the tropics, has raised concerns globally due to the significant degradation of many ES. In Indonesia, for instance, deforestation has had severe ecological consequences, such as the likely extinction of the Sumatran orang-utan, rhinoceros, tiger and elephant, and the local economy is harmed as crucial ecological functions of the forest decline (van Beukering, Cesar & Janssen 2003).

In contrast, proper planning of forest conversion and plantations may improve the provision of some ES, such as biodiversity enhancement, availability of wood for fire and energy, water quality and carbon sequestration, while at the same time diluting some others (Vihervaara et al. 2012). The selection of ES to be taken into account in plantation management depends both on local cultural values and on the particular environmental pressures considered to be most in need of justification. Therefore, policy makers and decision makers should consider the need to involve ES management in environmental policies and regulations. These policies can maintain sustainable forest management practices and enhance ecological resilience and human wellbeing (Ferraro et al. 2012).

2.5.4 Ecosystem services and land use change

Natural ecosystems provide a variety of direct and indirect services and intangible benefits to humans and other living organisms. The future capability of ecosystems to provide these services is determined by changes in socio-economic characteristics, land use and biodiversity (Metzger et al. 2006). Abundance of natural resources greatly influences human life; however, ecosystems' roles in supporting human wellbeing is often ignored in land use decision making (Daily et al. 2009). The impacts of land use changes are well documented in research studies (Lambin et al. 2001). In fact, land use changes in the last five decades have been intense due to urbanisation and a decline in natural ecosystems (Metzger et al. 2006). ES have been assessed for many different land uses and in many landscapes. A growing body of literature attempts to examine ES, yet uncertainty due to the lack of significant value estimates still hinders the use of this research in land use decisions (Johnson et al. 2012).

Converting a landscape to another land use category to meet human demand significantly influences the services provided by the land's ecosystems. Foley et al. (2005) argue that changes in land use lead to trade-offs between enabling humans to support their needs and sustaining the ecosystems that deliver goods and services. However, this argument is challenged by Chazdon (2008), who argues that plantations and restored forest may actually lead to recovery of ES, although not to an extent that equals the initial land cover. Studies in land use changes are considered essential to understanding the functions of ES (Estoque & Murayama 2012). One important type of conversion is the change from one land category to agriculture. It is envisaged that land used for crops will have expanded by nearly 23% by 2050 (Tilman et al. 2001).

In tropical forest regions, small-scale farmers still play a role in agricultural activities. The most common traditional technique for transforming forests to new open agricultural areas is slash and burn agriculture (Lambin et al. 2001; Palm et al. 2005). This technique is used by small-scale farmers in developing countries as a cheap way of clearing forests for agriculture, and usually involves cutting vegetation and setting fire to it (Varma 2003). Small-scale farmers use this method to produce food and make a living for their families, as they only have limited options other than clearing forests, especially when they are marginalised from society and lack government support (Palm et al. 2005). However, this technique is much criticised as a cause of deforestation, loss of biodiversity, and hence increasing global warming. Despite the disadvantages, the predominant role of small-scale farmers in using slash and burn agriculture has come into question (Geist & Lambin 2002).

Increasing land use change from natural ecosystems to croplands and urban areas has resulted in reduced or modified biodiversity, altered functional processes and diminished the provision of ecosystem goods and services to society (Li et al. 2007; Mendoza-González et al. 2012; Nagendra, Reyers & Lavorel 2013). Land use changes into urban or agricultural sites are detrimental to several ES, such as nutrient cycling, climate regulation, erosion, soil fertility and water availability; it also increases the risk of forest fires (Metzger et al. 2006). Land use change is considered the most important factor affecting ecosystem processes and services. However, monitoring and projecting the effects of land use changes is difficult due to the large volumes of data and precise interpretation required (Li et al. 2007).

Changes in land use or land management can cause changes in the provision and value of ES. In general, changes in land use or land management will increase the provision and value of some services but decrease others (Polasky et al. 2011). A study by Mendoza-Gonzalez et al. (2012) investigating land use change and its effects on ES finds that the expansion of agriculture, livestock and urban sprawl has a direct impact on ES. In this study, land use changes resulted in large economic losses. This situation occurred due to lack of information about the contribution of alternate landscapes to services during decision making processes. Therefore, it is important to include valuation of ES during decision-making processes and optimal land use and management to avoid further loss of value of these services (Mendoza-González et al. 2012; Polasky et al. 2011).

2.5.5 Ecosystem services in agriculture and oil palm plantations

Agriculture constitutes the most significant human activity in engineered ecosystems, and demands more than a third of total land globally (World Bank 2011; Zhang et al. 2007). Agricultural land, which is primarily used to produce crops and livestock, provides abundant ES, particularly food, fibre and fuel (Ma & Swinton

2011; Swinton et al. 2007). This delivery depends on supporting, regulating and cultural services in the processing stage (Power 2010; Zhang et al. 2007). However, agricultural ecosystems may also deliver dis-services, incurring costs in the process of provision.

A substantial body of literature documents studies in ES undertaken in different landscapes, particularly in agricultural sectors. Several studies investigate the effects of agricultural activities on ES (Heal & Small 2002; Johnson et al. 2012; Sandhu, Crossman & Smith 2012; Sandhu, Wratten & Cullen 2007, 2010a, 2010b; Sandhu et al. 2008). However, limited research is available on ES in plantation sectors such as oil palm plantations. Oil palm plantations produce palm oil, the most important vegetable oil produced and consumed in the world (Koh & Ghazoul 2010). Thus, it is important to examine the benefits people receive from ecosystems in this field.

The rapid development of oil palm plantations in Indonesia has resulted from land cover change (Carlson et al. 2012). The growing pathway towards unsustainable production of palm oil among the major global palm oil producers has been alleged largely by commentators because of the conversion of rainforests and peatland forests to oil palm plantations (Wicke et al. 2011). This land use change may result in losses of biodiversity and ES (Johnson et al. 2012; Yoshida et al. 2010).

Oil palm plantations clearly produce significant economic value in terms of ES as a cash crop for the farmers. However, the production of oil palm tends also generates trade-offs in ES, particularly those that are not yet valued in formal markets. One such example is that oil palm cultivation is thought to degrade freshwater quality and soil quality, which reduce the value of water regulation and soil protection services (UNEP 2011). Nonetheless, it can also generate increases in services such as carbon sequestration and soil protection if it is not grown in forest and peatlands (Fitzherbert et al. 2008). One case study by Barano et al. (2010) investigates an ecosystem-based spatial plan, intended to provide local governments in central Sumatra with a direction before allowing land concessions for businesses such as oil palm and pulp plantations. However, this study does not examine the ES within the area in detail, and does not reveal the importance of ES from the perspectives of other stakeholders, such as local farmers and private companies.

2.5.6 Rural livelihoods and ecosystem services

Livelihoods related to the use of ecosystems must involve ‘assets (natural, physical, human, financial, and social capital), the activities, and the access to these (mediated by institutional and social relations) that together determine the living gained by the individual or household’ (Ellis 2000b). The contribution of ES to livelihoods and poverty alleviation has become an important topic in current literature and studies. It is now globally acknowledged that efforts to alleviate poverty require understanding of the dynamics of ecosystems and ES on which the livelihoods of rural communities depend (Barrett, Travis & Dasgupta 2011). People have differing abilities to benefit from ES (Fisher et al. 2014).

Associations between poverty and environment have been acknowledged in developing countries, where poor rural people tend to have higher dependences on livelihood resources directly from nature (Fisher et al. 2013). However, this has been a global challenge, as the dependency of rural people on local natural ecosystems for livelihood has the potential to accelerate losses of ES (Sandhu & Sandhu 2014). The degradation of ES can occur, for instance, through the intensification of agriculture, making people disproportionately vulnerable to environment change (Fisher et al. 2013; MEA 2005). Over time, modes of livelihoods in developing countries have changed in association with their use of nature. For example, in forested landscapes, livelihoods have undergone changes from hunting and gathering to swidden cultivation and sedentary agriculture at forest frontiers (Sunderlin et al. 2005).

The pursuit of environment and development goals acknowledges the complex connection between economic-social-environment issues and choices of livelihood strategies of the people in rural areas (Salafsky & Wollenberg 2000). The ES approach can be used to support improved understanding between household rural activities and ecosystem function (Tallis et al. 2008). The sustainable livelihoods framework recognises the preservation of natural capital as one the key household capital assets. Natural capital is fundamental to the ES approach (Costanza et al.

1997; Daily 1997b). Natural capital also provides significant income sources as rural livelihoods simultanenously sustain ES, such as water regulation and soil conservation.

As noted above, the rural poor tend to depend directly on services, and are thus immediately vulnerable to harm from natural or anthropogenic changes, which may affect their livelihood resources or regulate the services that govern the habitability of an environment (Fisher et al. 2013). Therefore, the link between the benefits of ES and basic human needs, or the constituents of wellbeing, must be clearly identified to motivate better management of ES (Sandhu & Sandhu 2014).

2.6 Summary of Chapter

This chapter has presented a review of the literature on the importance of oil palm globally and in Indonesia, and the impacts of oil palm cultivation in relation to the environment and ES. The history of oil palm in different regions of the world has been discussed. The historical record on oil palm mostly relates to the journeys of oil palm exploration from Africa to South East Asia.

Oil palm is becoming one of the most important agricultural products in tropical regions, but at the same time is behind a variety of environmental issues. Environmental concerns regarding the oil palm industry include forest destruction, fires, loss of forest habitat, pollution and the drying out of peatlands leading to massive CO_2 emissions.

Current literature shows that ES offer various advantages for human wellbeing. An ES approach to natural resource management is one that integrates its ecological, social and economic dimensions. Importantly, this approach identifies and classifies the benefits that people derive from ecosystems, including their market and non-market, use and non-use, tangible and non-tangible benefits. ES provide a range of services that are of fundamental importance to human wellbeing, health and livelihoods. The most important contribution of the widespread recognition of ES is that it reframes the relationship between humans and the rest of nature. Sustaining and enhancing human wellbeing requires a balance of four assets: human individuals, society, the built economy and ecosystems.

Chapter 3 of this thesis will discuss the geography of the research area, Riau Province.

CHAPTER 3:
RIAU PROVINCE

3.1 Introduction

The aim of this chapter is to provide an overview of Riau Province by describing its location and biophysical and socio-economic characteristics. Land use issues are elaborated upon.

3.2 Riau Province

3.2.1 Location

Riau is one of 33 provinces in Indonesia. It is located in east central Sumatra bordering the Strait of Malacca, making it strategically located with reference to Peninsular Malaysia and Singapore. Sumatra is the sixth largest island in the world, with an area of around 476,000 km^2. Its tropical forest has been classified by UNESCO in 2011 as a world heritage environment in danger. Unsurprisingly, it is well known for its rich biodiversity, with approximately 10,000 plant species (Gillison et al. 2003; Susiarti, Purwanto & Walujo 2009). It is part of the Sunda Lowland Region, one of the world's top five biodiversity hotspots (Myers et al. 2000); global biodiversity hotspots are defined on the basis of high species richness, high levels of endemism and significant pressures on habitat.

Riau is located between 01° 05' 00" S–02° 25' 00" N, and between 100° 00' 00" and 105° 05' 00" E. The province forms part of the Strait of Malacca littoral and shares borders with North Sumatra Province (to the north), Jambi and West Sumatra Provinces (to the south) and West Sumatra and North Sumatra Provinces (to the west). In 2014, Riau Province comprised ten districts (Rokan Hulu, Rokan Hilir, Bengkalis, Kampar, Siak, Meranti Islands, Pelalawan, Kuantan Singingi, Indragiri Hulu and Indragiri Hilir) and two cities, Pekanbaru and Dumai (Figure 3.1).

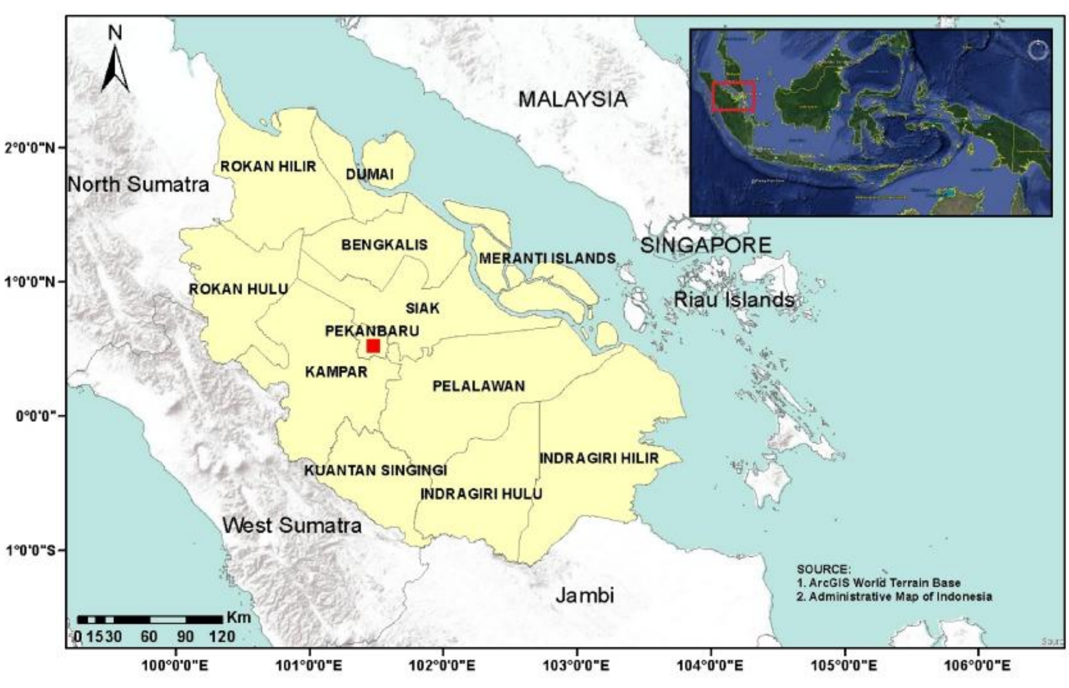


Figure 3.1. Riau Province

Source: ArcGIS World Terrain Base and Administrative Map of Indonesia

3.2.2 The biophysical environment

3.2.2.1 Topography

Riau has an area of approximately 8.9 million ha, with elevation ranging from 2–91 metres above sea level (masl) (Ramdani & Hino 2013), with an average of 10 masl (Ministry of Forestry 2013). The topography is, therefore, fairly flat (Ramdani & Hino 2013), and typically comprises lowlands with undulating and hilly terrain (Ministry of Forestry 2013). Areas with a mean slope angle < 2% cover around 1,100,000 ha, and those between 15 to 40% cover almost 738,000 ha. Steeply sloping terrain (> 40%) covers just over 550,000 ha (Ministry of Forestry 2013).

The land area consists of the mainland, islands in the Strait of Malacca and water bodies. There are 15 large rivers, four of which are considered significant for transportation (Ministry of Forestry 2013), namely the Siak (300 km in length, 8–12 m in depth), the Rokan (400 km in length, 6–8 m in depth), the Kampar and the Indragiri (500 km in length, 6–8 m in depth). These rivers have their sources in the Bukit Barisan (the Barisan Mountain Range), which divides Riau from the provinces to the west, and enter either the Strait of Malacca or the South China Sea.

The Batak Plateau and the Padang Highlands of the Barisan Mountain Range are the only major uplands. A belt of swamps, fed by the Rokan, Tapung, Siak, Kampar and Indragiri rivers flowing eastward from the highlands, extends inward from the coast to a maximum width of about 240 km. Swamps also cover the greater part of the Rupat and Bengkalis Islands in the Strait of Malacca.

3.2.2.2 Soils

Bappeda Riau (Bappeda Riau 2010) identifies four main types of soil in Riau:

1. Organosol gley humus soils;
2. Red–yellow podsolic soils developed on alluvium;
3. Red–yellow podsolic soils developed on sedimentary rocks; and
4. Red–yellow podsolic soils developed on igneous rocks.

BPS – Statistics of Riau Province (2014) provides more detailed information (Table 3.1):

Table 3.1. Soil types in Riau

Soil type	Bappeda Riau soil type (see above) (2010)	Dominant parent material	Physiography	Percentage of province (%)
Entisols	2	Alluvium	Flat	2.6
Histosols	1	Organic material	Flat	43.4
Inceptisols	2 / 3 / 4	Alluvium, metamorphic and sedimentary	Undulating, hilly flat, hilly	16.6
Mollisols	No equivalent	Limestone	Hilly	0.3
Oxisols	3 / 4	Metamorphic, sedimentary, volcanic	Hilly, undulating, undulating flat	7.6
Ultisols	3 / 4	Metamorphic, plutonic, sedimentary, volcanic	Hilly, undulating, mountainous	29.5

Source: Adapted from BPS – Statistics of Riau Province (2014)

Histosols, the highest proportional soil component, have developed on the extensive and deep contiguous tropical peat swamp forests found in several districts (Figure 3.2) (Susanti & Burgers 2011).

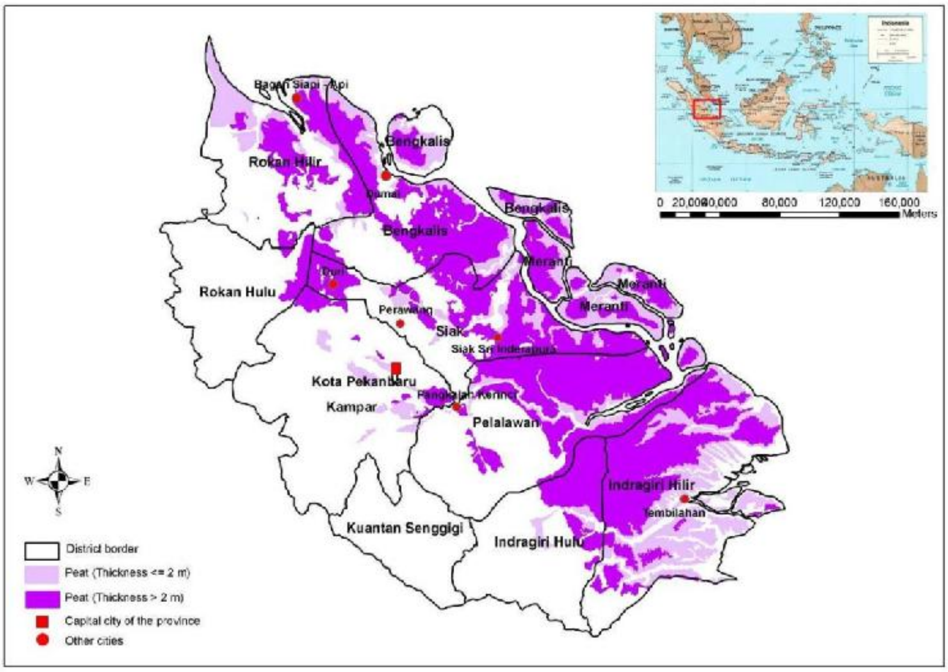


Figure 3.2. Peatland distribution in Riau Province

Source: Center for Soil and Agroclimate Reseach (1990), cited in Susanti and Burgers (2011)

3.2.2.3 Climate

Riau Province has a wet tropical climate (Ministry of Forestry 2013) and is an Af zone in the Köppen-Geiger climate classification: the tropical rainforest, or equatorial (Af) climate, straddles the Equator, has minimal seasonality, and is typically hot and wet throughout the year. The average annual rainfall in Sumatra ranges between 1,000 and 3,000 mm, which occurs in two seasons: a dry season, between April and September, and a wet season, from October to March (Ramdani & Hino 2013). The climate in Riau has strong maritime influences. Pekanbaru's average temperatures are 31°C in the daytime and 23°C at night throughout the year (Table 3.2), with monthly mean daytime highs around 31–36°C and average lows of around 21–23°C (Ministry of Forestry 2013).

Table 3.2. Temperature in Pekanbaru (°C)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Mean monthly maximum (°C)	30	31	31	31	32	32	31	31	31	31	31	30	31
Mean monthly minimum (°C)	23	23	23	23	24	23	23	23	23	23	23	23	23

Source: Weatherbase (2014)

3.2.2.4 Land cover and land use

Miettinen and Liew (2003) measure the distribution of land cover type in Riau in six classes (Table 3.3). However, given the continuing conversion to oil palm plantations, it is likely that these values will have changed significantly.

Table 3.3. Land cover distribution in Riau

Land type	2002 (%)	Area (ha)
Primary vegetation	38	3,387,706
Secondary growth	18	1,604,703
Plantation	18	1,604,703
Agriculture	1	89,150
Mosaic	24	2,138,604
Urban/settlement	1	89,150

Source: Miettinen & Liew (2003)

Uryu et al. (2008) and Isoguchi et al. (2008) identify two broad types of vegetation classes in Riau (the authors' categories are in fact combinations of land cover and land use classes; the term vegetation is used incorrectly). These are spontaneous vegetation, and cultivation and plantations (Table 3.4).

Table 3.4. Broad vegetation types in Riau

Land cover/use classes	Land area (%)
Spontaneous vegetation types	51
a. Natural forest	39
Dryland (dry lowland forests)	14
Swamps (peat, swamp and mangrove forests)	24
b. Secondary regrowth (dry and wetland)	13
Cultivation and plantations	49

Source: Isoguchi et al. (2008)

Of the total cultivated land, paddy rice dominates in terms of area and production (Table 3.5), as it can be grown under both dryland and wetland conditions. Wetland paddies are more extensive than the dryland systems. The area of maize was almost equal to that of dryland paddy rice in 2008, but declined significantly between 2008 and 2012, while dryland paddy increased slightly.

Table 3.5. Harvested area (ha) and production (tonnes) of food crops in Riau, 2008–2012

Crops	2008		2009		2010		2011		2012	
	Ha	Tonnes	Ha	Tonnes	Ha	Tonnes	Ha	Tonnes	Ha	Tonnes
Wetland paddy	120,849	433,855	127,522	478,343	131,263	507,370	123,038	481,911	117,649	453,294
Dryland paddy	26,947	60,405	21,901	53,086	24,825	67,494	22,204	53,877	26,366	58,858
Maize	21,397	47,959	25,016	56,521	18,044	41,862	14,139	33,197	13,284	31,433
Cassava	4,625	50,772	4,379	68,046	4,237	75,904	4,144	79,480	3,642	88,577
Soybeans	4,319	4,689	4,906	5,298	5,252	5,830	6,425	7,100	3,686	4,182
Peanuts	2,412	2,240	2,023	2,020	2,188	2,007	1,819	1,692	1,732	1,622
Sweet potatoes	1,429	11,330	1,230	9,736	1,252	9,967	1,203	9,912	1,137	9,424
Mung beans	1,577	1,688	858	1,014	1,140	1,228	938	995	865	920

Source: BPS – Statistics of Riau Province (2014)

Oil palm is the major estate crop in terms of area and production (Table 3.6). Its area has increased from 1,673,500 ha in 2008 to 2,372,400 ha in 2012, a 41.8% increase in area that has resulted in a 27.3% increase in the tonnage of oil palm fruit harvested in the same period. The other two major plantation crops are coconut and rubber, which have been relatively consistent in terms of area between 2008 and 2012—although in both cases production have declined. In 2012, they accounted for 22% (coconut) and 21.2% (rubber) of the equivalent area under oil palm.

Table 3.6. Major plantation crops in Riau, 2008–2012

Crops	2008		2010		2012	
	ha	Tonnes	ha	Tonnes	ha	Tonnes
Oil palm	1,673,551	5,764,201	2,103,174	6,293,542	2,372,402	7,340,809
Coconut	553,657	575,612	525,398	495,306	521,792	473,221
Rubber	528,655	409,445	499,490	336,670	500,851	350,476
Sago	69,917	171,594	81,841	291,665	82,713	281,704
Areca nut	11,377	5,805	18,078	9,402	19,005	10,818
Cacao	6,420	4,076	6,688	3,321	6,363	2,607
Coffee	7,978	3,244	4,325	1,416	4,862	2,513

Source: BPS – Statistics of Riau Province (2014)

Scholz (1987) mapped land potentials in Sumatra in 1983 and classified the island into seven agro-ecological zones (AEZs) (Figure 3.3). More contemporary mapping by Suryani (2013) also divides Sumatra into seven AEZs based on slope, land resource characteristics and climate (Table 3.7). These seven AEZs comprise three for food crops and horticultural commodities, and four for forestry, plantations, fisheries and pasture.

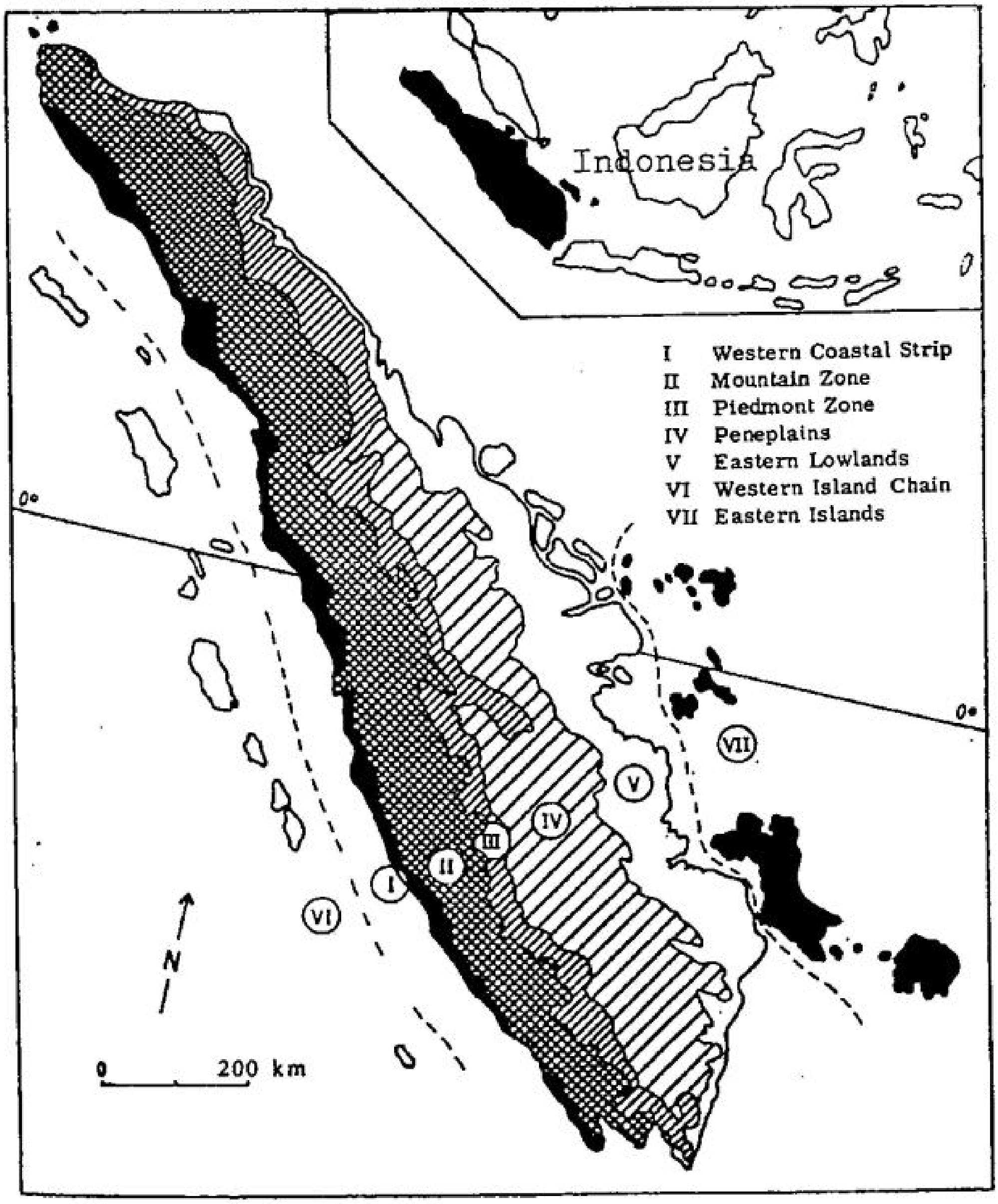


Figure 3.3. Agro-ecological zones in Riau Province

Source: Scholz (1987)

Table 3.7. Contemporary agro-ecological zones in Riau

Zone	Description	Land use type	Agriculture (ha) (63% of total Riau's area)	Non-agriculture (ha) (37% of total Riau's area)
I	Slope of > 40%	Forestry, production forest, protected forest	-	146,033
II	Slope of 15–40%	Plantations/ perennial crops	922,400	-
III	Slope of 8–15%	Perennial crops, food crops	1,109,687	-
IV	Slope of < 8%	Food crops	2,459,634	-
V	Slope of < 8% in peatlands	Thickness < 3m: perennial crops, horticulture; > 3m: non-agriculture	1,261,322	2,690,809
VI	Slope of < 8% on acid sulphate soils	Mangroves and fisheries	-	275,290
VII	Slope of < 8% on spodosols and quartz sands	Forestry, pasture	-	108,561
Others	Escarpment, settlement, water bodies, and mines		-	205,097

Source: BBSDLP (2013)

In 2003, 44% of land in Riau was forest, while non-forest uses covered 56% of the province (BKPM 2011). Forests may include upland primary and secondary forests, as well as peat swamp and mangrove forests. Secondary peat swamp forests dominate the forest area. Non-forest areas may consist of shrublands, plantations, agriculture, fishponds, settlements, mines and open spaces. Plantations dominated these land uses in 2003. These data can be compared to more recent statistics (Table 3.8) that quote a forest area of 70.6%, and non-forest land areas covering < 30% of the province. In terms of type of land, approximately 75% of total land in Riau falls into wetland categories, while the rest is dryland (non-flooded uplands; 25%) (BPS - Statistics of Riau Province 2014).

Table 3.8. Land use in Riau, 2011

Land use category	Total land (ha)	Percentage
Food crops (excluding vegetables)	173,910	1.4
Vegetables	21,972	0.2
Plantations	3,394,327	27.9
Forests	8,598,757	70.6

Source: BPS—Statistics of Riau Province (2014)

A recent study by Ramdani and Hino (2013) attempts to further classify land use in Riau into seven classes: cultivated land, oil palm plantations, other plantations (e.g., rubber and industrial forest plantations), forest (including primary, secondary, wetland and mangrove), oil and gas fields, settlements and water bodies (rivers and lakes). They estimate that the tropical rainforest area was reduced from 63% in the 1990s to 37% in the 2000s—a reduction of 27%—while in 2012 it covered only around 22% of the province. The proximate causes of the decline were related to the transmigration policy, changes from forest to agriculture, and from forest and agriculture to plantations, mainly oil palm and rubber. The expansion of oil palm in Riau moved from the western part of the province to the east, where most peatlands were located, during this period (Ramdani & Hino 2013). The discrepancies in deforestation rates in Riau Province in the studies referenced and statistics most likely result from the different methods of assessment used, biases reporting, slightly different areas being studied, or different time frames being considered.

3.2.3 Human dimensions

3.2.3.1 Recent political geography

On 9 August 1957, Central Sumatra Province was divided to become West Sumatra, Riau and Jambi Provinces. At that time, Riau Province included the neighbouring Riau and Lingga archipelagos, as well as the Anambas, Tambelan and Natuna island groups between the Malay Peninsula and north-western Borneo. Those island territories were separated administratively from mainland Riau in 2002 to become Riau Islands Province.

The provincial capital was originally at Tanjung Pinang, but in 1962 it was moved to Pekanbaru. At the time of its formation, Riau was virtually without any modern infrastructure. For example, the only road was that between Bukittinggi (the former capital of Central Sumatra Province) and Pekanbaru, a distance that then could take up to two or three days to drive by car, and was often impassable in the rainy season (Esmara 1975).

3.2.3.2 Population

According to the 2010 census, the population of Riau was then 5,538,367; according to estimates, by 2013 this had risen to 6,125,283 (Table 3.9) (BPS - Statistics of Riau Province 2014). The sex ratio is 106, meaning that there are 6% more males than females. The population growth rate from 2000 to 2012 was 3.59, well in excess of the national rate of 1.49 (BPS - Statistics of Riau Province 2014). The population density was 62 inhabitants/km^2 in 2010, with most living in Pekanbaru. The major ethnic groups are Melayu (Malay), Minangkabau, Jawa, Batak, Bugis, Tionghoa and Arab (Ramdani & Hino 2013).

Table 3.9. Riau population by region, 2010–2013

District	2010	2011	2012	2013
Bengkalis	498,336	516,348	530,191	543,857
Dumai	253,803	262,976	271,522	280,027
Indragiri Hilir	661,779	685,698	689,938	697,814
Indragiri Hulu	363,442	376,578	388,916	401,201
Kampar	688,204	713,078	739,655	766,351
Kepulauan Meranti	176,371	182,662	183,135	183,912
Kuantan Singingi	292,116	302,674	310,060	317,265
Pekanbaru	897,767	930,215	964,558	999,031
Pelalawan	302,129	312,738	332,075	352,207
Rokan Hilir	551,708	573,211	595,695	618,355
Rokan Hulu	474,843	492,006	517,577	543,857
Siak	376,742	390,359	405,850	421,477
Total	5,538,367	5,738,543	5,929,172	6,125,283

Source: BPS - Statistics of Riau Province (2014)

National transmigration programme

The national transmigration programme has had major influences on population growth and land use change in Riau. The programme began in the Dutch colonial era in 1905 and continued after independence, in particular between 1968 and

1988 (Fearnside 1997). During this time, transmigration programmes aimed to fulfil the demand for labour in low population areas (outside Java) to enable development (Jelsma, Giller & Fairhurst 2009). Importantly, it was also aimed at promoting national integration and security (Hoshour 1997). However, the programme has also been acknowledged as an important driver of forest loss in Indonesia (Fearnside 1997).

The government recruited volunteers from Java to join the transmigration programme and the government provided them with land and they became smallholders in the Nucleus Estates and Smallholders (NES) scheme. Although transmigration appeared to have finished in Indonesia after the fall of Suharto regime in 1998 and decentralisation in 2001, the rapid growth of oil palm plantations in the last decade has led to renewed calls for transmigration, and large areas of forest have been converted into agricultural land and oil palm plantations under contemporary transmigration programmes, especially in Kalimantan (Potter 2012).

Susanti and Burgers (2011) describe the development of transmigration projects in Riau Province. The first, which was associated with mining, was in the early twentieth century. The second occurred in the early 1970s, when forest concessions and large-scale forestry industries were being formed, bringing a large influx of migrants (Figure 3.4). From 1969 to 1973, 500 households joined the transmigration programme to Riau; this increased to 3,200 families between 1974 and 1978. The establishment of industrial forest plantations and the pulp and paper industry in the 1980s saw yet another influx of migrants to satisfy the demand for labour. The special transmigration project for oil palm plantation began in the 1980s (Jelsma, Giller & Fairhurst 2009). Subsequently, the number of transmigrants to Riau climbed to 35,626 households between 1979 and 1983, reaching a peak of more than 20,000 households between 1988 and 1989. When the forest business began to decline as a result of illegal logging and forest infringement, oil palm became a viable livelihood alternative, and the establishment of oil palm plantations spread rapidly among transmigrants who had settled in Riau to work in the forestry sector. The rapid expansion of these plantations triggered another influx of migrants, most of whom were spontaneous, seeking employment opportunities and better livelihoods (Hoshour 1997). Based on the 2010 census, about 15.5 million transmigrants have entered Sumatra, and about 1.4 million of these live in Riau.

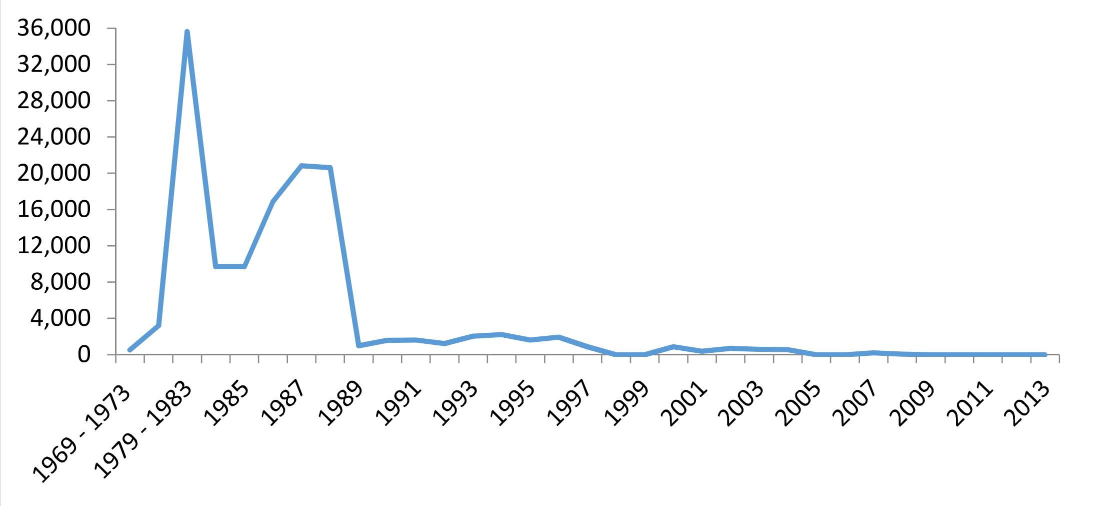


Figure 3.4. Number of new transmigrant households per year in Riau, 1969–2013

Source: Ministry of Manpower and Transmigration (2014)

3.2.3.3 Economic development

Riau is largely a resource-based economy. The province is rich in natural resources: oil and gas, forested land for agricultural development, and wildlife and fish. In 2011, the province's economy grew at a rate of 5.01% (including oil and gas), though this was below the national economic growth rate (6.46% including oil and gas) (Bappeda Riau 2012). However, when these economic growth rates are calculated without the oil and gas sector for the same year, Riau grew at 7.63%, above the national average growth rate of 6.95%. Building construction was the leading sector in the provincial economy, contributing 12.77% in 2011, followed by trade, at 10.09%. The agricultural sector contributed only 3.88% to Riau's economic growth.

Compared to other provinces in Sumatra (with the oil and gas sector included), the province's economic growth was the lowest of the ten provinces on the island. However, with oil and gas excluded, Riau's economic growth was the second highest at 7.63%, lagging only slightly behind South Sumatra, at 8.03% in 2011.

Fossil fuel exploitation in Riau began at the beginning of the twentieth century (Uryu et al. 2008) and has been Riau's main income source since then, contributing up to 50% of GDP (BPS - Statistics of Riau Province 2014). Crude oil is the dominant product in this sector Riau (Table 3.10).

Table 3.10. Mining production in Riau by commodity, 2010–2013

Mineral	Unit	Production			
		2010	**2011**	**2012**	**2013**
Crude oil	Barrels	133,590,634	144,049,484	135,474,058	126,556,612
Natural Gas	Thousand MSCF	3,077,608	6,083,885	5,716,756	10,960,322
Coal	Tonnes	2,741,023	1,952,958	1,885,041	2,057,140

Source: BPS—Statistics of Riau Province (2014)

Besides the economic development of oil and gas, agriculture is a major occupation for most people in Riau, with rice, maize and plantation tree crops being the main foci. Nearly 45% of the labour force is employed in the agricultural sector (BPS - Statistics of Riau Province 2014). This includes people involved in cash crop cultivation, estate crops, livestock production, fisheries and forestry; and in large-scale and small-scale agro-enterprises (BPS - Statistics of Riau Province 2014).

3.2.4 Land issues

3.2.4.1 Basic principles and history of land rights in Indonesia

A key theme in this research is land ownership and management, and therefore, a background to this area is provided at this juncture. Local indigenous laws had a major role in governing land rights in Indonesia during the Dutch colonial period (Biezeveld 2004). The Dutch colonial government passed the Agrarian Act in 1870, which took effect in Java and Madura, and prohibited non-Indonesians from using cultivated land owned by Indonesians, and only allowed them to lease land. In the outer islands, separate acts were issued, such as the Sumatran Domain Declaration in 1874 (Biezeveld 2004). The main objectives of the regulations were to encourage private businesses to invest in agricultural activities, and to lease indigenous-owned land to private parties.

Since independence, the Indonesian Government has attempted to develop a new land tenure system to replace the colonial laws. These changes have involved converting the prevailing colonial land rights into individual legal land rights, which are executed through private and state control processes (Daryono 2010). The private approach reduced government involvement, thus simultaneously reducing transaction costs, though state control protected lands from fraud by non-state agents and enhanced wider community interests. The most important existing legislation on land rights in Indonesia is the Basic Agrarian Law (BAL) No. 5 of 1960. This aims to provide a uniform land tenure system by transforming colonial land rights, customary land rights and state land rights into a unified statutory title, and safeguarding the existing property rights. This law comprises several land rights, the most pertinent of which are:

1. Rights to land (*Hak Milik*);
2. Rights of use (*Hak Pakai*);
3. Rights of building (*Hak Guna Bangunan*); and
4. Rights of exploitation (*Hak Guna Usaha*).

Only Indonesians can be granted rights to land, while overseas residents with dual citizenship are permitted to have rights of use, rights of building and rights of exploitation for, at most, 20 years. Other overseas citizens are allowed to have rights of use only.

However, the implementation of this law is still vague in practice. This is particularly so in rural areas, where traditional indigenous customs often still prevail. Problems occur in particular in land tenure arrangements and governance issues (Fitzherbert et al. 2008). Daryono (2010) argues that this is mainly due to a flawed legal structure and only partial administrative functionality.

The ambiguity of the BAL is that it stipulates that the customary law (*adat*) may play a role in regulating agrarian law, as long as it is in line with national interests. Customary land law is an approach to land rights regulation based on communal ownership, which means that anyone who wants to use land requires the consent of the community that holds that land. Hence, the government has authorised the rights of local villagers to use natural resources, such as land, in the public interest (Biezeveld 2004). However, customary law is limited by Article 33.3 of the Indonesian Constitution of 1945, which states that ‘all natural resources, land, water, and air, are managed by the government and exploited for the public interest'. In many situations, particularly in rural regions, the government provides for the public interest by challenging customary rights. An added complication is that the exact nature of customary law differs from one tribe to another (USAID 2010). It is these aspects of customary law that contribute to land disputes and property rights insecurity in Indonesia.

Sectoral laws have also been issued in Indonesia, which also interact with customary land rights in rural areas. It seems that customary law should gradually be adjusted 'into' the national law (Land Academy 2012). Even though the BAL apparently controls all types of land in Indonesia, in actual fact it does not control forests (USAID 2010). This is very important, because 48% of Indonesia (88.5 million ha) is covered by actual forest. In fact, government control in one form or another accounts for approximately 70% of terrestrial land in the form of forests (Land Academy 2012), which includes all non-agricultural land (USAID 2010). Most forested land in Indonesia is classified as state forest and is managed by the state through the Ministry of Forestry. The law that governs forests was initially Law No. 5 of 1967, but this has been superseded by Law No. 41 of 1999. Together with Mining Law No. 4 of 2009, the forestry law does not apply customary law for the land rights of communities living in forested areas or on mining concession areas (USAID 2010).

Another regulation, Plantation Law No. 18, was passed in 2004. This law also restrains customary rights in terms of land assets for plantation businesses (USAID 2010). Applicants for these rights are required to negotiate with the holders of customary rights together with any other land rights holders in order to reach a deal regarding land surrender and the division of rewards. This law limits the power of local communities to employ their customary rights to exploit natural resources.

As the pressure for government decentralisation mounted after the 1998 economic crisis, Regional Government Law No. 22 was passed and ratified in 1999. This was later revised as Law No. 32 of 2004. In response to the demand for coordination of land management, the Spatial Planning Law (Law No. 26 of 2007) was issued to harmonise with the regional autonomy laws and specify provincial and district government authority in the management of spatial planning.

Oil palm is not a destructive crop (Colchester et al. 2006), and it has been cultivated as an economic base for rural livelihoods in parts of Africa for many decades. It becomes problematic when it is grown without recognition for local land rights and freedoms (Colchester et al. 2006). In particular, during the new order regime (from 1966 to 1998), the repressive political leadership abused their power, resulting in severe hardship in the indigenous communities, as local people simply could not negotiate access to land resources. It is evident that in the post-reform era of mid-1998, local people strived to create land tenure conflicts around the issue of oil palm plantation businesses (McCarthy 2007; Suyanto 2007). As small landholders, the indigenous people repossessed land using fire, burning vegetation to regain their land entitlements.

3.2.4.2 Forest conversion, agro-ecosystems and land tenure

The development of industrial timber plantations in Indonesia was part of the Five-Year Plan (*Rencana Pembangunan Lima Tahun* [REPELITA] IV) in 1984. By the end of October 1998, 5.6 million ha of land had been allocated to establish timber plantations; however, by 1999–2000, only 2.4 million ha (less than 50% of the land area allocated) had been planted. Similarly, there was rapid development of oil palm plantations in Indonesia (Casson 2000), their area increasing from 120,000 ha in 1969 to almost 3,000,000 ha in 1999.

The allocation of land for plantation developments has often been undertaken without recognising the rights of local people who occupy and use the land. Since the start of the political reformation period in Indonesia in 1998, the manifestation of land tenure conflicts between local communities and large companies has increased (Suyanto et al. 2004). There are increasing visual signs of violence and burning of property, as companies are no longer able to rely on armed security to suppress the unrest.

Even forest fires have been used to force local communities from their land (Tomich et al. 1998). The resulting feeling of perceived injustice by smallholder farmers decreases their incentive to control the spread of fire onto large-scale tree plantations (Suyanto et al. 2004). As a consequence of land tenure conflicts, local communities frequently burn plantation-grown trees that have been established by large companies (Suyanto et al. 2004). The role of fire is not only political, as it is commonly used in land clearing for oil palm and timber plantations because it is cheap and effective (Tomich et al. 1998). Barber and Schweithelm (2000) and Suyanto et al. (2004) show that the development of oil palm and timber plantations contributed significantly to fire and smoke problems in Indonesia that have affected other South East Asian countries.

3.3 Oil Palm Development in Riau

Since the 1970s, the Indonesian Government has stimulated oil palm expansion in various ways, but initially through plantations. Until the early 1980s, oil palm was the only plantation commodity produced on large-scale plantations in Indonesia. Initially, the government played a direct role in stimulating investments in oil palm plantations through state agencies (such as institutional support, agricultural extension, access to land and capital), and plantation development policies were carried out in close affinity with other policy objectives, namely (i) population redistribution through the transmigration policy to stimulate the development of the outer islands, and (ii) revitalising the, by then, huge transmigration settlements that had often failed to produce more than rice and subsistence crops (Zen, Barlow & Gondowarsito 2006).

Since the early 1980s, Riau Province has become the primary target for oil palm plantation development as part of Indonesia’s agricultural development policy. The first large-scale oil palm plantation was established in Rokan Hulu District by the PTPN V (*Perseroan Terbatas Perkebunan Nusantara V* – Nusantara V Plantation Limited Company), a state-owned estate company (Budidarsono, Susanti & Zoomers 2013).

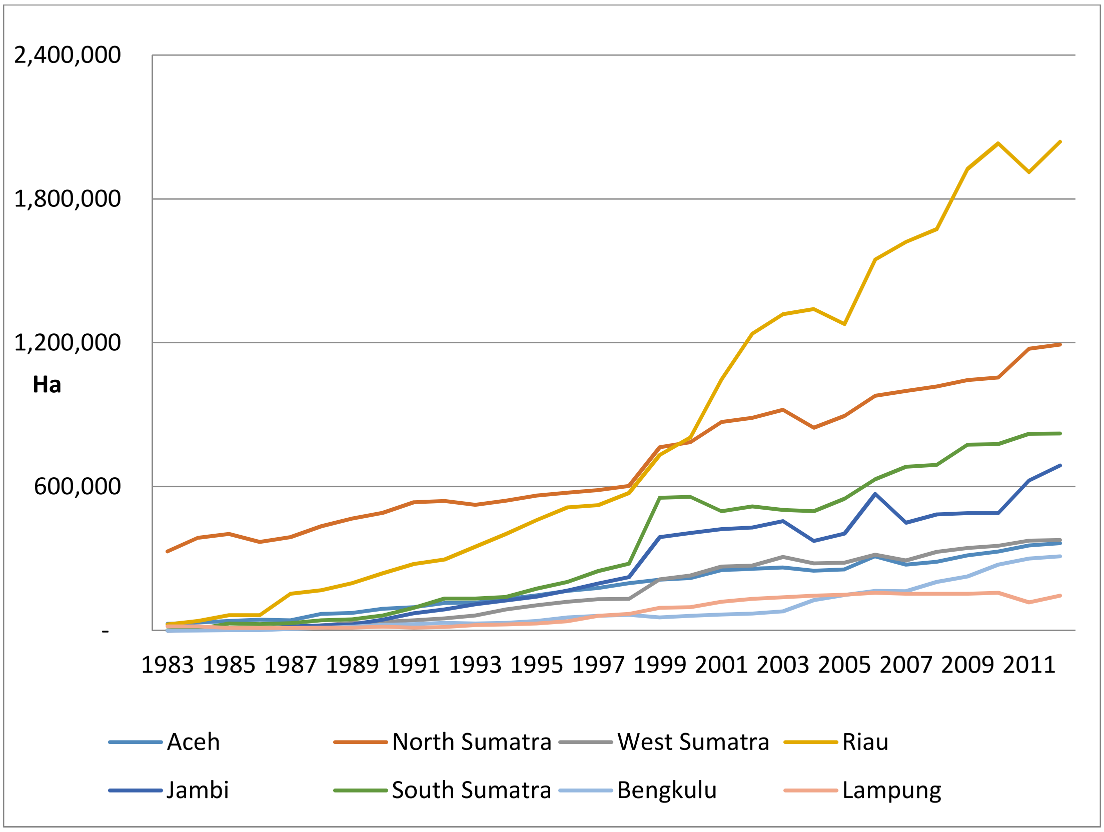


Figure 3.5. Oil palm area development in Sumatra, 1983–2012

Source: Ministry of Agriculture (2014)

Oil palm is grown in 23 provinces in Indonesia; more than 62% of the oil palm grown in Indonesia is in Sumatra (Section 2.2.5). North Sumatra was the first province in which it was grown. The expansion of oil palm plantations to other provinces, including Riau, promoted by the state-owned company, began in the 1980s. In less than two decades, Riau had overtaken North Sumatra as the leading province in palm oil production (Figure 3.5). Riau Province currently has the largest oil palm area and production in Indonesia, comprising around 21.2% of Indonesia's oil palm area and approximately 25% of national crude palm oil production.

The rapid expansion of oil palm plantations has been in line with the economic attractiveness and profitability of this perennial crop. Smallholders are increasingly becoming the dominant group among the owners of Riau's oil palm area, contributing to an increasing growth of production (Figure 3.6). The area of oil palm under different forms of smallholder tenure and the associated production has risen dramatically from 263,000 ha (32.7% of the total area under the crop in Riau in 2000) to 1.3 million ha (61.2%) in 2013. Production has increased in response to this, rising from 492 thousand tonnes of crude palm oil (29.6% of total oil palm production in Riau) in 2000 to 3.5 million tonnes (54.1%) in 2013. Smallholders benefit from a direct link with the plantation companies through the NES scheme, which provides technical assistance, good planting material, fertilisers and delivery contracts. This is discussed further in Chapter 5.

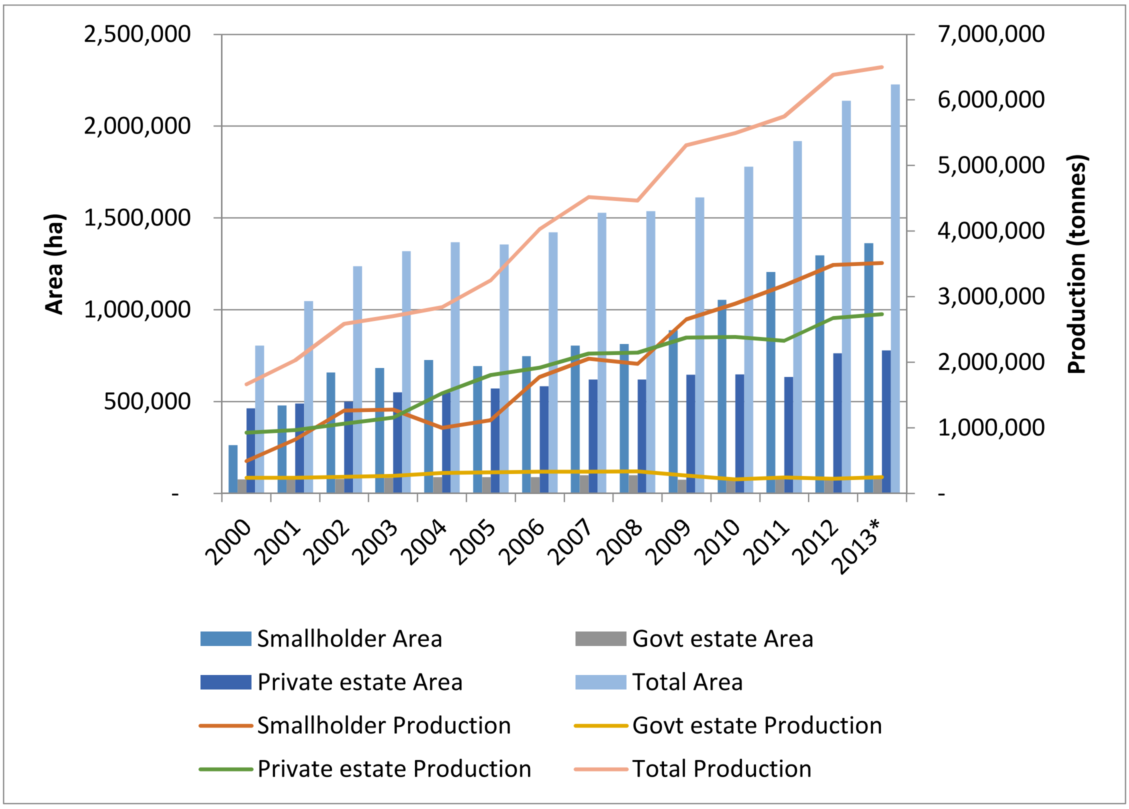


Figure 3.6. Oil palm area and production by producer type in Riau

Note: *2013 is a preliminary figure. Source: BPS - Statistics Indonesia (2014a); Chalid (2011)

3.4 Summary of Chapter

This chapter introduces Riau Province by describing salient characteristics of its landscape, economy and land issues pertaining to oil palm agriculture. The following chapter will discuss the research design and methodological elements of the study.

CHAPTER 4:
RESEARCH DESIGN AND METHODS

4.1 Introduction

This chapter presents the research project design and the methods I used to address the objectives of the study (Section 1.2). It begins with a description of the conceptual framework that underpins and guides the study. This is followed by a description of the research setting (see also Chapter 3) as it pertains to the sampling framework I used for data collection (Section 4.3). A discussion and justification of the methods I used to collect data follows (Sections 4.4–4.6) along with a discussion on the analytical methods used (Section 4.7). Ethical considerations are outlined in Section 4.8, and the chapter is summarised in Section 4.9.

4.2 Integrated Conceptual Frameworks

This study investigates sustainability in oil palm-dominated landscapes, and in doing so it attempts to characterise and assess the value of the ES underpinning oil palm-dependent households in rural areas of Riau. The two main concepts discussed in Chapter 2—ES and sustainable rural livelihoods—provide a basis leading into the conceptual models that respond to the study's objectives. Combining these approaches into a conceptual framework for the study is an essential component of the research, and is described in the following sections.

The combination of the concepts described above into a constructed framework provides an integrated research framework for the study to assist in the process of interpreting the findings. Figure 4.1 illustrates the integrated conceptual framework for livelihoods and ES in oil palm-dominated landscapes. This includes the central construct of sustainable livelihoods (DFID 1999) and is informed by the construct of the ES approach (MEA 2005).

Oil palm cultivation occurs in landscapes that have many potential ways to support rural livelihoods and provide ES. Oil palm landscapes therefore have the potential to provide important ES that have economic value. However, the production of oil palm has trade-offs, called ecosystem dis-services, which diminish other ES. These trade-offs interact with each other. The significant contributions of ES provide by the cultivation of the oil palm plantations have improved well-being of the rural people, whose livelihoods are often directly dependent on ES. At larger scales, oil palm dependent rural livelihoods contribute to provincial to global-scale economies. Meanwhile, ecosystem dis-services have impacted the ecosystems of the area where oil palm is cultivated. The ecosystem dis-services that can be attributed to oil palm production have placed costs on local- to global-scale economies as well. As the areas under oil palm have grown, the impacts of the related ecosystem dis-services on the environment have increased locally and globally.

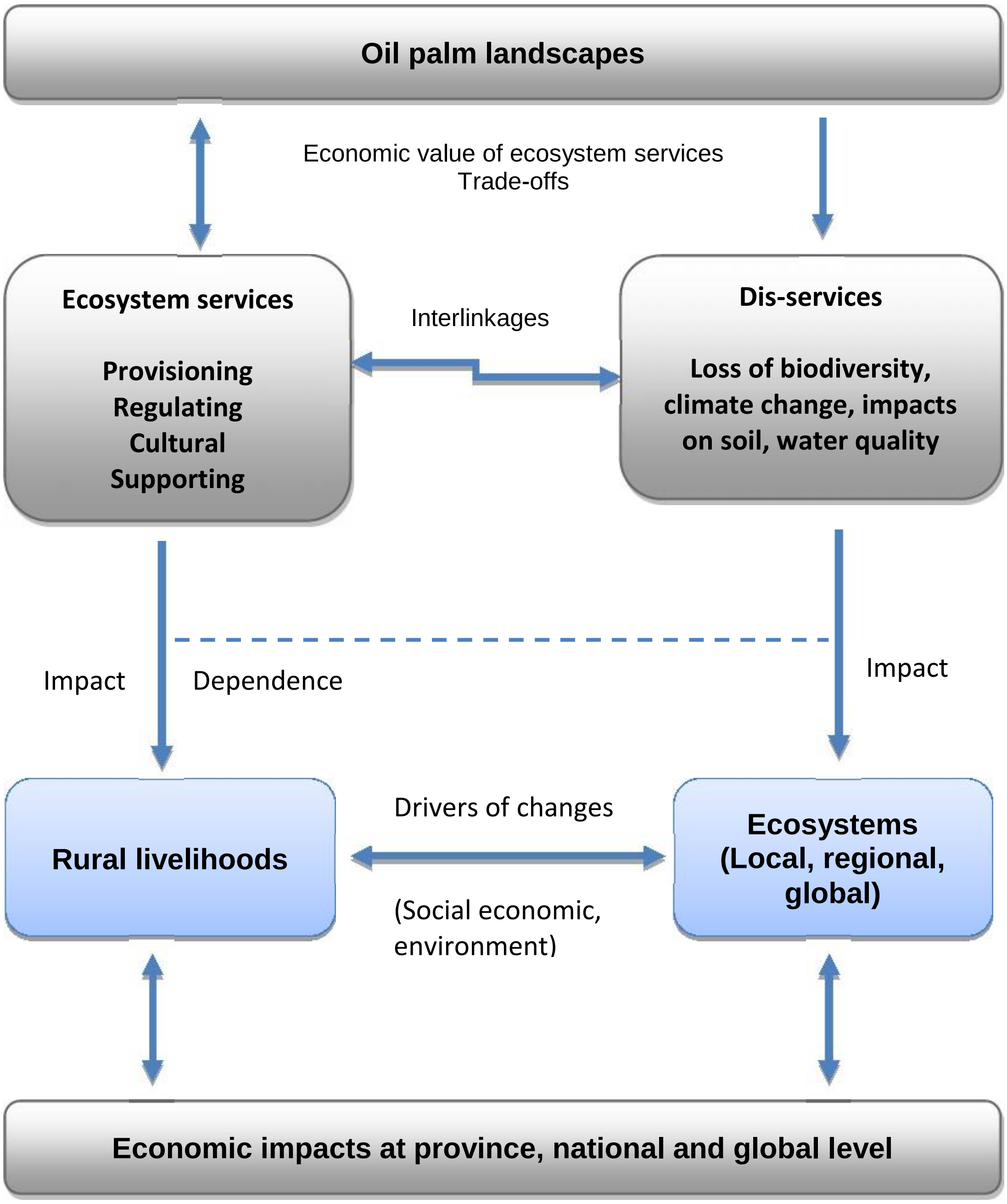


Figure 4.1. Integrated research framework

4.3 Project Design and Sampling

The main data collection method used in the research was a questionnaire administered to rural households in Riau Province, and semi-structured interviews with key informants in business in the oil palm sector, conservation organisations and government departments. Issues around sample design and administering the questionnaire are presented in Section 4.3.1, while methodological considerations for the interviews are discussed in Section 4.3.2.

4.3.1 Sample design for household survey

Sampling is a way of obtaining information about a relatively small part of a larger group or population so that inferential generalisations about the larger group can be made (Rice 2010). In survey research, sampling is a key issue, because the selected respondents can have a significant impact on the results (McLafferty 2010). I applied a two-stage purposive sampling scheme to select the study sites (hereafter 'villages') and then the households within the villages.

4.3.1.1 Stage one sampling: Villages

This study was conducted in Riau, the province with the largest oil palm area in Indonesia (21% of the Indonesian oil palm estates; Section 3.3). In the first stage of sampling, four oil palm-dominated communities were selected using a purposive sampling frame based on the agro-ecological zonation of Riau Province (Scholz 1987) (Section 3.2.2).

As oil palm plantations are of limited extent in the mountainous spine of Sumatra in western Riau (i.e. the mountain AEZ; Figure 4.2), the areas sampled were in the piedmont (one village), on the peneplains (two villages) and in the eastern lowlands (one village). Consequently, these four study sites are situated on an approximate east–west transect across central Riau, and are characterised by different landscapes, migration patterns and land use histories (Table 4.1).

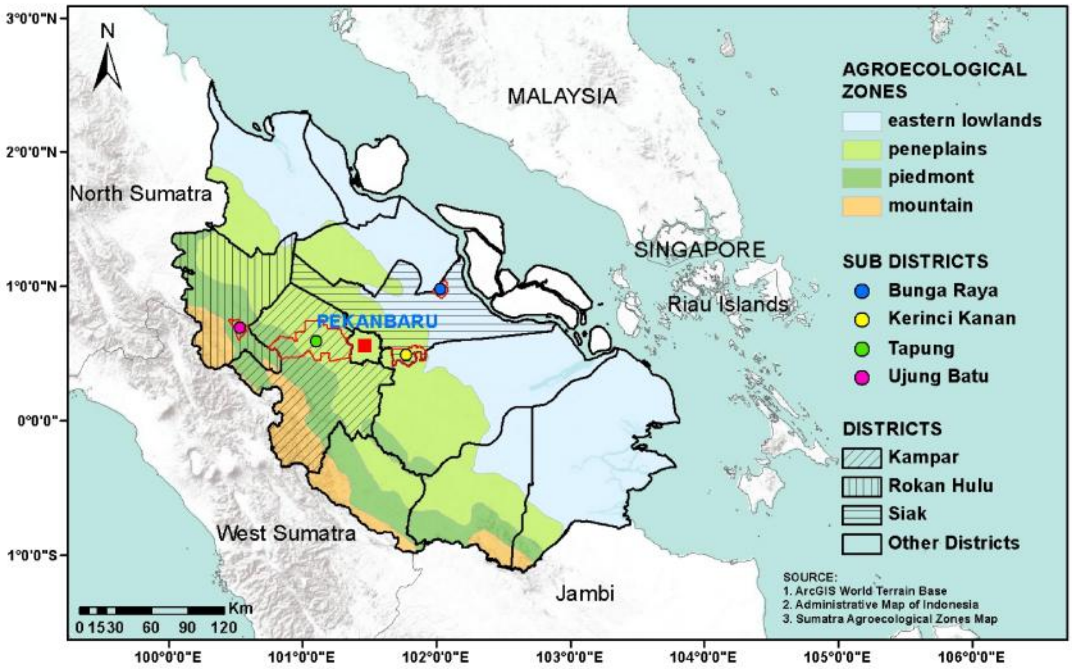


Figure 4.2. Riau Province, showing agro-ecological zones (after Scholz 1987), districts, subdistricts and villages researched

Table 4.1. Basic information, landscape characteristics, and migration and land use histories of surveyed villages

	Ujung Batu	Tapung	Kerinci Kanan	Bunga Raya
No. of respondents	12	20	15	26
Population (2013)[1]	48,925	92,977	23,952	22,454
AEZ	Piedmont	Peneplains	Peneplains	Eastern lowlands
Migration history	Trading centre with inter-provincial migrants (Sumatra)	Long established population, transmigrants in surroundings	Initial settlers were transmigrants who cultivated oil palm	Initial settlers were transmigrants who cultivated rice
Land use history in the context of OP	OP cultivation established around state-owned plantation in the 1980s	Timber production areas converted to OP in the late 1990s. Strong influences of a nearby private OP estate	Primary forest cleared for transmigrant settlement in the early 1990s	Peat swamp forest cleared for transmigrants in the 1980s. The rice farms began to be converted to OP in the 2000s

Source:[1] BPS—Statistics Indonesia of Rokan Hulu, Tapung, Kerinci Kanan, and Bunga Raya (2014); note OP: oil palm

To provide further context for the sampling scheme, Figures 4.3–4.6 provide image maps of the four sites drawn for Google Earth imagery, and Figures 4.7–4.10 are representative photographs of the landscapes in each community.

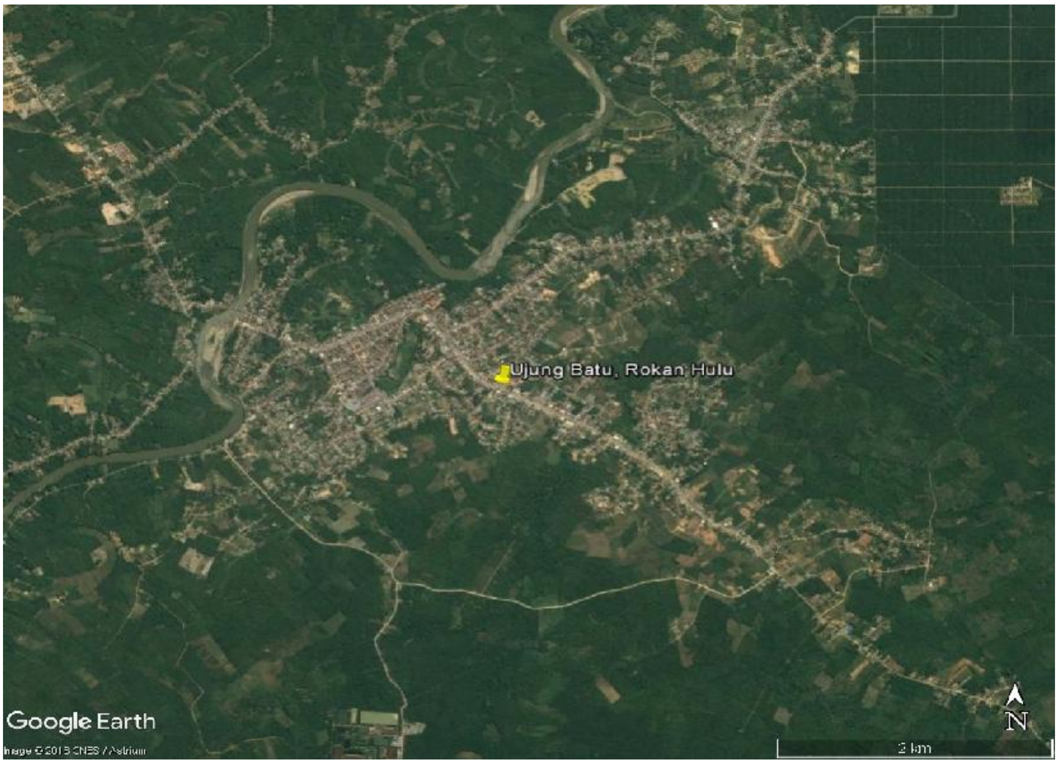


Figure 4.3. Ujung Batu (Google Earth imagery)

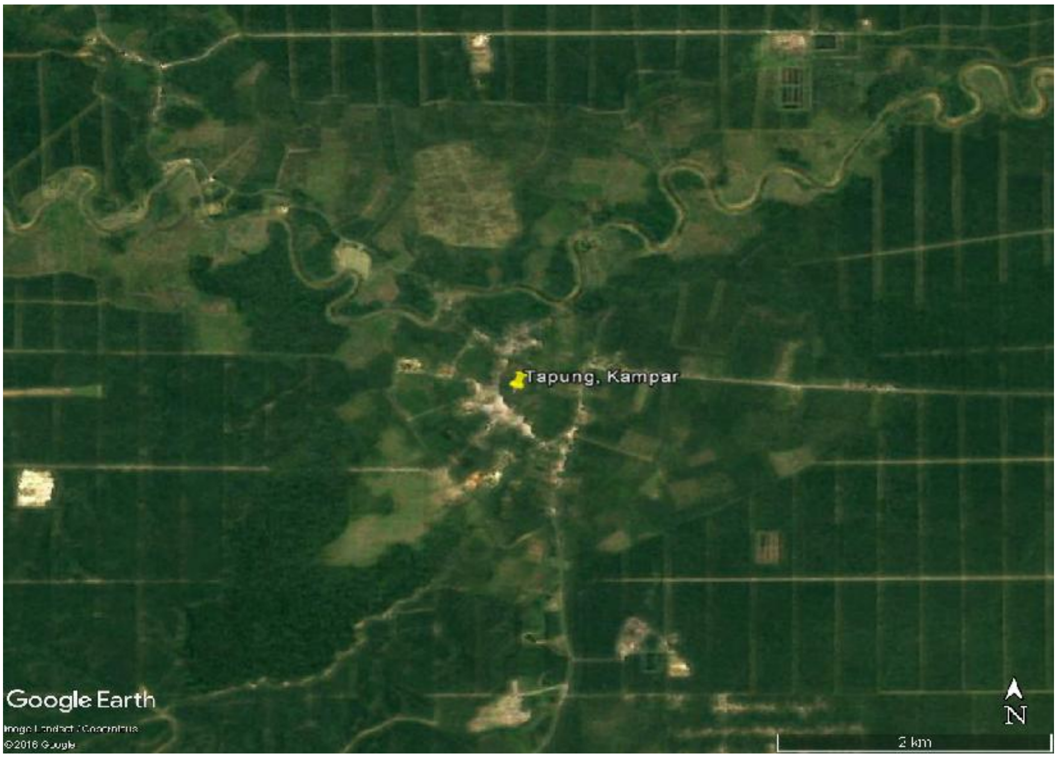


Figure 4.4. Tapung (Google Earth imagery)

Figure 4.5. Kerinci Kanan (Google Earth imagery)

Figure 4.6. Bunga Raya (Google Earth imagery)

Figure 4.7. Oil palm landscapes in Ujung Batu

Note the hilly terrain. Source: Ando Aulia

Figure 4.8. Oil palm landscapes at Tapung

Note the undulating terrain of the peneplains AEZ. Source: Ando Aulia

Figure 4.9. Oil palm landscapes in Kerinci Kanan

Note the undulating terrain. Source: Ando Aulia

Figure 4.10. Oil palm landscapes in eastern lowlands near Bunga Raya

Note the near level terrain, the high water table and the dark brown water in the drainage channel caused by the high humus content of the peaty soils. Source: Ando Aulia

4.3.1.2 Stage two sampling: Households

Household selection was initially a purposive element in the sampling framework. The research participants selected in each village were households of farming families who made at least part of their living from oil palm activities. This could be through owning land on which oil palm is grown, by selling oil palm fruit, or simply by working on an oil palm plantation or a neighbour's farm.

As the total population to be sampled was uncertain, I used purposive sampling to recruit participants for individual interviews. A local contact person (Table 4.2) helped to identify the households in the sites to be interviewed. I planned to sample at least 30 respondents over two weeks at each study site. I expected this number of questionnaires to show variations in within the population. However, due to logistical constraints (Section 4.5.2), I had to chose respondents according to a convenience sampling framework. Convenience sampling is a non-probability sampling technique, where respondents are selected due to convenience in terms of accessibility and proximity to the researcher (Creswell 2014; Rice 2010). Only respondents who agreed to participate in this study were interviewed. In total, I sampled 75 households across the four villages; however, two respondents were excluded as their households no longer had active roles in the oil palm sector.

Table 4.2. Local persons involved in recruitment processes

Study site	Position of local contact	Process of identification of local contact person
Ujung Batu	Oil palm farmer	I met this person in Ujung Batu during my first visit to this village.
Tapung	Business owner	I knew this person prior to the beginning of the study; he was a former neighbour in Pekanbaru.
Kerinci Kanan	Village head	I met this person in Kerinci Kanan during my first visit in this village.
Bunga Raya	Oil palm farmer	I was introduced to this person by a friend in Pekanbaru.

4.3.2 Interviews

I used a combination of passive and active strategies to recruit organisations (and participants within the organisations) to be interviewed. I began by contacting potential participant organisations by email, with an information sheet as an attachment (Appendix 4B). I chose this strategy because of the geographical distance between Adelaide, where I began the recruitment process, and Indonesia, where the organisations are located and where the interviews took place.

The organisations that I initially contacted by email were selected from three categories of organisations based on their position in the debates around the environmental record of the oil palm industry. These three categories were: (a) companies active in the oil palm business sector in Riau (identified in the current Oil Palm Plantation Directory); (b) central and local government agencies and departments related to palm oil industry; and (c) NGOs focusing on environmental conservation or development (identified from the Indonesian NGO portal). All were stakeholders in oil palm and/or development in the region, or in Indonesia specifically; and all organisations selected had to have at least commented on or been active in Riau Province at some time.

The next step in the recruitment process was to meet the potential participants after I had arrived in Indonesia. Prior to my visit, I had provided the participants with a 'participant's information sheet' (Appendix 4C) and a letter of introduction (Appendix 4D), which provided details of the study and contact details for myself, my supervisors and the executive officer of Flinders University's Social and Behavioural Research Ethics Committee, as per standard Australian research ethics guidelines. Before the interviews began, participants provided written consent by completing a consent form (Appendix 4E).

4.3.3 Participants

Participants in this study are divided into two groups: (i) households, and (ii) stakeholders in industry, government and conservation. A total of 73 households were surveyed in four villages in Riau Province. These comprised 12 households in Ujung Batu, 20 households in Tapung, 15 households in Kerinci Kanan and 26 households in Bunga Raya. The types of stakeholders interviewed in this study are listed above: eight government officials, five members of NGOs and three business organisations.

4.4 Data Collection

4.4.1 Justification of methods used

In line with the overarching aim of this project to examine the oil palm landscapes of Riau using the ES and livelihoods concepts, I adopted a hybrid quantitative and qualitative research approach. Quantitative and qualitative field campaigns both yield explicit reports—the most popular types of data collected in human geography (Montello & Sutton 2006). The explicit reports I used in this research were a household survey instrument (to collect both quantitative and qualitative data) and interviews with key informants (primarily to collect qualitative data).

Definitions of quantitative and qualitative methods are necessary at this point. For quantitative research, the definition adopted by Creswell (2014) was used: an approach to investigating objectives by assessing the relationships between variables that can be measured. In this study, the quantitative instrument used was a household survey. Survey research provides 'a quantitative description of trends, attitudes, or opinions of a population by studying a sample of that population' (Creswell 2014). This instrument was deemed suitable and effective for this study for several reasons. Survey research (McLafferty 2010):

1. Is used to obtain an individuals' attitude and opinions about social and environmental issues;
2. Reveals complex behaviour and social interactions;
3. It provides evidence which is not available from published sources; and
4. It can be used as a primary means of collecting data on people and their characteristics.

Qualitative research methods are generally used to explore and understand the issues or problems under study directly in the field using the participants' experiences to capture 'a picture of the issue' under investigation (Creswell 2014; Limb & Dwyer 2001). Qualitative data adds in-depth understanding to research and allows researchers to explore anomalies or subgroups within the data, in combination with quantitative data, to deliver information that can describe a situation based on statistical analysis (Hesse-Biber 2010). Additionally, most exploratory studies—and it could be argued that the present research is 'exploratory'—use qualitative rather than quantitative methods, because they are attempting to gain new insight into themes that may be used by subsequent researchers (Neuman 2011).

4.4.2 Data types

Both primary and secondary data sources were employed in the present study. This is in line with similar studies on rural livelihoods, plantation systems and ES (Dewi, Belcher & Puntodewo 2005; Gross, Erickson & Méndez 2014; Rist, Feintrenie & Levang 2010; Sandhu & Sandhu 2014).

Primary data is suitable for use in this study, as its collection can be deliberately tailored to answer particular research questions (Montello & Sutton 2006). I gathered primary data to obtain more robust findings. Having accurate and relevant data is important in research attempting to provide appropriate answers to important questions. In many developing countries, Indonesia being a prime example, these data are often unavailable or incomplete. Collecting new primary data was necessary, in part, to overcome these issues in the present study. I collected primary data during a fieldwork campaign undertaken between December 2012 and March 2013. I collected these data through a household survey and semi-structured interviews with key informants.

The secondary data sources used in this study comprise statistical data from the BPS (Indonesia Central Statistics Agency) and reports from provincial government agencies, government ministries and NGOs.

4.5 The Household Survey

Household surveys are used extensively to gather data on the rural livelihoods (Angelsen et al. 2011). In the present study, I used a questionnaire as the household survey instrument. A questionnaire is a quantitative research tool that can, and in the present study does, include both closed and open-ended questions. The answers can subsequently be coded to produce numerical descriptions of the sampled population. In this study I used a cross-sectional structured questionnaire, aimed at generalising about a population from a sample.

Among the many strategies available for conducting questionnaire surveys, I chose to conduct face-to-face interviews with households. McLafferty (2010) notes that personal contact between an interviewer and a respondent often results in more meaningful answers and generates a higher rate of responses. In addition, from my experience as an interviewer, I found that I could ask questions in complex sequences, manage the long questionnaire, clarify vague responses, and review hidden meanings while administering the survey instrument. The questionnaire I used was specifically tailored towards understanding the livelihoods of the people living in the oil palm-dominated landscapes and assessing the economic value of ES in these areas.

4.5.1 Questionnaire structure

A draft of the questionnaire was developed in Adelaide as part of the ethics approval process (Section 4.6). The questionnaire was refined in early December 2012 after a pilot test in a few households in Kerinci Kanan, Bunga Raya and Tapung.

The survey panel approach I adopted involved household characteristics (18 questions); household activities and income generation (19 questions); oil palm cultivation (29 questions); other rural production activities (9 questions for each of the other crops grown and livestock on farm) and environmental issues (13 questions). The questionnaire is presented in Appendix 4F.

It took between 90 minutes and two hours to administer the questionnaire. This was longer than anticipated, but interviewees consistently wanted to expand on their answers, and as the questionnaires were not administered while they were working, they appeared content with this time burden. I administered the questionnaire myself in Bahasa Indonesia and recorded the answers in that language. From a personal standpoint, a key advantage of interviewing people myself was that it helped in formulating and memorising the main ideas of the interviews, sharpened my understanding of any issues with the data, and enabled me to identify initial key themes and categories of data as the interviews progressed.

4.5.2 Issues in administering the questionnaire

I encountered two main issues while administering the survey instrument.

Timing: Most targeted participants approached were busy during the day, as they were working in the plantations or in shops and offices. This limited the times when it was possible to meet with the participants. As a consequence, most meetings were held in the evening at the participants' houses.

Weather: Field data collection was undertaken between December 2012 and March 2013 in the middle of the wet season. As a result, I encountered some difficulties in travelling.

I stayed between two and three weeks in each village to administer the questionnaire. The sample size for each individual village represents the outcome of the timing, weather and travel issues identified above, as well as real budgetary and time constraints. Ultimately, the decision of how many questionnaires to administer was a trade-off, involving anticipating how the information would be analysed and the patterns and trends that I saw emerging while I was interviewing, and contingencies of time and money.

4.6 Interviews

Interviews encompass a degree of verbal exchange and discussion between researcher and participants, and are the most commonly used method in qualitative research (Creswell 2014; Limb & Dwyer 2001). Before I conducted the interviews, and following the guidance provided by Creswell (2014), I carried out an exploratory analysis of literature to derive the key issues related to the oil palm business sector and the salient points regarding environment and development (see Chapter 2). I used the results of this literature review to structure the interviews.

Interviews are considered a useful method for exploring attitudes, values and beliefs (Clifford, French & Valentine 2010). They provide opportunities for participants to describe their situations using their own language and from their own viewpoints. Information and perceptions received directly from participants are important in developing an understanding of a situation by legitimately reflecting the participants' own experiences and allowing them to clarify their views themselves. However, researchers need to develop skills in conducting interviews: for example, the ability to ask for further clarification of an opinion, and to implement interview strategies that allow them to maintain control of the situation when interviewing domineering or lugubrious people (Creswell 2014). In order to gather information related to the issue under investigation, it is essential to determine the type of interview and questions to be asked in advance.

Interviews are generally described in three types: structured interviews, semi-structured interviews and in-depth interviews (Longhurst 2010). I used a semi-structured interview to explore stakeholders' perceptions and understanding of oil palm issues in the context of environmental and development issues. I developed a written interview schedule to ensure that all areas of questioning would be covered. These areas related to oil palm cultivation practices, community development and conservation. The interview questions are provided in Appendix 4F. I also used the interview schedule to explore the participants' understandings and perceived meanings, and to avoid imposing my own assumptions on the participants' descriptions (Longhurst 2010).

I obtained informed consent from all participants, and the interviews were conducted at a time and place nominated by the participants. I made appointments at least one day prior to the interview to ensure that the participants could be interviewed at the agreed time. Giving the participants the ability to designate the interview time and place resulted in an atmosphere that allowed participants to explore and express what they were really thinking. I used a digital recorder to record the interviews and took written notes as necessary. All participants in this study agreed to be recorded as part of the interview process.

4.6.1 Issues with interviews

Two major problems with interviews are that the answers are filtered by selection according to the views of the participants, and that the questions are easily contaminated by the researcher's perceptions, interests and agenda, possibly resulting in biased responses from the participants (Creswell 2014). Rice (2010) identifies difficulties inherent in interviewing that must be recognised, understood and managed. Additionally, the success of the interview depends on mutual trust between the interviewer and the participant (Marshall & Rossman 2011). In order to reduce bias in responses and the effect of my own 'agenda', I conducted the interviews as neutrally as possible by following a list of questions and trying to create an informal environment in which rich and descriptive information could be given by the participants.

4.7 Data Analysis

Data analysis is the process of evaluating and summarising data with the aim of extracting information to develop practical conclusions (Montello & Sutton 2006). The purpose of data analysis is to allow for an understanding of the phenomenon under investigation and to produce 'an understandable, coherent and valid account of the result' (Clifford, French & Valentine 2010; Montello & Sutton 2006; Neuman 2011). This section presents the data analysis methods used in the present study. Section 4.7.1 addresses the data analysis method used for the quantitative data obtained from the household survey; next, Section 4.7.2 discusses the analysis of the qualitative data obtained from interviews.

4.7.1 Household survey

As discussed previously (Section 4.5), I employed a household survey to collect data on the livelihoods of households living in oil palm areas. I used these data in a number of analyses. The initial analysis involved descriptive statistics, the results of which are presented in Section 5.4.1. Descriptive statistical procedures organise, summarise and describe numerical data with the purpose of describing what has occurred or been found in a study (Clifford, French & Valentine 2010; Thompson 2009). This includes counting frequencies and the calculation of central tendencies such as means, medians and measures of variability; for example, range, percentile and standard deviations (Clifford, French & Valentine 2010; Thompson 2009). In addition, descriptive statistics allow researchers to detect characteristics of participants that may influence later conclusions (Thompson 2009).

Descriptive statistical analysis was chosen because it allowed me to summarise and describe the numerical data collected in line with the goals of the research. The use of descriptive statistics also allowed me to identify aspects of the data relevant to the research questions (Section 1.2) and to explore relationships between the elements investigated in this study. I tabulated the survey data in Microsoft Excel spreadsheets, and then imported these into the Statistical Package for Social

Sciences version 22 (SPSS 22.0) for analysis. I calculated modes, means and standard deviations to characterise the households.

The data that I entered into Microsoft Excel spreadsheets was also used in the association analysis. I imported these data into the SPSS 22.0 to calculate non-parametric Kendall's tau correlation to examine the associations between the variables investigated in the household survey. Subsequently, I applied a multiple linear regression to examine household livelihoods, an outcome variable can be explained a series of factors, as predictors.

The household survey data was further employed to measure the economic value of ES in oil palm landscapes using the direct market valuation method (Section 4.2.3). The following is a brief introduction to the methods I used in this research; further details are provided in Chapter 6.

The total economic value of all ES was calculated by adding the market and non-marketed ES values obtained:

$$ES_{total} = \sum ES_{market} + \sum ES_{non\text{-}market}$$

All ES values were calculated in US dollars per ha per year after conversion from Indonesian Rupiah [IDR] values. The market value of the ES, including the economic value of the provisioning services, is that obtained by the household in the market. This included major crops (ground and tree crops) and livestock. The other ES values comprised non-market ES. Key regulating services included were water regulation, soil erosion and carbon storage. Water regulation was estimated from the groundwater recharge (Comte et al. 2012), soil erosion was valued from the amount of soil lost under different-aged trees, and carbon storage was calculated from above-ground biomass carbon and priced using historical carbon trading data. I found that cultural services existed in the four villages in terms of local beliefs related to the protection of forests. I valued these using surrogate price based on the average land price of oil palm plantations. The supporting services were discussed descriptively, as this research did not conduct field experiment studies.

The total economic value of ES in oil palm landscapes was calculated for the entire province by extrapolating the ES values from the four villages to the total oil palm plantation area in Riau using data from the Indonesia Central Statistics Agency.

4.7.2 Interviews

Thematic analysis enables the researcher to identify and develop patterns or themes within a dataset and to describe the details therein (Boyatzis 1998). Braun and Clarke (2006) suggest that thematic analysis is both a foundational and appropriate method for analysing qualitative data due to its flexibility and potential to provide rich and detailed information. Thematic analysis allows the researcher to integrate all identified aspects of the phenomenon in order to synthesise themes directly from the raw data (Boyatzis 1998).

All interviews were recorded digitally and then transcribed verbatim. To identify themes, the thematic analysis used for this study was informed by Braun and Clarke's (2006) framework for analysing qualitative data using six steps of thematic analysis, involving familiarisation with the data to generate initial coding, search for themes, review the themes, define and name the themes, and produce a report (Figure 4.11). NVivo 10.0 software was used at points of the data analysis to support the researcher in data management.

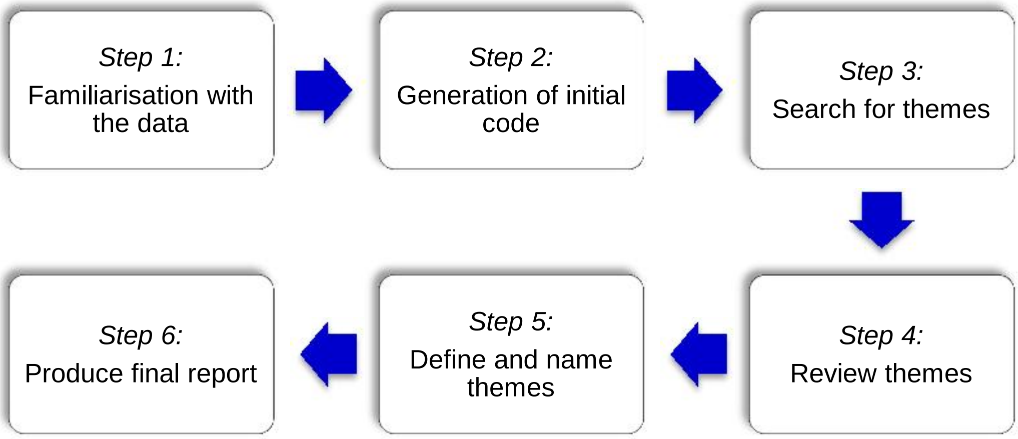


Figure 4.11. Steps of thematic analysis

Source: Adapted from Braun and Clarke (2006)

The methods and analyses used for the different types of data sources to answer the study's research questions are summarised in Table 4.3 below.

Table 4.3. Data sources, methods and analysis used in the present study

Research objectives	Type of data	Data collection methods	Data analysis methods	Participants
Investigate rural livelihood in the oil palm-dominated landscapes	Primary	Household survey	Descriptive statistics Regression analysis	Households
Examine the economic value of ES in the oil palm-dominated landscapes	Primary	Household survey	Direct market approach	Households
	Secondary	Statistical data	Direct market approach	-
Integrate ES into rural livelihoods in oil palm landscapes	Primary	Interview	Thematic analysis	Households Stakeholders

4.8 Researcher's Positionality

I was a lecturer in the Economics Department at Riau University before I undertook this research and have returned to that position after undertaking my doctoral research in Australia. I am a native of Riau and live in the provincial capital, Pekanbaru, with my family. I have never lived in any of these fieldwork communities. I conducted all of the interviews myself and was unaccompanied, except for some exploratory interviews at the start of my research when my principal PhD supervisor from Australia was present. Therefore, biases will be more-or-less the same for each interview. However, I was initially introduced to these villages by contacts at the Bank Riau Kepri (local development bank) and that would be known to some or all of the respondents and could have introduced some element of authority which would have played out differently with different households and communities.

4.9 Ethical Considerations

Before commencing data collection, an ethics proposal was submitted to and approved by the Flinders University Social and Behavioural Research Ethics Committee (Appendix 4G). A copy of the household survey instrument and the interview questions were provided to this committee. The research did not deviate significantly from the approved proposal.

The ethical considerations relevant to the study arise from the principles of autonomy, privacy, dignity, confidentiality, anonymity for persons involved in the study and beneficence. These principles are in accord with the National Statement on Ethical Conduct in Human Research (National Health & Medical Research Council 2007). The study followed procedures such as informed and signed consent, confidentiality and anonymity of participants.

4.10 Summary of Chapter

In summary, this chapter provides a description of the research framework, sample design, the data collection methods and post-collection data analysis strategies. Ethical considerations were applied throughout the study design.

There were two groups of participants in this study: households and stakeholders in industry, government and conservation. The methods used for data collection were a household survey, interviews with stakeholders, and the analysis of secondary data sources. I calculated modes, means and standard deviations to characterise households, and Kendall's tau correlation tests to examine associations between the variables investigated in the household survey. In addition, I used a multiple regression analysis to investigate relationships between dependent variables that could be explained by several independent variables. Direct expenditure analysis was used for valuing provisioning services, while surrogate price data were used for valuing other ES. A thematic analysis was used to adduce qualitative data.

The following two chapters present and discuss the results that were derived from these household survey.

CHAPTER 5:
WEALTH AND DEPENDENCY: RURAL LIVELIHOODS IN OIL PALM-DOMINATED LANDSCAPES

5.1 Introduction

The aim of this chapter is to assess and understand the livelihoods of oil palm smallholder households in the communities sampled in this study (see Chapter 4) from the perspective of a broad range of income sources, including oil palm. This broad perspective will assist in contextualising the dependent nature of the income derived from oil palm and underlining its importance, as well as identifying ways in which households are able to diversify their income sources. The focus is not solely economic, as rural employment is also considered.

This chapter begins by discussing the nature of oil palm cultivators in Indonesia in general and Riau Province in particular in Section 5.2. The information on oil palm cultivator households was derived from a household survey (see Chapter 4); these methods are expanded upon in Section 5.3. Information derived from the household survey is used to describe the characteristics of households in the four villages sampled in Section 5.4.1. These characteristics are analysed and explained using inferential statistics in Section 5.4.2. An initial discussion of the results is attempted in Section 5.5; this discussion is expanded upon in Chapter 7. Section 5.6 summarises the chapter.

5.2 Oil Palm Cultivators in Indonesia

In the oil palm industry globally, individual farmers who own land are called *smallholders*, defined as

> …farmers growing oil palm, sometimes along with subsistence production of other crops, where the family provides the majority of labour and the farm provides the principal source of income and where the planted area of oil palm is usually below 50 hectares in size. (RSPO 2007)

The term smallholder implies limited resource endowments relative to some other farmers. Importantly, the precise definition of these limits differs between countries and AEZs (Bijman, Ton & Meijerink 2007); however, for statistical purposes, a smallholder in Indonesia (called *perkebunan rakyat*) is defined as an individual farmer who organises or manages any plantation activity that is classified as a small business or household business and does not have any corporate liability (Directorate General of Estate Crops 2010).

Since the 1980s, the oil palm sector has been used by the Indonesian Government as an instrument for socio-economic development in rural areas, often alongside its transmigration programme, by encouraging people to become smallholders. In general, there are three types of smallholders in Indonesia, detailed in the sections below.

5.2.1 Nucleus Estates and Smallholders (NES) scheme

The first group includes those who are either members of a scheme (RSPO 2009), or those who are tied to (Molenaar et al. 2013) or supported by (Mahmud, Rehrig & Hills 2010; Vermeulen & Goad 2006) a parent oil palm company under the NES scheme. These types of smallholders have an initial arrangement or individual outgrower contract put in place by the government. The companies, as the nuclei in oil palm plantations, provide a wide range of technical assistance and cultivation inputs on a loan basis to smallholders in a geographical region known as *the plasma*. The smallholders are in turn obliged to sell the oil palm fruits—the FFBs they harvest—to the parent company's mill.

To boost the development of the oil palm industry further, the government introduced other schemes for smallholders in Indonesia. Zen, Barlow and Gondowarsito (2006) review these different types of schemes (Table 5.1), which include the following:

The *NES Transmigration (NES Trans)* scheme was prominent in the mid-1980s, initially as part of the national transmigration policy for migrants moving for purposes of oil palm cultivation. The government terminated this policy in 1998 due to the effects of the Asian financial crisis on Indonesia.

During the 1990s, a cooperative credit scheme, *Kredit Koperasi Primer untuk Anggota* (KKPA; Credit for Primary Cooperative Members) was introduced to reduce the government's role in financing outgrower schemes and provide cooperatives with a more influential role as intermediaries between companies and smallholders.

Both the NES and KKPA schemes have the aim of minimising the entry barriers smallholders face in starting oil palm cultivation (McCarthy & Cramb 2009). While the NES and KKPA schemes have similarities, they also have differences, particularly in terms of the land use rights. Under the NES scheme, the government typically provides a concession to estate companies, while in the KKPA scheme, in addition to acquiring land concessions, the companies are required to negotiate land access with local people (Zen, Barlow & Gondowarsito 2006). However, KKPA negotiations over land access have a particular drawback in the difficulty of obtaining transparent and fair negotiations for all local villagers, because companies negotiate access to village communal land with village elites (McCarthy 2010).

Table 5.1. Types of nucleus estate in Indonesia

Type of scheme	Characteristics
NES local (started 1978)	On state-owned company estates. Only available for residents around estates. Each settler allocated 2 ha of oil palm.
NES assisted (started 1984)	On state and private estates, partly funded by the World Bank and the ADB. Priority given to: (1) existing local residents, and (2) transmigrants. Each settler were given 2 ha oil palm and 1 ha for food crops, including the house plot.
NES special (started 1984)	On state and private company estates, funded by the Indonesian Government. Priority given to: (1) transmigrants, and (2) existing local residents. Areas similar with those for NES assisted (type 2), but 35m^2 included for a house plot.
NES accelerated (started 1984)	On state and private company estates, funded by the Indonesian Government. Only for transmigrants. Areas similar to those for NES special (type 3).
NES Trans and KKPA (started 1986, supersedes types 2, 3, 4)	On state and private company estates, funded by the Indonesian Government. Interest accrues on KKPA loans. For transmigrants and local residents. The latter group are included in the schemes in return for the land acquired from them by the company.

Notes:NES: Nucleus Estate and Smallholders;
KKPA: Kredit Koperasi Primer untuk Anggota (Credit for Primary Cooperative Members)
Source: Zen, Barlow & Gondowarsito (2006)

5.2.2 Other types of smallholders

A second major group is that of *full-managed smallholders*. This group represents a variant on the NES and KKPA smallholders identified by Lee et al. (2014). In this group, local smallholders own the land, but do not manage the cultivation practices. Instead, the smallholders surrender the planting and land management to an oil palm company, and in return they receive a monthly salary as part of a profit-sharing agreement.

A third group can be categorised as *independent smallholders*. They are characterised by the freedom they have to choose how to use and manage their land, and are not tied to any plantation company. This type of smallholder arrangement is becoming increasingly common, having spontaneously increased during the 2000s.

In addition to these three groups, oil palm farmers can have different roles under schemes as smallholders or outgrowers. They can be workers, shareholders or both (Molenaar et al. 2013). In addition, another type of farmer commonly found in oil palm growing communities is those who work for oil palm companies but do not own land. They are recognised as peasants or plantation workers.

5.2.3 The development of oil palm smallholders in Indonesia

Indonesia currently has the most extensive oil palm production in the world, and smallholders play a major role in the industry by providing a significant proportion of the oil palm fruit grown. It has been predicted that Indonesia's palm oil production will be led by smallholder farmers in the future (Feintrenie, Chong & Levang 2010; Feintrenie & Levang 2009). This is because smallholders experienced the highest rate of area expansion of all grower types in Indonesia during the first decade of this century (Table 5.2). Smallholders were also the group with the highest growth rate of oil palm land area for the decade of 2004–2013, at 9.14%. However, smallholders generated less CPO than the private estates over the same period. Smallholder areas also expanded significantly as a proportion, from 33.1% of the total oil palm area in Indonesia (5.2 million ha) in 2004 to 41.7% in 2013 (10.5 million ha). Smallholders contributed to 33.3% of all Indonesia's CPO produced in

2004 (10.8 million tonnes of CPO). This increased to 35.3% of the 26.9 million tonnes of CPO produced in 2013.

Table 5.2. Growth in land under oil palm and oil palm production in Indonesia by producer category

Year	Area growth under oil palm (%)				CPO growth in oil palm production (%)			
	SH	SC	PC	TOTAL	SH	SC	PC	TOTAL
2004	19.73	-8.59	-11.13	0.02	9.38	-7.59	3.72	3.73
2005	6.15	-12.55	4.42	3.20	16.99	-10.41	10.18	9.52
2006	8.18	29.74	30.81	20.92	28.49	59.65	56.54	46.28
2007	7.95	-11.81	1.50	2.61	9.95	-8.50	-0.70	1.81
2008	4.71	-0.54	13.81	8.82	8.88	-8.45	-5.56	-0.71
2009	6.23	4.57	7.80	6.92	8.59	3.50	12.93	10.17
2010	10.64	0.16	4.43	6.50	12.52	-5.75	18.45	13.63
2011	10.78	7.42	4.47	7.24	4.01	8.20	5.55	5.18
2012	10.26	0.71	4.16	6.45	4.54	4.27	19.85	12.64
2013	6.72	17.65	12.94	10.59	3.34	11.50	2.23	3
AVERAGE	9.14	2.68	7.32	7.33	10.67	4.64	12.32	10.56

Notes: CPO: crude palm oil; SH: smallholders; SC: state companies; PC: private companies
Sources: Calculated from Directorate General of Estate Crops (2012) and BPS—Statistics Indonesia (2014b)

As noted in Section 3.3, Riau is the province with the largest oil palm area and greatest production in Indonesia. In 2012, there were 512,125 oil palm smallholder families in Riau (Plantation Office Riau Province 2013). Table 5.3 shows that more than 88,000 households (17.3%) were located in the Kampar District (Figure 3.1). Other districts with high proportions were Indragiri Hilir (15.4%), Rokan Hulu (13.5%) and Siak (12.3%). In total, these four districts accounted for 58.7% of oil palm households.

Table 5.3. Oil palm smallholder areas and production by district in Riau, 2012

District	Oil palm area under smallholder tenure types (ha)				Production (tonnes)	Number of oil palm farming households
	Immature plantations	Mature plantations	Old or unproductive plantations	Total		
Rokan Hulu	59,278	140,135	0	199,413	525,079	69,175
Siak	46,872	163,380	19	210,271	549,131	63,228
Kampar	24,020	165,869	127	190,016	506,841	88,692
Rokan Hilir	18,223	145,769	2,999	166,991	491,279	49,516
Bengkalis	52,509	99,311	3,389	155,209	326,035	42,219
Indragiri Hilir	42,160	64,250	2,078	108,488	238,353	79,292
Pelalawan	5,703	111,568	364	117,635	436,865	39,211
Kuantan Singingi	12,986	57,930	177	71,093	127,941	38,773
Indragiri Hulu	6,142	50,598	146	56,886	202,622	31,209
Dumai	13,021	21,681	563	35,265	75,985	9,392
Pekanbaru	3,246	719	-	3,965	2,690	1,418
TOTAL	284,160	1,021,210	9,862	1,315,232	3,482,821	512,125

Source: Plantation Office Riau Province (2013)

Across the entire province, most the area planted to oil palm (77.6%) was under plantations with mature trees, while a little under a quarter (21.6%) was planted with immature trees (Table 5.4). The proportions of immature, mature and old or unproductive trees varied between districts. Pelalawan (94.8% under mature plantations), Indragiri Hulu (88.9%) and Kampar and Rokan Hilir (both 87.3%) are all well above the provincial average for area under mature plantation. Conversely, five districts are well above the mean for immature tree areas: Rokan Hulu (29.7%), Bengkalis (33.8%), Dumai (36.9%), Indragiri Hilir (38.9%) and Pekanbaru (81.9%). To a certain extent, this indicates the evolution and expansion of oil palm in Riau. Rokan Hulu was one of the first districts to convert to oil palm, and its higher than average number of immature trees shows that the first plantings have now been replaced by a second generation of trees. In contrast, Bengkalis, Dumai and Indragiri Hilir are relatively new areas of plantation in the peat-rich soils of the eastern lowlands. The high figure given for the proportion of immature trees in Pekanbaru can probably be disregarded, given that it is a small area adjacent to the main city.

Kampar is also an older oil palm area, which explains its high proportion of mature trees. In fact, until their subdivision in 1999, Kampar and Rokan Hulu were one district. In general, districts with high proportions of mature palms had significantly lower than average areas of immature palms, such as Bengkalis, Dumai, Indragiri Hilir and Pekanbaru. The district with the closest distribution to the provincial average was Siak, with 22.3% immature, 77.7% mature and < 0.1% old or unproductive trees; Bunga Raya is located in this district.

Table 5.4. Proportion of areas under different palm growth stages by district, Riau 2012

District	**Area under:**		
	Immature oil palm	**Mature oil palm**	**Old or unproductive oil palm**
	(%)	**(%)**	**(%)**
Rokan Hulu	29.7%	70.2%	0.0%
Siak	22.3%	77.7%	0.0%
Kampar	12.6%	87.3%	0.1%
Rokan Hilir	10.9%	87.3%	1.8%
Bengkalis	33.8%	64.0%	2.2%
Indragiri Hilir	38.9%	59.2%	1.9%
Pelalawan	4.8%	94.8%	0.3%
Kuantan Singingi	18.3%	81.5%	0.2%
Indragiri Hulu	10.8%	88.9%	0.3%
Dumai	36.9%	61.5%	1.6%
Pekanbaru	81.9%	18.1%	0.0%
Province	21.6%	77.6%	0.7%

Source: Plantation Office Riau Province (2013)

Production as a proportion of the region's total was greatest in Siak (15.8% of provincial production) in 2012, and equated to a mean production per household of 44,477.7 tonnes (Table 5.5). Siak was closely followed by Rokan Hulu (15.1% of production), Kampar (14.6%), Rokan Hilir (14.1%) and Pelalawan (12.5%). However, oil palm productivity per household was greatest in Pelalawan (57,057.8 tonnes/household). It also exceeded 50,000 tonnes/household in Rokan Hilir.

Table 5.5. Oil palm production by household, Riau, 2012

District	Production (tonnes)	Production (as % of provincial total)	Number of families	Mean production per household
Rokan Hulu	525079	15.1	69,175	38,873.3
Siak	549131	15.8	63,228	44,477.7
Kampar	506841	14.6	88,692	29,266.0
Rokan Hilir	491279	14.1	49,516	50,811.1
Bengkalis	326035	9.4	42,219	39,548.7
Indragiri Hilir	238353	6.8	79,292	15,394.6
Pelalawan	436865	12.5	39,211	57,057.8
Kuantan Singingi	127941	3.7	38,773	16,898.8
Indragiri Hulu	202622	5.8	31,209	33,249.3
Dumai	75985	2.2	9,392	41,432.9
Pekanbaru	2690	0.1	1,418	97,15.2
Province	3482821		512,125	6.8

Source: Plantation Office Riau Province (2013)

Comparing the productivity of oil palm cultivation in the three types of producer in Riau, it is clear that smallholders have lower productivity than private companies and state enterprises (Table 5.6). In 2012, smallholders produced 3.41 tonnes/ha, compared to 4.34 tonnes/ha for private companies and 4.10 tonnes/ha for state enterprises. It is noteworthy that Riau's smallholders had a lower mean production (2.65 tonnes/ha) compared to private companies (3.62 tonnes/ha) and state estates (4.05 tonnes/ha).

Table 5.6. Oil palm productivity by tenure type, Riau, 2012

Category	Productivity of mature area (tonnes/ha)	Productivity of total area (tonnes/ha)	Total land per farmers
Smallholders	3.41	2.65	2.57
State company	4.10	4.05	-
Private companies	4.34	3.62	-
Average Riau	**3.95**	**3.44**	**2.57**

Source: Plantation Office Riau Province (2013)

5.3 Methods and Analysis

I used a household survey to collect information from smallholder farmers. I administered the survey instrument to 73 smallholder farmers in four different villages in Riau between December 2012 and February 2013. I asked the same questions to all households. Details of the survey are provided in Section 4.5.1.

Data generated from this household survey was mainly analysed using SPSS 22.0 software to generate descriptive and inferential statistics. I analysed these data in two ways: (a) for all households, and (b) for the households in each of the four villages. The responses to the questions in the survey comprise ordinal and interval data. I examined the distributions of the interval data; they were not normally distributed. Because of the mix of non-normal interval data and ordinal data, I relied on non-parametric quantitative analyses.

The analytical methods used in this study comprise descriptive statistics and association analyses (correlation and regression). I used descriptive statistics to summarise the numerical and categorical data collected to (i) search for patterns in the data, and (ii) present the data in a meaningful way. The techniques used most commonly for the descriptive analyses were frequencies and percentiles of household characteristics. To find correlations between bivariate pairs of parameters (i.e. answers to questions in the survey instrument and parameters derived from these answers, such as household size; Table 5.7), I used the Kendall's tau correlation coefficients. It must be noted that labour costs in Table 5.7 were different in terms of harvesting, fertilising, weeding and pruning activities, because labour rates vary between these activities. I used a two-tailed test at 99% and 95% confidence intervals to identify the significant explanatory variables. I estimated the total household income using multiple regression analysis.

Table 5.7. Derived parameters used in the analysis of households

Derived parameter	Calculation used to derive parameter
Sum house	Wealth ranking (scores of house construction + roof materials + window type + presence of satellite TV + shop/business attached + on through road)
Household size	Sum of number of adults and children living in the household
Recommended fertiliser application rate	Number of 50kg bags used per ha
Cost of fertiliser use	Average price of 50kg bag of fertiliser x number of sacks used per ha
Spending on household school fees per year	Sum of school related costs for all children
Spending for transportation/year	Sums of costs of all vehicles owned
Oil palm average yield/ha/year	Average weight of oil palm fruits sold per year/Productive land area
Oil palm gross income/year	Annual yield x Average price
Oil palm gross income/ha/year	(Annual yield x average price)/Productive land area
Harvesting labour cost/year	Labour cost for harvesting per tonne x annual yield
Total fertilising cost/year	Labour cost + cost of all fertilising inputs per year
Total weeding labour cost/year	Costs of labour per weeding x number of times weeded each year
Total pruning labour cost/year	Costs of labour per pruning x number of times pruned each year
Total oil palm costs/year	Sum of harvesting labour, fertilising, weeding labour and pruning labour costs per year
Total oil palm costs/ha/year	Total oil palm costs/Oil palm productive and area
Oil palm net income/year	Oil palm gross income per year—total oil palm costs per year
Oil palm net income/ha/ year	Oil palm net income per year/total oil palm productive land area
Rubber sales income / year	Rubber production per year x Rubber price
Rubber net income/year	Rubber sales income—total costs
Areca nut sales income/ year	Areca nut production per year x Areca nut price
Cacao sales income/year	Cacao production per year x Cacao price
Rice sales income/year	Rice production per year x Rice price
Coconut sales income/year	Coconut production per year x Coconut price
Cattle sales income/year	Head cattle sold per year x Cattle price
Buffalo sales income/year	Head of buffalo sold per year x Buffalo price
Goat sales income/year	Goats sold per year x Goat price
Chicken sales income/year	Chicken sold per year x Chicken price
Chicken egg sales income/year	Eggs sold per year x Egg price
Other estate crops tree number	Sum of rubber, areca nut, cacao, and coconut trees
Staple food area	Sum of rice and cassava area (ha)
Fruits tree number	Sum of all types of fruit trees owned
Livestock number at present	Sum of cattle, buffalo, goats and chickens
Total other agriculture income/year	Sum of income from rubber, areca nut, cacao, coconut, rice, cattle, buffalo, goat, and chicken per year
Total household income/year	(Oil palm net income per year + other agricultural income per year)/(proportion of oil palm income to total household income)

5.4 Results

5.4.1 Descriptive statistics of oil palm smallholder households

There were 73 respondents in the sample. All were household heads; most were male, though in a few cases, wives joined the male head of household for the interview. The key demographics of the households are shown in Table 5.8. Most respondents (71%) were over 40 years old, and the majority were ethnic Javanese (47%) or Malay (35%). The modal category of highest level of education of heads of household was primary school. On average, the respondents had three children with a household size of five persons. Household heads had generally lived in their current village for more than 15 years, though a high majority (82%) had also lived elsewhere. More than 30% of the households I surveyed had moved to their current village because of economic factors (30%) or the presence in that village of family and friends (30%). Approximately 88% of the surveyed households owned their land (house plots and agricultural lands).

Though there are strong similarities among the profiles of the four villages (Table 5.7), there are some differences that should be highlighted at this point:

1. Household heads in Bunga Raya were slightly older than those in the other villages;
2. While Javanese were the dominant ethnic majority overall, they fell behind Malays in Tapung. This is related to the fact that in Tapung there are fewer transmigrants, which can be seen in the low proportion of people interviewed who had lived elsewhere; and
3. Kerinci Kanan had a lower proportion of landowners than the other villages.

Table 5.8. Basic descriptive statistics of surveyed households

Household characteristics	Ujung Batu	Tapung	Kerinci Kanan	Bunga Raya	All
No of respondents	12	20	15	26	73
Mode of age class of household head (percent of respondents in the modal class in parentheses)	30–39 (33) 40–49 (33)	40–49 (40)	40–49 (53)	> 50 (50)	40–49 (36) > 50 (36)
Ethnic majority (mode of class and %)	Javanese (58)	Malay (80)	Javanese (87)	Javanese (50)	Javanese (47)
Highest education level attained (mode of class and %)	Primary (42)	Primary (40)	Primary (67)	Primary (50)	Primary (49)
Number of children (Mean ± SD)	3 (± 1.7)	3 (± 1.5)	3(± 2.7)	4 (± 2.4)	3 (± 1.9)
Household size (Mean ± SD)	4 (± 1.6)	5 (± 1.6)	5 (± 1.4)	4 (± 1.6)	5 (± 1.6)
Number of years lived in the village (mode of class and %)	> 15 (67)	> 15 (85)	> 15 (73)	> 15 (54)	> 15 (68)
Proportion of heads of household who have lived elsewhere (%)	83	55	100	92	82
Main reason for migration to current village (mode of class and %)	Family/friend recommend-ation (50)	Have not migrated (65)	Economic (40)	Family/friend recommend-ation (42)	Economic (30) Family/friend recommend-ation (30%)
Household heads owning farm land (proportion of people interviewed in village as a percentage)	10 (83.3)	19 (90)	11 (73.3)	25 (96.2)	64 (87.7)

Note: M = mean; SD = standard deviation

Table 5.9 presents data on the characteristics of the surveyed households. From the visual wealth ranking of the houses, a little under half (49%) of the total households surveyed had a ‘better quality house’, for example, with a fancy finish to the walls, a tiled roof, glass windows, satellite TV, an adjoining shop and location on a through road in the village. In general, house construction in the four study areas was in ‘fancy finish’ condition, with glass windows indicating that the villages were relatively wealthy. The main differences were in roofing materials; 63% of all households had zinc rooves. Shops attached to houses were not frequent.

Table 5.9. Dominant house characteristics for the four study areas

House characteristics	Ujung Batu	Tapung	Kerinci Kanan	Bunga Raya	All
Construction	Fancy finish (9) (75%)	Fancy finish (18) (90%)	Fancy finish (8) (53%)	Fancy finish (14) (54%)	Fancy finish (49) (67%)
Roof	Zinc & roof tile (6) (50%)	Zinc (14) (70%)	Roof tile (11) (73%)	Zinc (22) (85%)	Zinc (46) (63%)
Window	Glass (9) (75%)	Glass (18) (90%)	Glass (13) (87%)	Glass (20) (77%)	Glass (60) (82%)
Satellite TV	11 (92%)	18 (90%)	13 (87%)	23 (86%)	65 (89%)
Shop-attached	3 (25%)	1 (5%)	3 (20%	5 (19%)	12 (16%)
On through road	9 (75%)	9 (45%)	7 (47%)	14 (54%)	39 (53%)
House wealth ranking score	Better (75%)	Better (50%)	Better (60%)	Standard (50%)	Better (49%)

Note: Percentage shows proportion of households surveyed

Table 5.10 displays summary information on oil palm farming systems. The average area of productive oil palm owned per household was approximately 11.3 ha; Ujung Batu had the lowest, at 4.4 ha, and Kerinci Kanan the highest, at 16.6 ha. These values are well above the two-hectare land allocation under the transmigration scheme and indicate a dynamic land market that allows farmers to accumulate land.

Overall, the mean annual yield was 15.9 tonnes/ha. Yields below this average occurred at Ujung Batu and Kerinci Kanan, and were at a maximum in Bunga Raya (18.3 tonnes/ha) (range = 11.9–18.3 tonnes/ha). This resulted in an average gross household income from oil palm cultivation of US$ 20,291 per annum (US$ 7,500–37,100 per annum). The total annual costs of oil palm cultivation were on average US$ 9,200 (range = US$ 2,200–21,000). The majority of respondents in three of the four communities (Ujung Batu being an exception) grew oil palm because it has good yields, is easy to cultivate and requires low maintenance compared to other crops. For example, plantations are fertilised approximately three times each year in Bunga Raya, Kerinci Kanan and Tapung, though in Ujung Batu fertiliser is applied only annually. Plantations are weeded approximately three times each year (range = 2.5 times in Tapung to 3.3 times in Ujung Batu), and trees only need pruning twice a year on most plantations, though in Kerinci Kanan they only prune once a year. These low maintenance levels are in stark contrast to the high frequency with which oil palm fruits are harvested. Fruits are harvested approximately every two weeks, and the range in harvest frequency is small, varying from 1.5 times per month in Ujung Batu to 2.2 in Kerinci Kanan. Yields themselves varied from 11.9 tonnes/ha/year in Ujung Batu to 18.3 tonnes/ha/year in Bunga Raya. Another reason that oil palm was preferred is because it requires less labour time, especially compared to rubber, the traditional crop in Sumatra. In general, in the mature phase, oil palm only requires harvesting once to three times a month, while rubber needs to be tapped every day.

The total annual costs of cultivating oil palm ranged from US$ 2,251 in Ujung Batu to US$ 21,088 in Kerinci Kanan, with an average of US$ 9,270. The net result of the low input costs, particularly from fertilisers, compared to the high levels of household income generated by oil palm plantations, was that the average net annual income from oil palm across all communities was US$ 11,780. However, the range for this parameter was high, with households in Ujung Batu only receiving US$ 5,512, compared to over three times that amount in Kerinci Kanan (US$ 16,710). The large differences in annual oil palm costs and net incomes were due to differences in tree ages, with older trees generating more yields with higher maintenance costs compared to younger ones. This range is reflected in the average net income per hectare; however, the differences among villages for this parameter were much smaller than those for annual oil palm income. Ujung Batu had the lowest net income adjusted for area (US$ 814), whereas the highest income from oil palm accrued to farmers in Kerinci Kanan. Both Bunga Raya and Tapung have high net incomes per hectare: US$ 1,115 and 1,092 respectively.

Table 5.10. Aspects of oil palm cultivation and income generation in surveyed villages

Characteristics	Ujung Batu	Tapung	Kerinci Kanan	Bunga Raya	All
Main reasons given for growing oil palm (modak class and percentage of respondents)	Majority nearby (42)	Good crop (40)	Good crop (47) Transmigrant (40)	Good crop (50)	Good crop (44)
Productive landholding size (ha) (M ± SD)	4.4 ± 8.8	13.8 ± 15.5	16.6 ± 47.3	9.7 ± 18.5	11.3 ± 25.4
Monthly harvesting frequency (M ± SD)	1.5 ± 0.8	2 ± 0.9	2.2 ± 1.4	1.9 ± 0.4	1.9 ± 0.9
Number of fertiliser applications per year (M ± SD)	1 ± 1	2.9 ± 1.8	3.3 ± 2.3	3 ± 2.2	2.7 ± 2
Weeding frequency (per year) (M ± SD)	3.3 ± 3.3	2.5 ± 1.3	2.8 ± 3.2	2.6 ± 1.2	2.7 ± 2.2
Pruning frequency (per year) (M ± SD)	2.6 ± 2.2	1.6 ± 1.1	0.9 ± 0.7	2.4 ± 1.5	1.9 ± 1.5
Oil palm yield (tonnes/ha/year) (M ± SD)	11.9 ± 8.4	16.7 ± 8	13.7 ± 9.6	18.3 ± 8.4	15.9 ± 8.7
Gross oil palm income (USD/annum) (M ± SD)	7,574 ± 18,185	24,652 ± 31,544	37,131 ± 111,319	13,092 ± 26,690	20,291 ± 55,498
Oil palm harvesting cost (USD/annum) (M ± SD	839 ± 2,067	2,130 ± 3,471	3,621 ± 10,471	1,759 ± 2,993	2,091 ± 5,390
Oil palm fertilising cost (USD/annum) (M ± SD)	800 ± 1,877	6,025 ± 8,133	13,639 ± 43,757	2,535 ± 4,322	5,487 ± 20,433
Oil palm weeding cost (USD/annum) (M ± SD)	269 ± 649	1,438 ± 2,786	2,742 ± 9,177	405 ± 783	1,146 ± 4,425
Oil palm pruning cost (USD/annum) (M ± SD)	342 ± 1,156	621 ± 882	1,086 ± 3,426	270 ± 524	546 ± 1,698
Total oil palm costs (USD/annum) (M ± SD)	2,251 ± 5,682	10,241 ± 14,552	21,088 ± 66,793	4,968 ± 7,984	9,270 ± 31,538
Net oil palm income (USD/annum) (M ± SD)	5,512 ± 12,439	14,587 ± 17,779	16,710 ± 44,329	9,670 ± 20,498	11,780 ± 25,504
Annual oil palm income per ha (USD) (M ± SD)	814 ± 596	1,092 ± 864	882 ± 732	1,115 ± 652	1,011 ± 720
Mean annual total household income (USD) (M ± SD)	9,907 ± 25,073	18,837 ± 23,538	24,236 ± 54,871	15,734 ± 27,544	17,373 ± 33,343
Oil palm contribution to total household income (%) (M ± SD)	76.7 ± 19.7	84 ± 11.4	84.7 ± 9.2	69.2 ± 21.5	77.7 ± 17.8

Note: M = mean; SD = standard deviation

Most households studied generated the majority of their income from oil palm. On average, this proportion was 77.7%, though it ranged from 69.2% in Bunga Raya to 84.7% in Kerinci Kanan (Table 5.6). Figure 5.1 illustrates the shares of oil palm-growing activities as a proportion of total household income. Overall, in the four study areas, more than three quarters of all households relied on oil palm for more than 60% of their total household income. In Bunga Raya, 77% of surveyed households generated at least 60% of their total income from oil palm, while in Kerinci Kanan all surveyed households generated over 60% of their income from oil palm; Tapung and Ujung Batu were intermediate. The high level of dependency of the interviewed households on oil palm can be stressed further by examining the proportions of households that depend on oil palm for over 80% of their income. In Kerinci Kanan and Tapung, over 70% of households were highly dependent on oil palm, while in Ujung Batu high dependency was experienced by approximately 50% of households. In Bunga Raya, household incomes were more diversified: only a third of households were highly dependent on oil palm.

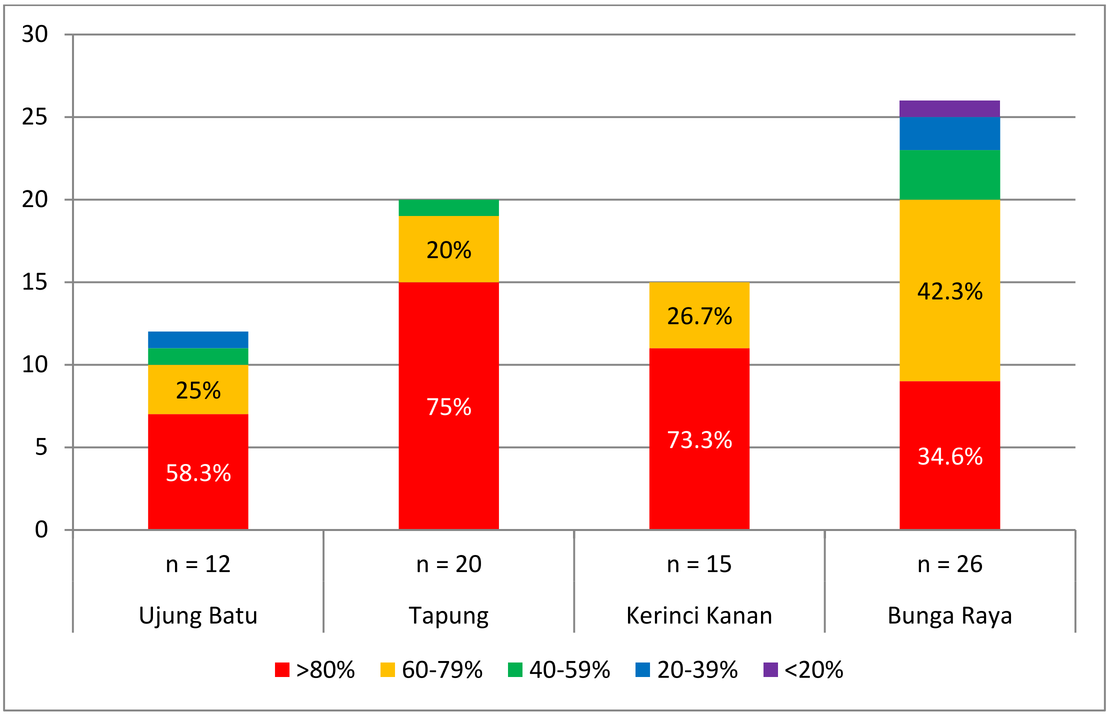


Figure 5.1. Proportion that oil palm contributes to total household income in the four study areas

Diversification of household income was accomplished in a number of ways (Table 5.11). Besides oil palm, on average over 60% of households relied on other agricultural activities—most notably, cattle and buffalo rearing and rubber—as major sources of income. This proportion varied from 45% in Tapung to 84.6% in Bunga Raya. The second most important diversified income source was income from a business. This was most important in Tapung (50% of households) and least important in Bunga Raya. Salaried jobs, such as teaching, were also quite a common form of employment in the four villages. Tapung had the largest proportion of households benefitting from at least one salaried member (65%), while Kerinci Kanan had the smallest (20%). This difference can be explained in terms of the size of the villages and their proximity to service centres where administrative offices and schools are located. Ujung Batu had the largest proportion of households receiving an income from a shop or business (41.7%); this proportion was quite low in the other three villages.

Table 5.11. Proportion (%) of households with other types of income sources

Type of income source	Ujung Batu	Tapung	Kerinci Kanan	Bunga Raya	All
Other farm activities	50	45	53.3	84.6	61.6
Retail income	41.7	10	26.7	7.7	17.8
Business income	41.7	50	40	34.6	41.1
Salaried job income	33.3	65	20	23.1	35.6

Table 5.12 displays various agricultural activities other than oil palm that contribute to household incomes in the four study areas. The figures are based on the number of agricultural activities that households use to generate income. In the present study, this figure also includes consumption of produce by the household or produce given freely to others. In terms of other agricultural incomes, cattle rearing is a common agricultural activity, and it occurs in all four villages (though only in six households in total). Rubber is another agricultural activity that contributes strongly to 14 households in the four villages, though it is concentrated in Bunga Raya and Tapung. Areca nut (*Areca cathecu*), cacao and chicken are other important agricultural activities, though of lower significance than cattle and rubber.

Table 5.12. Number of households with other agricultural income sources

Other Agricultural Income Source Frequency (%)	Ujung Batu (n = 12)	Tapung (n = 20)	Kerinci Kanan (n = 15)	Bunga Raya (n = 26)	All (n = 73)
Rubber	0 (0%)	3 (15%)	0 (0%)	11 (42.3%)	14 (19.2%)
Areca Nut	0 (0%)	1 (5%)	0 (0%)	8 (30.8%)	9 (12.3%)
Cacao	1 (8.3%)	2 (10%)	0 (0%)	3 (11.4%)	6 (8.2%)
Rice	0 (0%)	0 (0%)	0 (0%)	3 (11.4%)	3 (4.1%)
Coconut	2 (16.6%)	1 5%)	1 (6.7%)	0 (0%)	2 (2.7%)
Cattle	1 (8.3%)	2 (10%)	2 (13.4%)	1 (3.8%)	6 (8.2%)
Buffalo	0 (0%)	1 (5%)	0 (0%)	1 (3.8%)	2 (2.7%)
Goat	0 (0%)	2(10%)	0 (0%)	2 (7.6%)	4 (5.5%)
Chicken	1 (8.3%)	0 (0%)	2 (13.4%)	5 (19.2%)	8 (11%)
Chicken eggs	0 (0%)	0 (0%)	0 (0%)	1 (3.8%)	1 (1.4%)

While there are differences between the four villages, the analysis of variance of several major income and cost variables (Table 5.13) shows that there is no statistically significant difference between the villages in terms of income.

Table 5.13. Analysis of variance (ANOVA) of major selected variables

Variable	F-value	Significance
Oil palm productive land area (ha)	0.604	0.614
Oil palm average production/ha/year (tonnes)	1.959	0.128
Oil palm gross income/year (USD)	0.852	0.470
Oil palm total cost/year (USD)	1.071	0.367
Oil palm net income/year (USD)	0.558	0.644
Oil palm net income/ha/year (USD)	0.720	0.543
Total household income/year (USD)	0.436	0.728

5.4.2 Explaining total household incomes

Assessing and measuring associations between the parameters obtained from the household surveys in the present study is critical in developing an understanding of how household livelihoods are constructed and function. A common approach is to begin by investigating significant correlations between variables obtained in and derived from surveys. Correlation coefficients are used extensively in the social sciences to explain the strength and direction of associations between variables (bivariate pairs). In essence they answer the question, ‘How much of the variation in one variable can be explained by another variable (or other variables)?’

In the present analysis, I used non-parametric correlations, as many of the variables that I recorded or derived later were categorical variables of a binary, nominal or ordinal nature. I calculated both Kendall’s tau and Spearman’s rank correlation coefficients (Spearman’s rho), but ultimately used Kendall’s tau, because its population estimates provide more accurate generalisations than those of Spearman’s rho (Field 2013). In addition, it has been argued that Kendall’s tau generates tighter confidence intervals and clearer interpretations (Arndt, Turvey & Andreasen 1999). I selected two-tailed tests of significance with Kendall’s tau because the nature of some of the relationships between variables was unclear at the outset of the analyses (Field 2013).

There are 276 variables in this study, including the parameters introduced in Table 5.7. This is far too many to comprehend easily, and there were high levels of autocorrelation between parameters, which I needed to eliminate before conducting the next stage in the analysis. The procedure in selecting variables was data driven, but as the comprehensive questionnaire was developed by reference to theory and case study, the theoretical underpinnings were strong. Therefore, I initially divided the variables into six categories:

1. Household characteristics (30 variables);
2. Oil palm cultivation (67 variables);
3. Oil palm-related income variables (29 variables);
4. Other income sources and assets (21 variables);
5. Other agricultural and related activities (98 variables); and
6. Environmental variables (31 variables).

I correlated all the variables in each category against each other: first, for all of the villages together, and then for each village individually. This enabled me to identify the auto-correlated variables and to select variables that could be used in regression analysis in the next stage of the analysis. However, as the focus of this chapter is on total household income, I concentrated on variables that were strongly associated with total household income.

Subsistence agricultural production was also accounted for in the questionnaire. I valued subsistence production using replacement cost, i.e. what it would have cost for the household to buy the equivalent production. I calculated this from farmgate prices obtained from my questionnaire. However, none of the specific subsistence production parameters had statistically significant correlations with household income.

As Section 5.4.1 shows, total oil palm income contributes significantly to total household income, the evidence being significant correlations between these variables and total oil palm income. Therefore, total oil palm income and total household income are determined as the outcome variables. Table 5.14 summarises the results of these correlations; the 101 independent variables listed in Table 5.14 were selected on the basis that their p-values were significant (p = < 0.05).

Table 5.14. Significant bivariate correlations (p < 0.05) with dependent variables in all study areas

Independent variables	Dependent variables	
	Oil palm net income/year	Total household income/year
House wealth ranking	.246**	.204*
Malay	.228*	.209*
Education	.252**	.253**
Dependents	.222*	.179*
Household Size	.227**	.189*
Years in Village	.337**	.258**
Live Elsewhere	-.205*	-.172
Not Migrant	.273**	.215*
Economic	-.240*	-.266**
Own Land	.215*	.221*
Years Cultivate OP	.293**	.248**
Transmigrant	.292**	.230*
Area Owned	.618**	.577**
OP Farm Owner	-.253**	-.268**
Cooperative member	.310**	.241*

Tree Age	.347**	.280**
Frequency to Harvest/Month	.252**	.222*
Amount Harvest/Year	.361**	.346**
Average Sales/Year	.310**	.277**
Employ People	.437**	.416**
No Permanent worker	.543**	.549**
Frequency to Fertilise/Year	.314**	.302**
Urea	.267**	.253**
Urea Dose	.326**	.297**
Urea Cost	.269**	.226**
TSP	.407**	.373**
TSP Dose	.393**	.354**
TSP Cost	.304**	.274**
KCL	.306**	.323**
KCL Dose	.281**	.321**
KCL Cost	.263**	.288**
Dolomite	.198*	.205*
Dolomite Cost	.226*	.209*
Borate	.324**	.275**
Borate Dose	.280**	.222*
Borate Cost	.260**	.199*
Manure	.251**	.257**
Pest Rats	.232*	.220*
Pest Pigs	.183	.195*
Pest Fire Worm	.193*	.230*
Pest Porcupines	.222*	.221*
Pollination	.149	.212*
Machine Grass Strimmer	.285**	.260**
Business Income	.185	.210*
% OP Income	-.025	-.210*
Fuelwood Cooking	-.246*	-.279**
Other Fuel Cooking	.399**	.368**
No Scooter	.339**	.372**
No Car	.343**	.316**
No Pickup	.413**	.385**
No Truck	.375**	.360**
School Expense/Year	.268**	.239**
Transport Expense/Year	.471**	.454**

Rubber	.184	.196*
Rubber Area	.201*	.209*
Rubber Sales Income/Year	.175	.203*
Rubber Net Income/Year	.182	.201*
Coconut	.300**	.276**
Coconut No Tree	.337**	.296**
Coconut Sold	.313**	.288**
Mango	.190*	.237*
Mango No Tree	.170	.224*
Banana No Tree	.168*	.122
Cattle	.449*	.440*
Cattle No Present	.458**	.450**
Cattle Sold	.412**	.426**
Cattle Sold No	.412**	.417**
Cattle Sales Income/Year	.413**	.427**
Chicken Sold	-.235*	-.075
Chicken Sold No	-.241*	-.081
Chicken Sales Income	-.242*	-.081
Other Estate Crops No Tree	.358**	.362**
Fruits No Tree	.233*	.212
Livestock No Present	.171	.242*
Own Pets	-.231*	-.245*
Natural Forest Nearby	.321**	.298**
Distance Natural Forest	.246**	.233**
Elephants Farm	.207*	.199*
Birds Hunted	.210*	.163
Historical Land	.140	.188*
NES Trans	.360**	.324**
NES Coop Full Managed	.299**	.258**
NES Coop Partly Managed	.309**	.291**
OP Productive Land Area	.643**	.601**
OP Average Production/Ha/Year	.250**	.225**
OP Average Price/Tonne	.353**	.307**
OP Gross Income/Year	.774**	.710**
OP Gross Income/Ha/Year	.334**	.313**
OP Harvest Cost/Year	.647**	.624**
OP Fertilising Labour Cost/Year	.489**	.484**
OP Total Fertilising Cost/Year	.613**	.589**

OP Total Fertilising Cost/ Ha/Year	.363**	.344**
OP Weeding Cost/Year	.575**	.597**
OP Pruning Cost/Year	.545**	.528**
OP Total Cost/Year	.659**	.627**
OP Total Cost/Ha/Year	.425**	.394**
OP Net Income/Year	1.000	.834**
OP Net Income/Ha/Year	.220**	.211**
Total Other Agricultural Income/Year	.260**	.347**
Total Agricultural Income/Year	.882**	.852**
Total Household Income/Year	.834**	1.000

Note: *Correlation is significant at 0.05 (two-tailed); **Correlation is significant at 0.01 (two-tailed)

As can be seen from Table 5.14, total household income is highly correlated with net household income from oil palm (0.834) and the areal extent of the productive part of an oil palm plantation (0.601). These are intuitive associations, especially when the high positive correlation between net household income from oil palm and the areal extent of the productive part of an oil palm plantation (0.643) is taken into account. The number of years the household head had lived in the village, whether they were a member of a NES Trans scheme, the oil palm price and the number of other estate crops are also significantly correlated with total household income; however, the strength of these associations only ranges between 0.257 and 0.324.

Other significant correlations suggest that other patterns may exist within these data. For example, household size and membership of a NES Trans oil palm scheme are positively correlated with total oil palm income and total household income. Moreover, the longer households have cultivated oil palm through a NES Trans scheme, the larger the family is likely to be, and therefore the better they are able to make greater contributions to their net income from oil and total household income.

The number of other estate tree crops, which include rubber, areca nut, cacao and coconut, correlates positively with net income from oil palm and total household income. This is most likely due to the fact that as more land is converted to oil palm, some land is set aside for other tree crops. Interestingly, number of livestock is not correlated at all with oil palm income; however, it correlates positively with total household income.

I repeated these correlation analyses for each of the villages individually (Table 5.15). The area devoted to oil palm correlates positively with oil palm income in all four study areas, while total net income from oil palm correlates significantly with total household income (range = +0.697 in Ujung Batu to +0.924 in Kerinci Kanan). Likewise, the costs incurred in oil palm cultivation, such as harvesting and fertilising labour and input costs, correlate with both oil palm income and total household income. However, other independent variables differ between villages. For example, the highest education level attained and household size are only significant for Kerinci Kanan. Full results of the correlation analyses, including that of all households together and those of each village individually, are provided in Appendix 5A.

Table 5.15. Significant bivariate correlations ($p < 0.05$) with dependent variables in each study area

Independent variables	Ujung Batu		Tapung		Kerinci Kanan		Bunga Raya	
	OP net income/year	**Total HH income /year**	**OP net income/year**	**Total HH income /year**	**OP net income/year**	**Total HH income /year**	**OP net income/year**	**Total HH income/year**
House wealth ranking	.166	.071	.054	.162	.504*	.504*	.219	.188
Education	.139	.453	.242	.304	.678**	.678**	.093	-.019
Dependents	.179	.082	.224	.141	.499*	.431*	-.098	-.063
Household Size	.183	.050	.168	.096	.507*	.462*	-.028	.007
Years in Village	.146	-.229	.389*	.289	.413	.470*	.306*	.253
Transmigrant	.260	.260	.216	.183	.469*	.524*	-.166	-.211
Economic	-.566*	-.522*	-.363	-.399*	-.239	-.345	.028	-.009
Own Land	.165	-.055	.435*	.435*	.383	.383	-.255	-.255
Majority Nearby	-.354	-.520*	.236	.163	.104	.104	-.168	-.188
Area Owned	.462	.249	.661**	.637**	.638**	.638**	.475**	.428**
OP Farm Owner	-.134	.027	-.435*	-.435*	-.383	-.383	-.064	-.145
Tree Age	.206	.056	.429*	.329	.529*	.529*	.041	.019
Amount Harvest/Year	.425	.263	.564**	.564**	.443*	.467*	-.221	-.330*
Average Sales/Year	.304	.101	.360*	.417*	.239	.266	-.102	-.222
Employ People	.239	.202	.528**	.528**	.496*	.496*	.240	.080
Number of Permanent worker	.357	.469	.548**	.596**	.490*	.511*	.455**	.389**

Frequency Fertilise/Year	.369	.404	.368*	.428*	.221	.199	.223	.097
Urea Dose	.389	.423	.310	.332*	.192	.192	.276	.216
Urea Cost	.230	.263	0.000	.044	.179	.179	.291*	.194
TSP	.260	.186	.411*	.443*	.322	.297	.344*	.280
TSP Dose	.280	.359	.313	.313	.340	.295	.429**	.370*
KCL	.288	.173	.411*	.443*	.239	.239	.162	.291
KCL Dose	.448	.481*	.334*	.334*	.272	.250	.171	.385*
KCL Cost	.249	.282	.266	.344	.064	.064	.242	.378*
Dolomite	.165	-.055	.472*	.445*	.239	.239	-.057	-.081
Dolomite Dose	-	-	.376*	.350	-.104	-.104	.024	.010
Borate	.165	-.055	.364*	.323	.318	.318	-.112	-.096
Manure	.165	-.055	.435*	.435*	.452*	.452*	-.112	-.096
Pest Pigs	.123	-.041	.246	.246	.545*	.545*	-.174	-.174
Pest Fire Worm	.186	.074	.383*	.397*	.227	.250	-.026	.184
Pest Bettles	.206	.023	.528**	.528**	.452*	.452*	-.048	-.176
Pollination	.041	-.041	.256	.242	.452*	.452*	-.243	-.128
Frequency Pruning/Year	-.052	-.190	.268	.307	.266	.266	-.341*	-.320*
Grass Strimmer	.334	.186	.508**	.476*	.544*	.568**	.045	-.015
Other Farm Income	.123	.082	.430*	.343	.078	.130	.012	.035
Shop Income	-.603*	-.312	.145	.266	.353	.412	0.000	.048
Business Income	.062	.187	.334	.377*	.186	.239	-.013	.058

% OP Income	0.000	-.304	-.106	-.269	-.029	-.147	-.059	-.322*
Fuelwood Cook	-.312	-.687**	0.000	0.000	-.059	0.000	-.106	-.118
Other Fuel Cook	.432	.507*	.302	.245	.151	.104	.293	.276
Drink Water	.533*	.462	-.021	.007	.100	.100	-.089	-.071
No Scooter	.299	.299	.252	.240	.375	.418*	.104	.239
No Car	.111	-.037	.222	.281	.225	.282	.503**	.472**
No Pickup	.111	-.037	.330	.259	.498*	.498*	.440**	.463**
No Truck	.403	.295	.320	.320	.507*	.507*	.270	.281
Transportation Expenses/Year	.473*	.351	.490**	.423*	.265	.265	.302*	.358*
Rubber Prod/Year	-	-	.395*	.375*	-	-	.222	.092
Rubber Sales Income/Year	-	-	.395*	.375*	-	-	.244	.170
Rubber Net Income/Year	-	-	.395*	.375*	-	-	.236	.131
Coconut	.123	.041	.226	.260	0.000	0.000	.445**	.531**
Coconut No Tree	.259	.190	.177	.111	.010	-.073	.484**	.521**
Coconut Sold	.123	.041	.285	.300	.089	.089	.445**	.531**
Mango	-.021	-.062	.111	.142	.497*	.497*	.041	.071
Mango No Tree	-.037	0.000	-.058	-.104	.452*	.452*	.137	.157
Cattle	.408	.408	.144	.099	.498*	.498*	.327*	.354*
Cattle No Present	.408	.408	.090	.076	.470*	.470*	.340*	.353*
Cattle Sold	.408	.408	.435*	.435*	.498*	.498*	.144	.144

Cattle Sold No	.408	.408	.417*	.417*	.470*	.470*	.144	.144
Cattle Sales Income/Year	.408	.408	.417*	.417*	.470*	.470*	.144	.144
Song Bird	.260	.260	-	-	-.391	-.443*	-.102	-.102
Other Estate Crops No Tree	.315	.183	.349*	.327*	.042	-.042	.358*	.264
Livestock No Present	.259	.259	-.069	-.106	.507**	.507**	.126	.177
Pigs Farm	.437	.270	.133	.148	-.500*	-.500*	.103	-.114
Birds Hunted	.308	.166	-.049	-.091	.235	.235	.332*	.255
Historical Land	.213	.261	.307	.334	.443*	.443*	-.096	-.175
Flood	-.111	.037	-.415*	-.385*	0.000	-.077	.077	.128
River Water Quality	-.603*	-.687**	-.073	-.105	.293	.293	.033	.033
NES Trans	.408	.408	.237	.158	.607**	.607**	-	-
NES Coop Partly Managed	-	-	.284	.386*	-	-	-	-
OP Productive Land Area	.520*	.331	.546**	.589**	.631**	.611**	.607**	.513**
OP Average Prod/Ha/Year	.400	.369	.544**	.501**	.259	.239	-.076	-.165
OP Average Price/Tonne	.497*	.272	.259	.174	.486*	.507*	-.040	-.062
OP Gross Income/Year	.708**	.554*	.836**	.772**	.716**	.696**	.735**	.545**
OP Gross Income/Ha/Year	.443*	.412	.533**	.470**	.473*	.453*	-.050	-.124
OP Harvest Cost/Year	.559*	.679**	.706**	.663**	.679**	.658**	.593**	.445**
OP Fertilising Labour/ Year	.280	.280	.374*	.385*	.635**	.635**	.443**	.388*
OP Total Fertilising Cost/Year	.461*	.362	.565**	.544**	.657**	.638**	.518**	.499**

OP Fertilising Cost/Ha/Year	.164	.197	.248	.227	.481*	.461*	.173	.179
OP Weeding Cost/Year	.540*	.477*	.599**	.663**	.552**	.599**	.568**	.531**
OP Pruning Cost/Year	.510*	.510*	.515**	.472**	.458*	.505*	.455**	.364*
OP Total Cost/Year	.509*	.445*	.607**	.586**	.657**	.638**	.616**	.450**
OP Total Cost/Ha/Year	.445*	.445*	.343*	.322*	.539**	.520**	.210	.092
OP Net Income/Year	1.000	.697**	1.000	.895**	1.000	.924**	1.000	.711**
OP Net Income/Ha/Year	.504*	.412	.459**	.396*	.343	.363	-.169	-.237
Tot Other Agriculture Income/Year	.225	.315	.452*	.384*	.403	.454*	.197	.255
Total HH Agriculture Income Year	1.000**	.697**	1.000**	.895**	.962**	.962**	.735**	.705**
Total HH Income/Year	.697**	1.000	.895**	1.000	.924**	1.000	.711**	1.000

Note: OP: oil palm; HH: household; *Correlation is significant at 0.05 (two-tailed); **Correlation is significant at 0.01 (two-tailed)

5.4.3 Regression analysis

I used multiple regression analysis to explain household income quantitatively using the key variables selected from the correlation matrices (Section 5.4.2 and associated appendices). Regression analysis predicts an outcome variable from one (simple regression) or several predictor variables (multiple regression), with the goal of finding the causal effect of one variable or series of variables upon another (Field 2013). Stepwise multiple regression allows additional factors to enter the analysis separately, either by addition or subtraction, so that the effects of each can be estimated. This is valuable for quantifying the impact of simultaneous influences upon a single dependent variable.

I calculated a series of multiple regressions using variables from the following sets of parameters for all households, and for the households in the individual villages. I used the significant variables from the correlation analyses (Tables 5.14 and 5.15) that were likely to be important in explaining total household income as the basis for selecting the independent variables, as follows:

1. Household characteristics: education level, household size and number of years lived in the village;
2. Seven surrogates for income from oil palm: mean age of oil palm trees, harvest frequency, fertiliser application frequency, membership of a NES Trans scheme, membership of a partly managed NES cooperative, oil palm productive area and oil palm price;
3. Income from other agricultural activities: number of other estate tree crops and number of livestock;
4. Non-agricultural sources of income: retail income and business income;
5. Other household assets: use of fuelwood in cooking (indicating low asset levels), number of pickup trucks (high income leads to investment in pickup trucks, which generates more income by transporting goods for others), and transport costs (a surrogate); and
6. Environmental factors: adjacent natural forest.

The regression analysis therefore provides an estimate of total household income as the quantitative measure of livelihood. I used stepwise multiple regression models in SPSS 22.0 using different ways of entering data. The first model used forced entry, with all of the independent variables being used simultaneously. The list of predictors and the regression results are shown in Table 5.16; the full result is presented in Appendix 5B.

Table 5.16. Multiple regression model using the forced entry method

Predictor Variable	Unstandardised Coefficient		Collinearity Statistics	
	B	Standard Error	Tolerance	VIF
Constant	26822.142	20885.615	.552	1.810
Education	707.160	2438.721	.444	2.253
Household Size	-2585.113	1805.864	.465	2.151
Years in Village	-878.563	3008.970	.146	6.864
OP Tree Age	1993.125	3841.373	.160	6.247
Frequency to Harvest	773.239	5190.321	.494	2.026
Frequency to Fertilise	-545.066	1361.268	.341	2.929
Other Agric Income	-662.535	5124.291	.811	1.233
Retail Income	-150.652	6009.239	.526	1.900
Business Income	-4105.719	5296.704	.574	1.741
Fuelwood Cooking	-8618.066	5379.584	.442	2.264
No of Pickups	10435.442**	5289.719	.402	2.488
Transport Expense	3.611***	1.345	.408	2.453
NES Trans	19836.374**	7823.518	.454	2.204
NES Coop Part Managed	-6967.696	8131.548	.407	2.459
OP Productive Area	824.247***	111.608	.115	8.684
OP Average Price	-193.887	150.117	.710	1.409
Other Estate Crop No	.758	1.728	.476	2.102
Livestock No	134.901	118.375	.556	1.798
Natural Forest Nearby	-895.197	5054.841	.651	1.536
R^2 = 0.789 F = 10.437*** Durbin–Watson = 2.292				

Note: dependent variable is total household income (USD); *** Significant at 1% level;**Significant at 5% level; * Significant at 10% level; VIF = variance inflation factor.

The model outcome shows that 78.9% of variance in total household income is explained by variations in the predictor variables included in the model (R^2 = 0.789). The F-ratio is 10.437, which indicates that as a whole this model is significant ($p < 0.01$). The t-test indicates that at a p-value < 0.05, the number of pickup trucks owned, annual transport expenses, membership of a NES Trans scheme and oil palm productive area significantly contribute to increased total household income.

To test the validity and reliability of this model, it is necessary to check certain assumptions. First, to avoid multi-collinearity where two predictor variables are perfectly correlated—which makes independent prediction impossible—I used collinearity statistics. To satisfy the criterion of no collinearity, the tolerance data must be > 0.1 and the variance inflation factor (VIF) value < 10 (Mayers 2013). The model above is well within these limits.

Second, multiple regression analysis must satisfy an independent error assumption, which means that there is no correlation between residuals or there is no autocorrelation. To check this, the Durbin–Watson test is used. The Durbin–Watson statistic is measured on a scale of 0–4, with 2 denoting no correlation and values < 1 and > 3 causing concern (Mayers 2013). The Durbin–Watson statistic is 2.292, denoting minimal correlation.

I ran the multiple regression again using a stepwise approach with the same independent variables as the predictors in Table 5.16. This is an economical way of predicting optimum outcomes using the fewest possible predictor variables by assessing the relative contributions of each to the model (Mayers 2013). Three models resulted from the stepwise method (Table 5.17; full results presented in Appendix 5C).

Table 5.17. Multiple regression model using the stepwise method

Predictor Variable	Unstandardised Coefficient		Collinearity Statistics	
	B	**Standard Error**	**Tolerance**	**VIF**
Step 1				
Constant	5011.881	2413.102		
OP Productive Area	1086.719***	87.138	1.000	1.000
R^2 = 0.687 **F = 155.532*** **				
Step 2				
Constant	3006.529	2389.619		
OP Productive Area	962.649***	92.772	.795	1.257
No of Pickups	12470.751***	4217.271	.795	1.257
R^2 = 0.721 **F = 90.621*** **				
Step 3				
Constant	1172.108	2505.708		
OP Productive Area	887.709***	97.952	.683	1.464
No of Pickups	12554.915***	4126.024	.795	1.257
Livestock No	195.632**	96.174	.832	1.203
R^2 = 0.737 **F = 64.501*** ** **Durbin–Watson = 2.235**				

Note: dependent variable is total household income (USD); *** Significant at 1% level;**Significant at 5% level; * Significant at 10% level.

The result from the third sequence of the stepwise method regression generally confirmed the results from the forced entry model: the greater the area of oil palm productive land and the number of pickup trucks owned, the higher the household income. Additionally, using the stepwise method, I found that the greater the number of livestock (cattle, buffalo, goat and chicken), the higher the household income. Table 5.17 shows that total household income can be explained by three variables: oil palm productive area (p-value < 0.01), number of pickup trucks (p-value < 0.01) and number of livestock (p-value = 0.05). These three independent variables explain 73.7% of the variability in total household income. The F-ratio in the accompanying ANOVA indicates that these three independent variables are statistically significant in predicting total household income. Although almost a quarter of the variation in income is unexplained, other candidate variables included in the analyses did not prove significant.

It can be argued from this model that only cultivating oil palm, rearing livestock and owning a pickup truck (a vehicle asset) positively and significantly improve household income. Therefore, if livelihoods in the area under study are measured from the point of view of income only, these are the three important income sources. However, livelihoods are more nuanced and complex, a point that will be returned to later in the thesis.

5.4.3.1 Regression results for each village

Using the stepwise method, I estimated the total household income from each village. The stepwise regression methods resulted in four model outcomes for Ujung Batu, two for Tapung, five for Kerinci Kanan and one for Bunga Raya. The results from the final stepwise regression model for each village are shown in Table 5.18; the full results are presented in Appendix 5D.

Table 5.18. Multiple regression result using the stepwise method in each study area

Predictor Variable	Unstandardised Coefficient		Collinearity Statistics	
	B	Standard Error	Tolerance	VIF
Ujung Batu				
Constant	-59992.197	4245.312		
NES Trans	68565.595***	4310.177	.029	34.816
Fuelwood Cooking	-3012.274***	439.967	.866	1.154
OP Productive Area	515.854***	140.618	.029	34.667
Retail Income	-1318.186**	426.454	.922	1.084
R^2 = 1.000 **F = 3532.660***** **Durbin–Watson = 1.653**				
Tapung				
Constant	821.779	2220.629		
OP Productive Area	899.917***	140.761	.588	1.700
Transport Expense	2.735***	.553	.588	1.700
R^2 = 0.914 **F = 90.108***** **Durbin–Watson = 2.220**				
Kerinci Kanan				
Constant	-8012.240	1799.572		
OP Productive Area	728.564***	11.996	.377	2.655
No of Pickups	60199.873***	2248.192	.194	5.153
Education	4242.975***	686.688	.466	2.145
Business Income	3208.528***	840.612	.668	1.496
Fuelwood Cooking	-2215.645**	954.893	.636	1.573
R^2 = 1.000 **F = 4956.265***** **Durbin–Watson = 1.778**				
Bunga Raya				
Constant	6742.517	3309.177		
No of Pickups	38964.115***	5335.888	1.000	1.000
R^2 = 0.690 **F = 53.323***** **Durbin–Watson = 1.957**				

Note: dependent variable is total household income (USD); *** Significant at 1% level;**Significant at 5% level; * Significant at 10% level.

The regression models for each village strengthen the argument that oil palm cultivation has a very significant explanatory role in determining total household incomes in Riau. However, the model for Ujung Batu should be treated with caution, as there are serious concerns about multi-collinearity between two of the oil palm cultivation variables—NES Trans membership and oil palm productive area—and total household income (VIF > 10). In Bunga Raya, it is surprising that only the ownership of pickup trucks contributes to total household income. This may indicate that income sources are generally more diverse in Bunga Raya (Figure 5.2; Tables 5.12 and 5.13). Fuelwood used for cooking is another significant factor that contributes to total household incomes, albeit as a negatively correlated variable, in Ujung Batu and Kerinci Kanan. The use of fuelwood may conflict with agricultural use of the land, especially oil palm, though this did not come up in the discussions generated in interviews.

5.5 Discussion

In general, household incomes are strongly related to their ability to generate income from oil palm. The richest households have re-invested their profits into oil palm, as well as into other agricultural and non-agricultural activities to a lesser extent. Key investments and assets related to oil palm include increasing the size of their land holdings. The other main agricultural activities that appear to lead to increased household incomes are investment in livestock, particularly cattle, and diversifying activities to more traditional tree crops in the region, such as rubber and coconuts. In addition, investments in non-agricultural activities diversify and increase household income, the most important factor being ownership of a pickup truck, which can be used to transport oil palm fruits (by owners and other farmers) to processing facilities, and can be used for other family-related or commercial purposes.

The level of education of heads of households may significantly correlate with household income and asset accumulation. Rist, Feintrenie and Levang (2010) argue that oil palm provides a regular income for smallholder households and, therefore, offers better access to education. With increased education, not only is knowledge acquired, but also the value of education is more appreciated in a household. Highly educated members are much more likely to establish off-farm busineses and gain salaried employment. Most farmers surveyed had a primary school educational background (49.3%); Hasnah, Fleming and Coelli (2004) claim that less well-educated oil palm smallholders (i.e. ones with primary level schooling) are generally technically better farmers than more highly educated farmers.

The longer a smallholder head of household has lived in a village, the higher their net income from oil palm as well as total household income. Transmigrants, considered as the pioneering oil palm smallholders from the NES scheme, have cultivated oil palm since the late 1980s in Riau. These pioneer households have higher incomes than later arrivals and local farmers (defined as those that lived and farmed in Riau before the transmigration period) because they have accumulated land beyond their initial allocation under the transmigration scheme (by buying more land and clearing it, or buying existing farms) and own larger areas under mature oil palm (Zen, Barlow & Gondowarsito 2006). As early transmigrants, they may have a greater capacity to take risks, and therefore to act in a more entrepreneurial manner than others.

Smallholders with higher incomes generally adopt better agricultural practices. For example, they regularly apply the different types of fertilisers required to achieve higher yields. This is partly because most are NES partners who have been trained in oil palm cultivation by the nucleus oil palm company. Being a member of a cooperative (formed as part of the NES scheme) has advantages beyond support in cultivation practices for smallholders: usually, cooperatives are in a better bargaining position with milling companies compared to individual farmers. Therefore, it can be assumed that a NES smallholder has a better oil palm cultivation performance and higher income than an individual farmer.

Income diversification is a very important aspect of rural livelihoods that has been investigated extensively around the world (Ellis 1999; Niehof 2004). The nature of agricultural activities does not depend solely on cultivation and production, but also on supply and demand, weather, geographical regions and other factors. As farmers in Riau have the ability to generate relatively high incomes from oil palm, they also have opportunities to invest in other income-generating activities. One route is to diversify their land holdings outside oil palm agriculture. Livestock, such as cattle in feedlots that do not use much land, is becoming integrated into oil palm landscapes and farming systems in Riau: this has been noted in other oil palm-dominated farming systems (Devendra 2009). Further, as incomes increase, oil palm farmers tend to accumulate fixed assets, predominantly housing and vehicles. Some of their income is used to build new houses or renovate the house they live in. Different types of vehicles, such as scooters, cars, pickup trucks and lorries, are needed in rural areas, where public transport is very limited. Consequently, transport expenses are high, and opportunities for investments, especially in pickup trucks, can reduce household outgoings on transport and generate further income through developing a transport business. An indicator of increased wealth being re-invested within the household is that richer farmers rely more on gas as the primary cooking fuel: the use of fuelwood and kerosene is rare in such households.

The regression models confirm the dependency of households on oil palm in the four villages. Oil palm is widely perceived by the rural communities as the best option for meeting financial needs (Feintrenie, Chong & Levang 2010; Rist, Feintrenie & Levang 2010). Even though some households studied were engaged in a range of employment types, including full-time jobs as teachers and office workers, most of their income came from oil palm. With an average of 77.7% of their income coming from oil palm, this crop has proved to be a major source of livelihoods; these findings are generally in line with those of other studies (Table 5.19).

Table 5.19. Oil palm household incomes reported in previous studies

Oil palm household net income		Total household net income	Location	Source
US$	%	US$		
708–1,264	60–61	1,190–2,030	Sumatra	Susila (2004)[1]
-	63–78	-	Sumatra	Budidarsono et al. (2012)
-	31–61	-	Kalimantan	Budidarsono et al. (2012)
2,075	-	-	Sarawak	Cramb and Sujang (2013)[2]
6,660 (gross)	77	-	Sumatra	(Lee et al. 2014)[3]

Notes: [1] 2002 average mid exchange rate US$ 1 = IDR 9,318 (Bank Indonesia 2014); [2] US$ 1 = MYR 3.2 in November 2011; [3] US$ 1 = IDR 8,540 in July 2011)

The average yield across all households—15.9 tonnes/ha of FFB—is in line with average yields in other studies (e.g., 13 tonnes FFB/ha/year, (Molenaar, 2013 #719); 15.4 tonnes/ha, (Lee et al. 2014). In addition, Zen, Barlow and Gondowarsito (2006) note that many plasma smallholders who are already in the later stages of the NES scheme had better yields, and hence better incomes than other farmers. Plasma smallholders had yields of 19 tonnes/ha of FFB, higher than individual independent smallholders, who produced between 10 and 17 tonnes/ha of FFB. However, oil palm production from NES smallholders was still less than that of estates, which yielded around 21.3 tonnes/ha (Zen, Barlow & Gondowarsito 2006).

5.6 Summary of Chapter

This chapter presents an assessment of the livelihoods pattern of the people living in four villages in the oil palm-producing regions in Riau Province. Income from oil palm cultivation dominates employment patterns and total household incomes in the vast majority of households sampled, regardless of location. Other, non-oil palm incomes were identified: these included a diverse array of other agricultural crops, other natural resource off-takes and non-agricultural activities. Although none dominated household livelihoods in the way that oil palm does, nevertheless, in the analysis of explanatory variables that influence household income, livestock activities such as cattle rearing were significant, as were growing rubber and coconuts and investing in local transport.

Regardless of whether they were resident in the region prior to the ‘oil palm boom’ or were part of the transmigrant program, the majority of smallholder farmers have adopted oil palm at the expense of any other significant livelihood activities. Whether they were part of the NES scheme or whether they decided to cultivate oil palm independently, many people have been attracted by oil palm, and it has contributed substantially to their total household incomes.

Oil palm has undoubtedly improved the livelihoods of people in rural areas. It has helped them to escape poverty and enabled some to accumulate capital, which they have been able to reinvest in oil palm, cattle, off-farm activities and in educating their children. However, diversification of household livelihoods through reinvestment of capital was not commonplace across the households researched. The conclusion is that, although many households are relatively wealthy, they are also highly dependent on a single crop. This means that many households are in a ‘high wealth-high dependency’ position that exposes them to high risks in the future, either in the context of economic boom-and-bust cycles in the oil palm industry, or due to other natural or synthetic products being substituted (in an economic sense) for oil palm.

CHAPTER 6:
QUANTIFYING ECOSYSTEM SERVICES IN OIL PALM LANDSCAPES

6.1 Introduction

ES are important in ensuring sustainability in agricultural sectors around the world. Valuing ES in agriculture has been an increasing trend in this area over the last decade; however, ES have rarely been estimated for perennial crops such as oil palm. The purpose of this study is to assess and estimate the total economic value of ES in oil palm landscapes in Riau Province, Indonesia, using current market valuation methods. The ES being quantified include provisioning services (e.g., oil palm fruits and other cash crops grown on farms), regulating services (limited to water regulation, soil erosion, and carbon storage), and cultural services (sacred forest). This study identifies some ways to frame ES. I combine classifications of Fisher, Turner & Morling (2009) to reframe ES that focuses on valuing final benefits to people, with the most widely accepted MEA (2005) classification.

This chapter begins by elaborating frameworks for ES classification and valuation and is followed by a discussion of the relationship between ES and oil palm landscapes. Next, the method I used to estimate ES in this study is presented. This is followed by a presentation and analysis of the results. The final section summarises the chapter.

6.2 Ecosystem Services Frameworks

Several studies have attempted to categorise ES schemes. MEA (2005) classifies ES as provisioning services, regulating services, cultural services, and supporting services. This MEA classification is a holistic concept which is, in my opinion, the best to elucidating understandable categories. However, for a decision-making context in which economic valuation of ES is required, the MEA classification in not the most appropriate classification available because it is argued that it can lead to double counting of some ES (Fisher, Turner & Morling 2009; Fu et al. 2011).

This study, therefore, acknowledges some plurality to framing ES valuation. Wallace (2007) uses MEA classification extensively and proposes three levels of classification, namely processes, ES or end services (what is valued) and benefits. However he argues that only end services which should be included in the valuation. Boyd and Banzhaf (2007) consider services as end products of nature, instead of benefits, that should be included in the economic valuation. Fisher, Turner & Morling (2009) uses final benefits, such as drinking water, water for irrigation, and water for hydroelectric power, which are valued in economic terms. Apart from these variations of ES valuation frameworks there is anoter issue. Due to the complexity of ecosystems, a consensus is still lacking on a coherent and integrated approach to ES assessment. Research efforts to fill these gaps are still ongoing (de Groot et al. 2010; Fu et al. 2011; Ojea, Martin-Ortega & Chiabai 2012).

In this study, the final benefits scheme proposed by Fisher, Turner & Morling (2009) is used to measure economic value of ES in oil palm landscapes. However, as the focus of this study is at the landscape level, where there are other landscape elements besides oil palm, the final benefits provided by ES that are associated with the oil palm landscapes is grouped into the four MEA categories. These final benefits can be classified as private and public goods. All farming activities undertaken in oil palm landscapes are local-scale ES benefits that farmers receive as a private good. Other ES, whose property rights are not well-defined (e.g., groundwater recharge, soil, carbon, and sacred groves) and that contribute to regional or global ES, are considered as a public good.

6.3 Ecosystem Services and Oil Palm Landscapes

In Chapter 5, the livelihoods of rural communities living in oil palm regions were analysed and discussed. These include income generated from oil palm, other agricultural activities and non-farm activities. However, income-based approaches do not fully value livelihood systems in agricultural landscapes, and there has been a growing public interest in the role and value of the ES that underpin human quality of life and wellbeing (DEWHA 2009). Conserving ecosystems and ES is critical for economic development and poverty alleviation (Sandhu & Sandhu 2014, 2015; Turner et al. 2007). Biodiversity is implicated in numerous ES that are important to human wellbeing (Diaz 2014; Haines-Young & Potschin 2010); however, biodiversity is threatened by the many facets of global environmental change that the activities of human society are bringing about globally. Of particular relevance to this research is agricultural expansion (Brooks et al. 2006; Díaz et al. 2006; Tilman et al. 2001; Turner II, Lambin & Reenberg 2007) and agricultural intensification (Firbank et al. 2008; Sandhu et al. 2015; Tscharntke et al. 2005).

Current agricultural practices affect ecosystem functions, which in turn affect ES, as well as receiving ecosystem dis-services that lessen yield and escalate costs of production (Kragt & Robertson 2014; Wratten et al. 2013; Zhang et al. 2007). In this research, it has been established that the rise in demand across the globe for palm oil has driven the conversion of natural forests to human-dominated ecosystems such as oil palm plantations (Daily et al. 1997). The increasing global demand for palm oil and its diverse uses, including its role as a biofuel, has made it the most important oil crop globally. However, this significant growth in demand has brought about further expansion of oil palm plantations, particularly in tropical forests in South East Asia, during the last decade. This expansion has incurred a price, mostly at the expense of a wide range of environmental issues, such as loss of biodiversity, greenhouse gas emissions, increased frequency of fires and changes to the hydrological cycle. Oil plam landscapes differ from forest ecosystems that supply many ES, particularly in biodiversity conservation. Unexploited tropical forests are able to support many ES, but not food production. Managed oil palm plantations, on the other hand, provide economic benefits at the cost of diminishing other ES. Consequently, trade-offs are inevitable in oil palm-growing activities, which constitute major threats to biodiversity and ES (Phalan et al. 2013).

Previous studies have investigated the impacts of oil palm cultivation on biodiversity (Fitzherbert et al. 2008; Foster et al. 2011; Koh & Wilcove 2008). Traditional opinion has linked the conservation of nature with foregoing wellbeing; more recently, however, environment has been recognised as natural capital and one of the most crucial assets that the human race has (Liu et al. 2010). As many ecosystems globally have been in significant decline since the eighteenth century, their capability to provide ES has also been in decline; despite the fact that the demand for ES has been increasing due to an expanding population and improvements in living standards (Costanza et al. 1997; Costanza et al. 2014). To slow down this widening supply–demand gap (and even to try and reverse the trends) the current challenge is to force society to acknowledge the issue of valuing natural capital, and put this valuation into practice.

The ES approach is considered the most appropriate contemporary methodology in attempting to ensure sustainability in terms of food security and conservation in rural landscapes. The application of ES to plantation agriculture is, so far, relatively uncommon. As a major global vegetable oil, the assessment of ES in the oil palm production sector is a crucial test for the ES approach. This is in part because, while considerable recent attention has been focused on the impact of oil palm plantations on humid tropical biodiversity, much less is known about the ES that oil palm plantations provide. The present study is motivated by this lack of research, especially given that ES might contribute to oil palm management in a number of ways.

Many ES are not easy to observe or record, and hence it is difficult to formally count them in economic terms. Humans generally overlook or ignore the unseen ES provided in oil palm-dominated landscapes. Accordingly, the value of ES in oil palm landscapes remains poorly understood, particularly in Sumatra. Of the literature reviewed in this research, limited studies have characterised and valued ES in oil palm-dominated landscapes. Therefore, the objective of this chapter is to report on research that aims to identify the ES and dis-services that underpin oil palm-dependent households in Riau Province, and to estimate the economic value of the identified ES in the oil palm landscapes.

6.4 Methods for Economic Valuation of Ecosystem Services

I undertook economic valuation of the ES provided by oil palm landscapes using a combination of direct and indirect methods. Direct estimation is applicable to any ES that can be sold in the market, while indirect valuation is used for ES that are not traded in the market (de Groot, Wilson & Boumans 2002; Farber, Costanza & Wilson 2002).

6.4.1 Detailed economic valuation of ecosystem services

I measured provisioning services in oil palm-dominated landscapes using a direct valuation method, as these services have real market prices. The economic value of the provisioning services included oil palm fruit, other ground and arboreal crops, timber and non-timber forest products and livestock. I valued regulating and cultural services using a proxy indirect market price.

I valued the provisioning services on the basis of the household survey responses (Chapter 4). Although 73 households were sampled, I only used 62 in the valuation phase only that number provided complete data. A household is defined in this valuation study as a farming family that receives income from their own oil palm farmland, living in the rural areas under study. I excluded those households that just provide labour to the plantations.

I estimated the economic value of associated provisioning services using total potential income of the households interviewed in each village per hectare per year using direct market valuation. I used farm gate prices of oil palm FFBs. I calculated the original potential incomes in IDR, then converted to US dollars (USD) at the average appropriate conversion factors in 2013 (US$ 1 = IDR 10,451) (Bank Indonesia 2014), to allow for changes in economic value over the period. The provisioning services (Table 6.1) used in this study are:

1. Oil palm fruits (ES_1);
2. Rubber (ES_2);
3. Coconut (ES_3);
4. Bamboo (ES_4);
5. Areca nuts (ES_5);
6. Cacao (ES_6);
7. Rice (ES_7);
8. Cattle (ES_8); and
9. Chickens (ES_9).

I calculated the economic value of all provisioning services by adding the potential income received by farmers per hectare per year. When area data was not provided by the farmers, I used per-hectare unit measurement provided by the Directorate General of Estate Crops (2010). I collected all data between December 2012 and March 2013 during the wet season.

The regulating services (Table 6.1) used in this study are:

1. Water regulation (groundwater recharge) (ES_{10});
2. Soil erosion (ES_{11}); and
3. Carbon storage (ES_{12}).

This study concentrated on these three regulating services, as these were key issues raised by farmers during the survey. Water regulation was defined in this study as groundwater recharge or infiltration (i.e. annual precipitation minus evapotranspiration, run-off and interception). An assumption is that all the water that infiltrates into the ground in oil palm plantations is groundwater recharge. There is no separation between percolation and infiltration due to the limitations of the hydrological data available. I used annual rainfall data for 2012 held by BPS—Statistics of Riau Province (2014). I used evapotranspiration rates for 5 to 25 year-old oil palm trees from Corley and Tinker (2003) and Carr (2011). I determined the average annual run-off to be 25% of the total annual rainfall (Comte et al. 2012; Corley & Tinker 2003), and an interception rate of 17% of precipitation, although this is known to vary with tree age and rainfall intensity (Comte et al. 2012). In the calculations, I used the price of water (US$ 0.72/kL) charged by the water company in Pekanbaru.

I use two soil erosion measurements: first for oil palm trees less than ten years old and the second for those older than ten (Hartemink 2005, 2006). I estimated the market value of soil erosion by multiplying the amount of soil erosion (in Mg/ha/year) by the market price of soil. I used the average price of soil sold for housing construction in Pekanbaru in 2014 (USD 3.86/Mg).

Carbon storage was also quantified in this study. I used two measurements depending on the type of soil: CO_2 fixation in oil palm plantation (Lamade & Bouillet 2005) to calculate carbon stock available in oil palm plantations grown in mineral soils, and aboveground biomass carbon in oil palm located on the organic-rich soils in peat swamp (Murdiyarso, Hergoualc'h & Verchot 2010). Mineral soils are prevalent in Ujung Batu, Tapung, and Kerinci Kanan, while peaty soils dominate Bunga Raya. For the carbon emission price (€ 4.36/tonne) I used the average monthly price in 2013 available in Fusion Media (2014). I converted euros to US dollars (€1 = USD1.328) using the mean of the average monthly exchange rates for 2013 obtained from x-rates.com (2014).

The main cultural service that I found in the oil palm-dominated landscapes was that of protected sacred groves of trees (ES_{13}). Protected sacred groves are included as cultural ES because they are used to provide spiritual non-material benefits, including sense of place and belonging, to the indigenous communities who maintain them, and provide recreational experience to a wider range of people (Bhagwat 2009; Daniel et al. 2012; de Groot et al. 2010; Milcu et al. 2013; Wadley & Colfer 2004). This study quantifies cultural services due to the arguments made by some researchers that their value can be measured since they are expressed in human action (Boyd & Banzhaf 2007; Daniel et al. 2012). I quantified the economic value of these protected forests (ES_{13}) by the avoided cost method. The estimate derived for cultural services puts cultural value in terms of a conversion cost. To do this, I calculated the price of forestland as if it has been converted to oil palm. I obtained the average sale price of oil palm plantations in Riau at a productive age (tree average age = 7.5 years) from sales advertised online. Then, I divided the 'shadow price' by 25, as an opportunity cost which is used as a proxy for total years of economical life of oil palm tree.

Table 6.1. Ecosystem services used in the economic valuation of oil palm landscapes

Provisioning Services
ES_1 Oil palm
ES_2 Rubber
ES_3 Coconut
ES_4 Bamboo
ES_5 Areca nuts
ES_6 Cacao
ES_7 Rice
ES_8 Cattle
ES_9 Chicken

Regulating Services	Cultural Services
ES_{10} Groundwater recharge ES_{11} Soil erosion ES_{12} Carbon storage	ES_{13} Sacred grove

6.4.2 Total economic valuation of ecosystem services in Riau Province

To illustrate the potential of the relative value of ES for oil palm landscapes, I extrapolated the ES values obtained from four villages studied to total area under oil palm in Riau Province. In doing so I took appropriate caveats, which will be explained in the discussion section (Section 6.5.4). I extrapolated the total economic value of ES for oil palm landscapes in Riau Province by calculating the average value per hectare of ES in four study areas with the total oil palm area grown by smallholders and companies (state and private-owned companies) in each district (Table 6.2). I used district level data on oil palm plantations in 2012, which was obtained from the Plantation Office of Riau Province (2013). Then, the total economic values for smallholders, companies and total smallholders and companies in each district were mapped across districts in Riau using ArcGIS 10.2. The polygon grid is based on district boundaries.

Table 6.2. Oil palm land area by ownership in Riau, 2012

District	OP Smallholders Area (ha)	OP Companies Area (ha)
Rokan Hulu	199,413	214,939
Siak	210,271	76,794
Kampar	190,016	196,777
Rokan Hilir	166,991	90,382
Bengkalis	155,209	44,785
Indragiri Hilir	108,488	62,084
Pelalawan	117,635	187,995
Kuantan Singingi	71,093	57,610
Indragiri Hulu	56,886	62,084
Dumai	35,265	0
Pekanbaru	3,965	6,780
Meranti Islands	0	0
Total	1,315,232	1,000,230

Source: Plantation Office Riau Province (2013)

6.5 Results

6.5.1 Ecosystems services identified in the oil palm landscapes

In the following section, the ES associated with the oil palm landscapes are categorised into provisioning, regulating, cultural and supporting services and dis-services. The ecosystem dis-services identified involved both trade-offs due to conversion of forests and other types of agriculture to oil palm landscapes, e.g., reduced production from ther types of agriculture and reduction in biodiversity, and the dis-services that are generated by converting forest to oil palm, e.g., disruption to the water cycle and increased soil erosion. These ecosystem dis-services imply a negative value on the balance sheet of total economic value. These services are summarised in Table 6.3. This table combines ES found in previous studies and those that I identified in my research on households in Riau. These ES are discussed briefly below.

Table 6.3. Ecosystem services identified in oil palm landscapes

Ecosystem services	Ecosystem dis-services
Provisioning services: Oil palm fruit*—palm oil, kernel oil, biofuels, fibre Oil palm fronds (leaves)*—cattle fodder Oil palm trunks—processed wood, bioethanol Other crops*—rubber, cacao, etc Intercrops (1–5 years)*—cassava, banana, vegetables Livestock*—cattle rearing	**Provisioning dis-services** Reduction in other production agricultural lands *
Regulating services: Water regulation Soil erosion control Carbon sequestration	**Regulating dis-services:** Loss of forest Reduction in biodiversity Reduction in carbon storage Disruption to the water cycle Increased soil erosion
Cultural services: Local beliefs—sacred protected forests *	
Supporting services: Pollination * Biological control of pests *	**Supporting dis-services:** Loss of forest Reduction in biodiversity Soil nutrient reduction

Note: * Those that I identified in Riau are indicated with an asterisk.

6.5.1.1 Provisioning services

Oil palm in agricultural landscapes is an important crop that underpins the household incomes of many smallholder farmers in Indonesia and Malaysia and, as the area under oil palm expands globally, into countries far from South East Asia such as Colombia and Peru (Section 2.2.3). Oil palm landscapes are a type of human-modified ecosystem that is dominated by one main provisioning service—FFBs—by utilising other ES. In this context, the latter context is similar to other agricultural commodities in that it aims to yield direct benefits to human beings. UNEP (2011) acknowledges a broad range of ES in oil palm landscapes. The most important feature of provisioning services in oil palm landscapes is their capability to provide a cash crop to farmers and the rural community, which is in high demand globally. As a perennial crop, the FFBs are harvested all year, every fortnight, two to three years after planting. Trees are considered to be at their most productive when they are between 9–15 years old (Sheil et al. 2009). The oil palm fruit can be processed for CPO and palm kernel oil, for a range of consumer and industrial products (uses that range from food to energy), and as a fibre. Most of these services are provided to people who do not live in the oil palm landscapes, but some provisioning services are proximate. For example, oil palm leaves (fronds), which are used for roofing thatch or fodder, are a form of direct provisioning.

My findings are supported by previous studies (Devendra 2009; Zahari et al. 2003) which have observed that oil palm fronds are used to feed ruminants, especially cattle. Oil palm frond comprises 70% fibre, 22% nitrogen, and small proportions of other chemicals, such as crude protein and ether extract, making them suitable to be used as roughage for ruminants (Ishida & Abu Hassan 1997). In addition, old oil palm trunks can be used as a material in producing compressed wood and bioethanol (Sulaiman et al. 2012; Yamada et al. 2010); however, I did not find any instances of the use of trunks during my research, which may be due to the absence of a replanting stage in the area under study.

Other provisioning services in oil palm-dominated landscapes emanate from other crops and livestock. Beyond oil palm, the other important crops in Riau are rubber, areca nuts (betel), cacao, rice, bamboo and coconut. The main forms of livestock by both number and value are cattle, goats and chickens. Most of the crops and livestock listed in the household questionnaires are sold off farm, and are, therefore sources of external income, with most of their services being provided to people outside the household that grew or reared them. That said, a small proportion of the harvest of these crops will be used within the household, such as bamboo for construction, or chickens for eggs and meat. There are many other crops (Table 5.12 in Section 5.4.1) that are almost entirely subsistence in nature, and whose provisioning services mainly benefit the households directly. Non-oil palm activities such as these strengthen livelihoods of rural communities through diversifying income sources and developing elements of self-reliance and self-sufficiency in households.

I found some evidence of oil palm production being integrated with ruminant production; this is in line with the observation that oil palm plantations can play a role in integrated oil palm–ruminant systems without harming the environment (Devendra 2009). Integrated systems have been shown to decrease costs and maximise land use, and thereby increase incomes, from both the oil palm and livestock elements of the system (Gabdo & Abdlatif 2013; Latif & Mamat 2002). Generally, however, the integration of oil palm and ruminants is poorly developed in the oil palm landscapes in Riau. I found that cattle and goats were mainly kept in the feedlot located in the oil palm plantations, though there was evidence of a mutual symbiotic relationship between oil palm fronds being fed to cattle and the cattle dung being used as manure. Oil palm plantations can also be used as a place for cattle grazing (Slade et al. 2014). The grass grown in between rows of trees is used as pasture. This can reduce weeding costs by 16–40% (Devendra 2004). Cattle grazing in the oil palm landscapes has been proven to foster increased biodiversity (of dung beetles) and conserve soils (Slade et al. 2014). However, the grazing can have a negative impact in terms of soil compaction, impaired drainage and damage to the trees themselves (Devendra 2011).

Intercrops can be grown on oil palm plantations, especially when the trees are between one and five years old. Accordingly, during the establishment of a plantation, smallholders intercrop with food crops including cassava, corn, fruits and vegetables (Amoah et al. 1995; Putra et al. 2012). Although oil palm is considered a monocrop, especially when shade becomes more intense (Corley & Tinker 2003), mature oil palm trees can be under-planted with other perennial crops; for example, cocoa can be grown to optimise land use and has the advantage that it has a different labour calendar (Amoah et al. 1995). No instances of intercropping were observed in any of the villages that I studied.

Ecosystem dis-services occur in oil palm landscapes in respect of producing services. These mostly relate to reductions in productivity of other agricultural crops. This comes about because as oil palm is considered such a lucrative crop for smallholders: farmers have converted their traditional farmland, particularly rubber in Sumatra, and their secondary forests into oil palm plantations (Koh & Wilcove 2008).

6.5.1.2 Regulating services

In addition to providing oil palm fruits and other provisioning services, oil palm-dominated landscapes impact many ecosystem regulating services, such as water regulation, biodiversity (through habitat change) and soil erosion. Comte et al. (2012) evaluate oil palm cultivation practices that affect hydrological processes. Water use in oil palm is difficult to quantify because it depends on time periods between intra-annual and inter-annual variations in climate; nevertheless, mean monthly rainfall and potential evapotranspiration have proven the most suitable variables for estimating water supply for oil palm (Corley & Tinker 2003). It is estimated that the evapotranspiration rate of mature trees is around 4–5 mm/day (Carr 2011).

As one the most rapidly expanding crops in the world, oil palm contributes to regulating dis-services. Similarly to other man-made landscapes, which often bring about environmental degradation (Foley et al. 2005), oil palm has triggered the loss of tropical forests in South East Asia, which has in turn led to substantial loss of biodiversity (Fitzherbert et al. 2008). Biodiversity is important, as high levels of it are required to regulate diverse ecosystem functions (Hooper et al. 2012; Hooper et al. 2005). One of the biggest threats posed by oil palm agriculture to biodiversity relates to large animals such as elephants, tigers, rhinoceroses and orang-utans.

This is effect is inevitable, and common to any agricultural expansion that leads to habitat conversion (Tilman et al. 2001). Foster et al. (2011) summarise biodiversity loss in terms of reduction in species richness and total abundance in oil palm plantations compared to other habitats. Conversely, they also argue that oil palm plantations provide positive outcomes in terms of habitat for biodiversity: for example, bee species richness is higher in oil palm plantations compared to tropical forests. Oil palm plantations have more dung beetle communities in riparian reserves within oil palm plantations than in surrounding logged forests (Gray et al. 2014).

Another regulating disservice identified in oil palm plantations is soil erosion. Oil palm has been implicated in increasing erosion rates when forest clearance to create plantations exposes soils to intense rainfall before ground cover is re-established (Schrier-Uijl et al. 2013). In general, accelerated soil erosion is restricted to young oil palm plantations (Hartemink 2006); however, as the trees mature, soil erosion still occurs and the rates may continue to increase depending on slope properties and soil management practises (Hartemink 2006). Soil erosion also often leads to a reduction in soil nutrient levels (Comte et al. 2012; Hartemink 2006). It is estimated that soil erosion rates range from 7–21 Mg/ha/year (Hartemink 2006).

6.5.1.3 Cultural services

Oil palm landscapes also contribute cultural services. However, as it is common that large amounts of forest have been converted to oil palm, these services may not originate from primary forests, but rather stem from logged forests or degraded land (Foster et al. 2011). However, the opposite is also true, as found in the present study: in Tapung, primary forest adjacent oil palm plantations has been kept intact. The reason behind the maintenance of this forest is that it is considered a sacred grove by the people who live in the surrounding oil palm plantation landscape. This protected forest has a direct impact on human wellbeing, providing recreational, spiritual and religious benefits. It is, in some ways, similar to the concept of land sparing, where block areas are reserved for biodiversity conservation and interspersed with homogenous farm landscapes (Fischer et al. 2008).

6.5.1.4 Supporting services

In addition to providing provisioning, regulating and cultural services, oil palm plantations provide supporting services. The supporting services elaborated below are drawn from the household survey; however, I did not include these services in the economic valuation of ES provided by oil palm landscapes, as these services need to be further investigated through field assessment. Therefore, the supporting services described here are based on previous studies.

Pollination is an important supporting service provided by oil palm landscapes. Oil palm was initially considered to be a wind-pollinated crop, but insects are now recognised as a major pollinator of oil palm flowers (Syed 1979; Tandon et al. 2001). Lack of pollination opportunities is known to constrain growth in younger oil palm trees (Tandon et al. 2001). This is because oil palm is a monoecious species—a plant that has male and female flowers in the same tree (Tandon et al. 2001). However, as male and female flowers in the same tree bloom at different times, cross pollination is essential and assisted pollination is needed (Syed 1979). Weevils have been found to pollinate oil palms in Cameroon and Malaysia (Syed 1979).

Biological control of pests is another supporting service that has been recognised in oil palm plantations. Pests, of course, reduce oil palm growth and yields (Aneni et al. 2012; Gitau et al. 2009), and insects are considered the most significant group of pests in oil palm plantations (Aneni et al. 2014). Ponnamma (2001) reviews common forms of biological control of insect pests in oil palm plantations. Further, Koh (2008) reveals that insectivorous birds can be used as natural pest control.

6.5.2 Total economic value in the study areas

The total economic value estimates yielded from the above investigations are presented in Table 6.4. These are conservative estimates based on the information collected during the household survey. The average potential ES value in all agricultural activities dominated by oil palm is estimated at US$ 6,520/ha/year, ranging between US$ 2,970 and US$ 7,729/ha/year across the four villages. Overall, the values of the total ES outweigh the dis-services identified in Riau’s oil palm landscapes.

Table 6.4. Potential total economic value in the four villages investigated (US$/ha/year)

Ecosystem services	Mean economic value (and range) in US$/ha/year				
	Ujung Batu [n = 9]	Tapung [n = 18]	Kerinci Kanan [n = 11]	Bunga Raya [n = 24]	Average
Provisioning services					
Oil palm fruit	**1,315** (459–2,488)	**1,823** (574–4,306)	**2,043** (1,091–3,359)	**1,645** (332–3,100)	**1,707**
Rubber	–	**170** (0–735) [5]	–	**1,569** (0–8,551) [14]	**869**
Coconut	**65** (0–97) [6]	**75** (0–97) [14]	**71** (0–97) [8]	**44** (0–97) [11]	**64**
Bamboo	–	**80** (0–478) [3]	–	–	**80**
Areca nuts	–	**0.4** (0–3) [4]	**0.02** (0–0.2) [1]	**1,594** (0–16,046) [9]	**532**
Cacao	**561** (0–5,052) [1]	**738** (0–6,486) [3]	–	**240** (0–1,768) [4]	**513**
Rice	–	–	–	**317** (0–2,679) [3]	**317**
Cattle	**296** (0–2,662) [1]	**257** (0–1,914) [6]	**332** (0–3,349) [2]	**48** (0–478) [4]	**233**
Chicken	**26** (0–230) [3]	**1** (0–18) [2]	**8** (0–25) [8]	**32** (0–479) [16]	**17**
Regulating services					
Groundwater recharge	**631** (225–2,853)	**3,038** (1,530–5,315)	**1,392** (62–2,690)	**2,163** (1,779–4,407)	**1,806**
Soil erosion	**-73** (48–91)	**-77** (48–91)	**-78** (48–91)	**-63** (48–91)	**-73**
Carbon storage	**149**	**149**	**149**	**140**	**147**
Cultural services					
Sacred forest	–-	**309**	–-	–	**309**
TEV	**2,970**	**6,563**	**3,917**	**7,729**	**6,520**
Marketed ES	**2,263**	**3,144**	**2,454**	**5,489**	**4,331**
Non-marketed ES (% of TEV)	**707** **(23.8%)**	**3,419** **(52.1%)**	**1,463** **(37.3%)**	**2,240** **(29.0%)**	**2,189** **(33.6%)**

Note: TEV: total economic value.

In terms of oil palm alone, the total economic value of ES is US$ 1,707 on average, with a range of US$ 1,315–2,043/ha/year, while the total value of provisioning services averages US$ 4,331/ha/year (range US$ 2,263–5,489). Other commodities that offer significant economic value include rubber (US$ 170–1,569/ha/year), areca nut (US$ 0.02–1,594/ha/year) and cacao (US$ 240–738/ha/year).

6.5.3 Non-marketed ES in oil palm landscapes

Across the four study areas, the non-marketed ES contributed on average US$ 1,852/ha/year, with contributions ranging from US$ 707 to US$ 3,110/ha/year. This component accounted for nearly a quarter (23.8%) of the total economic value in Ujung Batu, and just over half (52.1 %) in Tapung. These figures were not surprising, as most of these ES (regulating and cultural services) are not available in the marketplace. The study also quantified the non-marketable ecosystem disservice that was soil erosion. The value of this disservice was estimated at around US$ 63–78/ha/year.

Water is a basic resource for growing crops such as oil palm. The economic value of water regulation in oil palm landscapes ranged between US$ 631 and 3,038/ha/year, with an average of US$ 1,806/ha/year. In Tapung, groundwater recharge was the highest compared to other three areas; this may be due to high annual rainfall, soil types, or a combination of both.

Moreover, I measured one particular ecosystem disservice that impacted these oil palm landscapes: soil erosion, which is often associated with conversion of tropical forests to oil palm plantations. I estimated soil erosion to incur costs on average at US$ -73/ha/year, with the least costs in Bunga Raya (US$ -63/ha/year) and the highest in Kerinci Kanan (US$ -78/ha/year).

In Tapung, there is a 200 ha patch of remnant local forest located in the centre of the community owned-oil palm plantations that are managed by private company that is considered sacred by the local community. It is common pool forest resource and it is claimed by the local people that they it has never been exploited. In this study, this sacred forest is considered as a cultural service. Using a proxy of converting this forest to productive oil palm plantations, I estimated the value of cultural services of this sacred forest as US$ 309 ha/year.

The total economic values of ES associated with oil palm landscapes are illustrated in Figure 6.1. This figure exhibits clearly the difference between the marketed (provisioning) services and non-marketed (regulating and cultural) services. In all four villages, the value of all provisioning services was greater than all other services, and markedly so in all villages except Tapung. This could be explained by the fact that not all non-marketed services have been included in the valuation, and in any case that the other services are individual services, not a group of services. Groundwater recharge is high in all villages except Ujung Batu. The values of the other three services and dis-services measured are relatively very small compared to provisioning services and groundwater recharge.

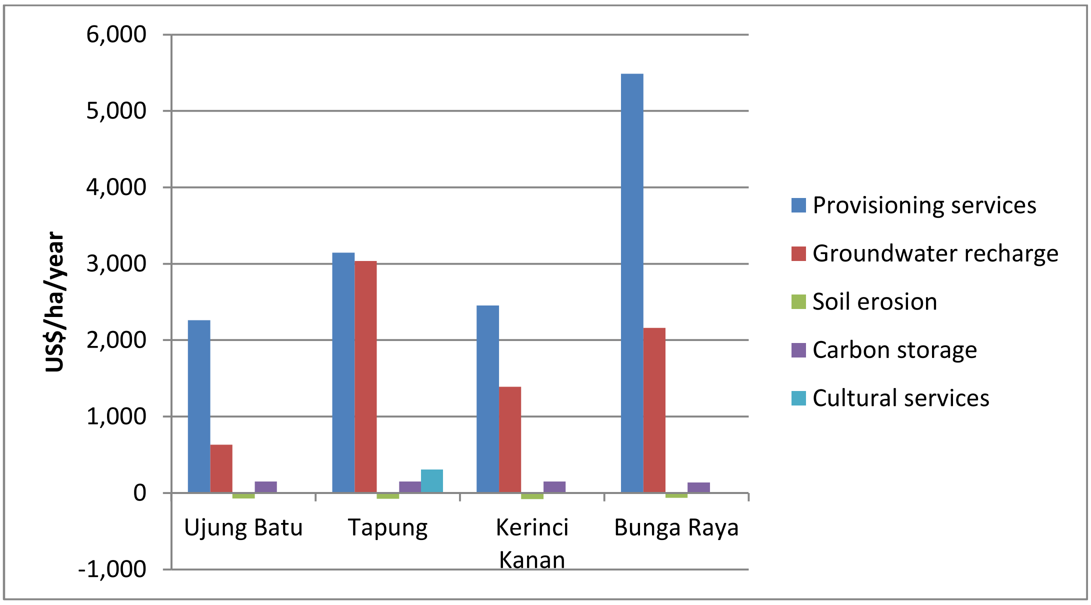


Figure 6.1. Summary of economic value of ES provided by oil palm landscapes in the four villages studied

6.5.4 Extrapolated value of ES in oil palm landscapes in Riau

In the next step in the research, I calculated the total economic values of ES associated with oil palm landscapes in all districts in Riau Province. To do this, I took the mean total economic values for the four villages and extrapolated them to the wider region of each village.

Table 6.5 exhibits the total economic values of ES in oil palm landscapes in Riau by province. The estimated aggregate annual value of ES provided in the oil palm landscapes in all 12 districts of Riau was approximately US$ 15,000 million in total. This figure includes the economic value of marketed and non-marketed ES. The total economic value for oil palm smallholders in Riau was US$ 8,500 million per year (approximately 56.7% of the value of ES in oil palm landscapes in the province) and the economic value of oil palm companies' holdings was slightly lower than that of smallholders, at US$ 6,500 million.

Table 6.5. Total economic value of oil palm landscapes in Riau (US$ million billion/year)

District	TEV smallholders	TEV companies	TEV
Rokan Hulu	1,300	1,401	2,702
Siak	1,371	501	1,872
Kampar	1,239	1,283	2,522
Rokan Hilir	1,089	589	1,678
Bengkalis	1,012	292	1,304
Indragiri Hilir	707	405	1,112
Pelalawan	767	1,226	1,993
Kuantan Singingi	464	376	839
Indragiri Hulu	371	405	776
Dumai	230	-	230
Pekanbaru	26	44	70
Meranti Islands	-	-	-
Total Riau Province	8,576	6,522	15,097

In terms of districts, Siak has the highest annual ES value for all services among oil palm smallholders, at nearly US$ 1,400 million per year, followed by Rokan Hulu (US$ 1,300 million) and Kampar (US$ 1,200 million). Rokan Hulu has highest ES value of oil palm landscapes among large holders (companies), at just above US$ 1,400 million per year, followed by Kampar and Pelalawan. In terms of the total economic value of ES from all holdings types in oil palm landscapes in Riau, Rokan Hulu District had the highest (US$ 2,700 million per year), followed by Kampar District and Siak (Table 6.5). As the four villages sampled in this study are located in these districts, support is provided for them being representative of much of the oil palm landscape in the province. Figure 6.2 depicts the total economic value of ES in oil palm landscapes based on each district in Riau.

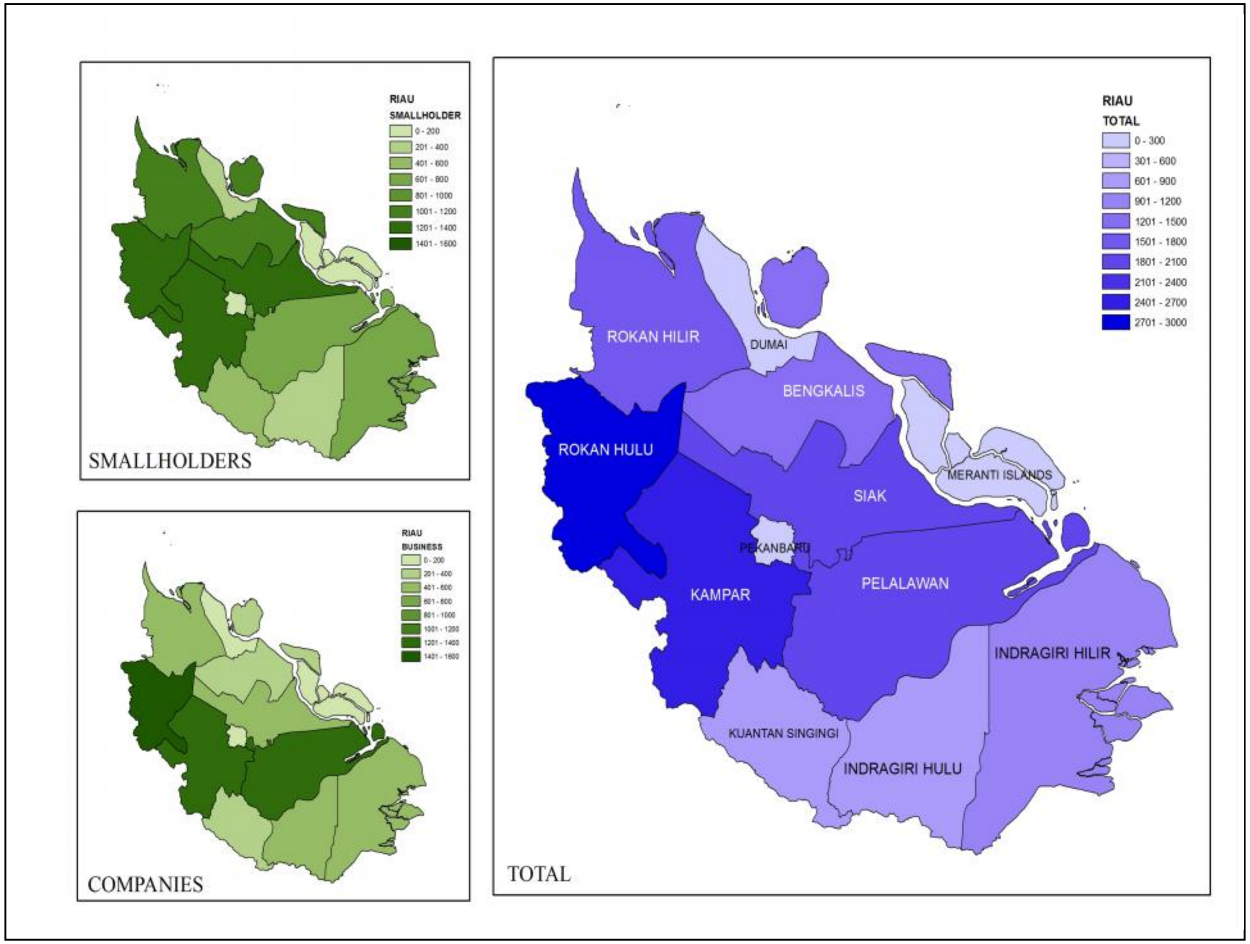


Figure 6.2. Total economic value of oil palm landscapes in Riau (US$ million/year)

6.6 Discussion

6.6.1 ES associated with oil palm landscapes

The majority of the research literature reporting the impacts of oil palm on the environment focus on forests and biodiversity. Prior studies on the ES provided by oil palm landscapes are limited. This study recognises that oil palm landscapes provide many ES that benefit human beings, despite the changes in biodiversity brought about by forest conversion.

Oil palm is grown via industrial-scale monoculture farming practices (Edwards et al. 2014b; Kongsager & Reenberg 2012), including oil palm grown on estates by companies and by smallholders who are generally attached to companies in some way (Feintrenie, Schwarze & Levang 2010). It can be argued that oil palm landscapes not only provide products for the market, but that in doing so, they benefit human beings. This study argues that these benefits derive not just from the oil palm cultivated, but also from other crops and livestock that share the oil palm landscapes. This study, therefore, conforms with an earlier study that contends that smallholders in Indonesia grew various tree crops to hedge fluctuations in income from the main crop grown (Barlow & Tomich 1991). Because of the substantial amounts of liquidity among rich farmers in the oil palm landscapes, increasing the local ruminant population is another livelihood diversification strategy (Zahari et al. 2003) and one that provides a return to the landscape through organic manure to manage soil fertility (Devendra 2004; Gabdo & Abdlatif 2013; Owolabi et al. 2014). However, in both cases diversification into other tree crops and livestock is not widespread.

It is not inevitable that the expansion of oil palm production has had an impact on deforestation, and hence loss of biodiversity in oil palm landscapes (Fitzherbert et al. 2008). These impacts will result in changes to ES, particularly regulating and supporting services. However, this impact also takes place as a result of other human activities, especially agriculture, which alters environments significantly (Hooper et al. 2005). According to my research, oil palm landscapes still provide positive regulating services such as water regulation and carbon storage. Similarly, there is space in the oil palm landscapes for cultural service, such as sacred forest groves, which provide similar services to tracts of natural forest (Gokhale & Pala 2011).

In addition to the ES identified by farmers in my research, current literature reveals the availability of supporting services associated with oil palm landscapes. Pollination, soil nutrients and biological control are some examples considered as important non-traded ES in agriculture (Sandhu et al. 2015; Schulp, Lautenbach & Verburg 2014). Therefore, this study argues that incorporating an ES approach contributes significantly to the understanding of oil palm landscapes.

6.6.2 Economic value of ES in oil palm landscapes

The economic values of 13 provisioning, regulating and cultural services in oil palm landscapes in Riau were calculated. Revenue from each provisioning service was generated from the marketable commodities. Since the areas researched are managed for oil palm production landscapes, the potentials of other marketable products were only partially investigated. This is because they do not dominate in these areas, and therefore could be missed by the relative small number of households surveyed. Examples of crops and livestock that might have been missed are cassava, maize, and goats.

Nonetheless, this study shows that oil palm generates the highest potential value in terms of per-hectare land use (US$ 1,315–2,043/ha/year) compared to other commodities. Some of the other crops do, however, generate reasonable returns per unit area. These include rubber (*Hevea brasiliensis*) (up to US$ 1569/ha/year) and areca nut (*Areca cathecu*) (up to US$ 1.594/ha/year). Such crops could provide significant alternatives to oil palm, but in any case these ES returns underline their importance as diversification various ways.

The mean total economic value of oil palm-dominated landscapes in Riau is approximately US$ 6,520/ha/year, with the range between the village with the highest value (Bunga Raya) and the lowest (Ujung Batu) being US$ 4,759/ha/year (Table 6.3). If these estimates of total economic value are compared to claims about the economic value of Riau's forest in its original condition (i.e. tropical lowland forest), they are higher than the total economic value of ES in tropical forests.

Estimates of which are between US$ 5,264–5,382/ha/year (Costanza et al. 2014; de Groot et al. 2012). Further, the average economic value of provisioning services in this study (US$ 4,331/ha/year) is much larger than that of provisioning services of 'unconverted' tropical forests, which consist of food, water, raw materials, genetic and medicinal resources, estimated at US$ 1,828/ha/year (de Groot et al. 2012). However, the actual estimation of the total economic value is lower than the potential value, as the actual incorporated costs of managing each agricultural activity were not reflected in the market. This is due to different qualities of fruits, prices, types of cultivation management practices, soil types and age of plantings.

People who largely depend on growing oil palm on their land tend to have lower values of provisioning services obtained from their farmland than those who are less dependent on oil palm. For example, farmers in Kerinci Kanan—an area that was opened up specifically for oil palm transmigration—largely grow oil palm with disregard to other crops and livestock, even though some like rubber, areca nuts and cattle have high potential. Initially, this tied into the politics of transmigration, but the continued reliance on oil palm is more likely a mix of the historical antecedents and the fact that since the settlement has been established oil palm has provided a stable high income. In that respect, oil palm is similar to other high value, high demand stable crops grown by smallholders in well-established plantations, e.g. vanilla in Madagascar and coca in La Paz Department in Bolivia.

This study considered four non-marketed ES in the economic valuation of the areas dominated by oil palm-growing activities. The figures generated in quantifying services were mostly based on secondary data. The differences in estimation that arise between this study and previous studies can also be ascribed to differences in assumptions when calculating the values in the different studies and this does bring into question issues of confidence limits on these ES compared to more accurately estimated provisioning ES in similar research. Nevertheless, the estimates can be considered as indicative of values the services provide. The average economic value of groundwater recharge is about US$ 1,806/ha/year. This is much higher than the average value of water regulation in tropical forest (US$ 8/ha/year) estimated by Costanza et al. (2014). On the other hand, the value of carbon storage quantified in this study (US$ 147/ha/year) was much lower than ascribed to average climate regulation provided by tropical forest, representing US$ 2,044/ha/year (Costanza et al. 2014).

Soil erosion in tropical forest has been valued at about US$ 337/ha/year by Costanza et al. (2014); this figure is much larger than the dis-services impact of soil erosion from oil palm calculated in this study of US$ 71/ha/year on average. Like other crops, oil palm is also vulnerable to soil erosion. However, this study indicates that the negative economic value of soil erosion is not very large. My observations, supported by some of the statements made by farmers when surveyed, is that the rapid establishment of ground covers makes oil palm landscapes relatively resistant to erosion compared to other types of agricultural crops (Corley & Tinker 2003). This is accentuated by the relatively low frequency of manual weed control. Finally, the use of tropical forest for recreation and cultural activities was estimated at $ 867/ha/year by Costanza et al. (2014). This is greater than the value assigned to sacred forest in this study ($309/ha/year), but given that there was only one example of remnant forest being ascribed to cultural significance in this study, this can only be a tentative comparison.

Many non-marketed ES have not been included in the estimations for Riau. This is a limitation of this study and is related to the methodology used. A household survey is a tried and tested method, and one that can be used to identify ES. However, it favours provisioning services. Having completed this research I think it would be possible to obtain more information on non-marketed ES, but to do so would involve more interactive survey methods that would significantly increase the time burden imposed on farmers. An alternative way to improve this aspect of ES estimation would be complementary biophysical assessments in the field. There is also the lack of recognition of proven important ES such as pollination in oil palm that farmers did not recognise in the villages I surveyed.

Tropical forest plantations, such as oil palm, have gained a bad reputation globally. They are typically assumed to be poor substitutes for natural forests, particularly in terms of biodiversity conservation, carbon storage, provision of water and other goods and services. Often they are monocultures that do not appear to invite recreation opportunities or other direct uses. Yet, this study clearly shows that oil palm can play a vital role in the provision of ES, when compared to agriculture and other forms of land use, or when natural forests have been degraded.

It is believed that oil palm landscapes have a legitimate place in the sound management of forests. Well-planned plantations can actually alleviate some of the social, economic and ecological pressures currently being placed on natural forests (Paquette & Messier 2009). Utilising the economic benefit here must be the key management objective, yet this is hampered by the fact that proper economic valuation of ES in oil palm landscapes areas was not done thoroughly in the past. Holistic economic valuation might help to facilitate sustainable management of the many ES that oil palm landscapes provide. Such economic valuations could help redesign oil palm landscapes based on sound ecological knowledge to enhance ES provision more broadly. That could improve smallholder incomes by replacing unsustainable inputs and by better managing natural resources, in order to support and ensure long-term sustainable oil palm cultivation in the face of very rapid human population growth.

6.6.3 Economic value of ES oil palm landscapes in Riau Province

The potential economic value of ES provided by oil palm landscapes has been illustrated by quantifying its value for the totality of oil palm landscapes in Riau Province. From 2012 data on oil palm areas in Riau, I estimated that total economic value of ES was about US$ 15 billion per year. That is about one third of GDP (current price) of Riau Province in 2012 (BPS - Statistics of Riau Province 2014). This illustrates the high potential economic value of ES provided by the oil palm landscapes in the province that are co-jointly generated for smallholders (56.7% of total economic value of ES in oil palm landscapes) and companies.

The purpose of extrapolation to quantify total economic value of all oil palm landscapes in Riau has been to exemplify the potential relative magnitude of ES provided by these landscapes. But it should be noted that this value is not a precise estimate. Extrapolations such as this could be used to support ‘what if’ scenarios to show future illustrations of potential value (Sandhu et al. 2015). In this case, the total value yielded in this study can be used as an initial estimation and to encourage recognition of the potential contributions of ES associated with oil palm landscapes to Riau’s economy.

6.6.4 Limitations of the study

The economic value of ES provided by oil palm landscapes illustrated in this study looks appealing; however, it should be deployed with caution. Different methods to the one that I used in this study (Section 6.3.1) could have significant impacts on total value. Some caveats that I have identified include the following.

1. I used current value for all estimations. The value assigned to all resources is dependent on the context of the valuation, and varies across time and space. If there are changes to the demand and supply of oil palm, the value will change, and so will the valuation;

2. The results for economic value yielded in this study are derived mostly from data generated from the household survey, that is from smallholders. Different samples (villages) may result in different responses, though the data suggests the villages are representative of the main oil palm growing districts in Riau. For example, agricultural commodity prices were based on the respondent’s answers in the household survey. Prices may vary across provinces and depend on the cultivation or livestock rearing cycles;

3. The value of provisioning services is considered to be an overestimate, because as farm goods, they were produced and valued with a combination of both their ES from nature and capital investments, such as fertilizer, farm equipment, built infrastructure, etc;

4. For groundwater, I made assumptions about evapotranspiration rates and water prices. Different water balance models and surrogate prices would produce different valuations;

5. Similarly, I used an average price of soil sold in Pekanbaru for housing construction, and for the carbon price I used data from the carbon emissions global market. These are both subject to variation;

6. There could be some biases in using benefit transfer method to determine proxy values for water and soil as, in rural areas, supply is higher and demand is lower;

7. In estimating sacred forest, I used an assumption that the land value of sacred forests equalled the value of land if were used for oil palm over 25 years. A different estimation approach would lead to different value; and

8. The result of total economic value of ES in oil palm landscapes for the whole Riau Province needs to be carefully assessed if one wants to use extrapolation. I extrapolated by multiplying average value for the total area occupied by smallholders and companies (large holders). Large holders of oil palm production may not engage in other agricultural activities, i.e. they tend much more to being a monoculture and have better cultivation practices much more attuned to commercial production than some smallholders. The limitations in extrapolation ideally should also incorporate knowledge about the characteristics of demand and supply in each landscape (Balmford et al. 2002); that it tends towards simplification, which can cause bias (Balmford et al. 2011) and bring about misleading or uncertain results (Barrios 2007).

6.7 Summary of Chapter

This study reveals that oil palm landscapes provide a range of ES. Thirteen ES were identified and valued in the oil palm landscapes in four areas in Riau Province. The economic value of the direct and indirect benefits derived from the ES was substantial, averaging at US$ 6,520/ha/year (range: US$ 2,970 – 7,729/ha/year). Of these averages, US$1,315 to 2,043 ha/year (average: US$1,707/ha/year) resulted from the production of oil palm fruits. Diversifying agricultural activities through the cultivation of other, mainly tree crops, and rearing livestock increases the value of provisioning services derived per hectare of land. Approximately a quarter (24%) to a half (52%) of the total economic value of ES is provided by four non-marketed ES (groundwater recharge, soil erosion control, carbon storage, and the cultural values of sacred forest groves). Spatial extrapolation revealed that the total economic value of ES provided by all oil palm landscapes in Riau Province (both smallholders and companies) is around US$ 15 billion/year, and that 56.7% of this value (US$ 8.5 billion) is generated by smallholders. In comparison, Costanza et al. (1997) estimate the global value of ES with an average of US$ 33 trillion/year in 1995 US$. Using an updated 2007 US$ data, Costanza et al. (2014) estimate the ES global value of US$ 125 trillion/year.

The household survey was an effective instrument to provide the data from which to estimate ES. However, it could have been improved. Perhaps that would have been best done in used in conjunction with biophysical studies in the oil palm plantations. Non-marketable ES have a major contribution to the total economic value of the oil palm agroecosystems. However, these are an undervalued group of ES as this study did not measure some components, especially supporting services, which could be used in future research. In particular, biological control of pests and pollination would be expected to increase oil palm ES.

Furthermore, as the results of this study were generated from a smallholder perspective, future research should focus on company estates. That is an entire PhD research thesis in itself.

CHAPTER 7:
INTEGRATING LIVELIHOODS PRODUCTION AND THE ECOSYSTEM SERVICES FRAMEWORK IN OIL PALM LANDSCAPES

7.1 Introduction

The boom in oil palm cultivation due to the dramatic increase in global demand has created opportunities for farming families in rural regions to improve their standards of living while simultaneously impacting ES associated with oil palm landscapes.

This chapter presents a discussion at the nexus of livelihoods production and ES in the oil palm landscapes. Section 7.2 summarises the results of the rural livelihoods study from Chapter 5, and is followed by an exploration of the various various ways that have characterised livelihood strategies in four villages studied. Section 7.3 considers the results from economic valuation of ES provided by oil palm landscapes as per Chapter 6. Section 7.4 examines the potential for integrating ES with the rural livelihoods approach in oil palm landscapes. A summary is presented in Section 7.5.

7.2 Livelihood Strategies

In part of this thesis, I focused on livelihood outcomes through the optic of total household income. The household was used as the fundamental component of production that generates incomes (de Sherbinin et al. 2008). The importance of oil palm activities in supporting livelihood outcomes in rural communities is well established (Rist, Feintrenie & Levang 2010; Susila 2004). However, I have found only a limited number of studies that have examined the livelihood patterns of the oil palm farming families. I have assessed the factors that influence total household incomes in four representative villages in the oil palm-dominated landscapes of Riau, and found that there are at least two significant patterns of the rural livelihoods in these villages:

1. Households where oil palm provides a substantial contribution to the livelihoods because of the high degree of reliance on oil palm activities as the main source of income. An average of 77.7% of the surveyed households across the four villages depend highly on oil palm income; and
2. Although oil palms dominate all households investigated, there are those households with more diversified livelihood strategies – although a minority overall. Diversification strategies fall into two groups:
    a. Those where livestock production, particularly cattle rearing, is an important contribution to total household income; and
    b. Those where non-agricultural activities are carried out, in particular the purchase of pick-up trucks which then enable transportation businesses to be established.

Minor diversification livelihoods strategies include other tree crops, salaried jobs, jobs in businesses, and local retailing.

7.2.1 Livelihood strategies compared across the four villages

Most households in these four villages were quite similar in terms of oil palm livelihood-dominated strategies. But how they started oil palm cultivation and how they reinvest oil palm income, either to accumulate land and increase their old palm holdings or to diversify, does highlight key differences between villages. I base this analysis on the notes taken during the administration of the questionnaires as well as the results of the correlation and multiple regression analyses (Chapter 5).

Figure 7.1 shows how oil palm-dependent households in Ujung Batu generate their incomes. As mentioned earlier (Section 3.3) oil palm was introduced to Riau by the state-owned estate, PTPN V, which opened plantations in Rokan Hulu, the district in which Ujung Batu is located. Respondents in Ujung Batu revealed that some of the earliest (and therefore longest established) smallholders were transmigrants who came to cultivate oil palm as part of the NES scheme with PTPN V. The independent smallholders interviewed in this location were individuals who migrated to Ujung Batu to work as contract workers at PTPN V in early 1980s. These two cohorts of smallholders indicate that Rokan Hulu is a mature and well-established oil palm landscape: a point reinforced by the fact that some estates that belong to PTPN V in

Ujung Batu have been replanting since the late 2000s.

Furthermore, as Ujung Batu is on the main interprovincial road to northwest Riau and North Sumatra Province, it has grown into a major commercial hub. This has triggered people to migrate into the town of Ujung Batu to take advantage of these opportunities. Some of these people, as well as residents who lived there before the oil palm boom, have also invested in oil palm – either as full-time smallholders or combining oil palm cultivation with forms of employment in the town. Unlike the transmigrant households who are tied to PTPN V, the other two cohorts of smallholders have bought land to start farming and many cultivate independently of PTPN V.

In Tapung, many household surveyed were long-term residents – meaning that they or their predecessors had lived in the area for a long time before oil palm arrived. But, there are different ways into oil palm here as well (Figure 7.2). As usual, there is a transmigrant cohort who moved to Tapung to grow oil palm, in this case in the early 1990s. As part of NES transmigration scheme, around 20% of the NES oil palm area was allocated to the cohort of existing local residents, mainly rubber tappers who owned their own plantations. In the early years of oil palm cultivation in Tapung fruit production was poor and the price of palm oil was low, compared to prices from 2000 onwards, and some of the NES members (both local residents and transmigrants) could not afford to wait to obtain an income from oil palm. As a consequence, they sold their allocated plots, usually to other NES members in the area.

The long-term residents organised two types of NES-cooperative (KKPA) schemes, in 1997 and 2001 on customary land, which were previously logged concessions. The first is a part managed scheme. Initially the private estate organised this for the first five years and then transferred the cultivation management practices when the farmers were able to buy the land on credit. The second is a fully managed scheme, where the private estate company manages all the cultivation practices and the local people receive a monthly 'salary'. In addition, local people can convert part or all of their own cultivated land to oil palm.

Kerinci Kanan is relatively more homogenous in terms of oil palm livelihoods compared to Ujung Batu and Tapung. It was identified as an oil palm region for transmigration purposes in the late 1980s (Figure 7.3). As part of the NES-transmigration scheme, each household received two hectares of land for oil palm and 0.5 hectare for housing and food crops. As in other NES-Trans schemes, some local people were also allocated land for oil palm, however as the location was remote and oil palm prices were low many of these local people sold their land allocations. Some spontaneous migrants came to Kerinci Kanan in the late 1990s, largely due to the attractiveness of oil palm in generating incomes in the area.

Finally, in Bunga Raya (Figure 7.4) a transmigration policy was introduced in the early 1980s with the focus on growing food crops, particularly rice. The local government also introduced paddy rice to local people in the area. The area is still considered central to rice production in Siak District and Riau Province due to the flat topography and peat-rich soils. An irrigation project was introduced in the 1990s, however this failed and farmers in this area began to convert their land to other crops, including to oil palm, which by the late 1990s was becoming increasingly popular in Riau. They began planting oil palm as an experiment, and for many farmers it has now become their major source of income. Most of these smallholders grow oil palm independently without any assistance from companies.

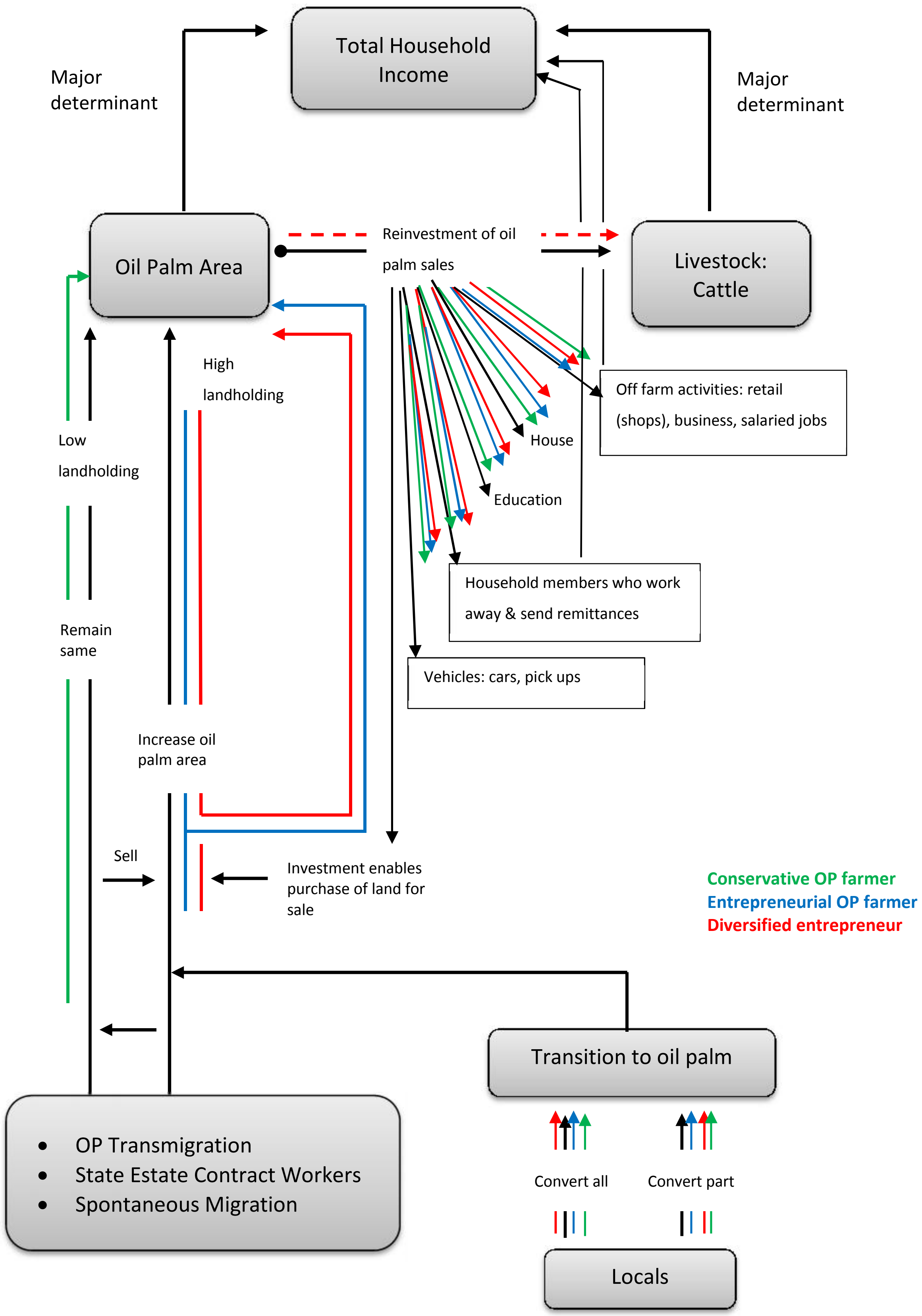


Figure 7.1. Various various ways of livelihood strategy development for oil palm-dependent households in Ujung Batu

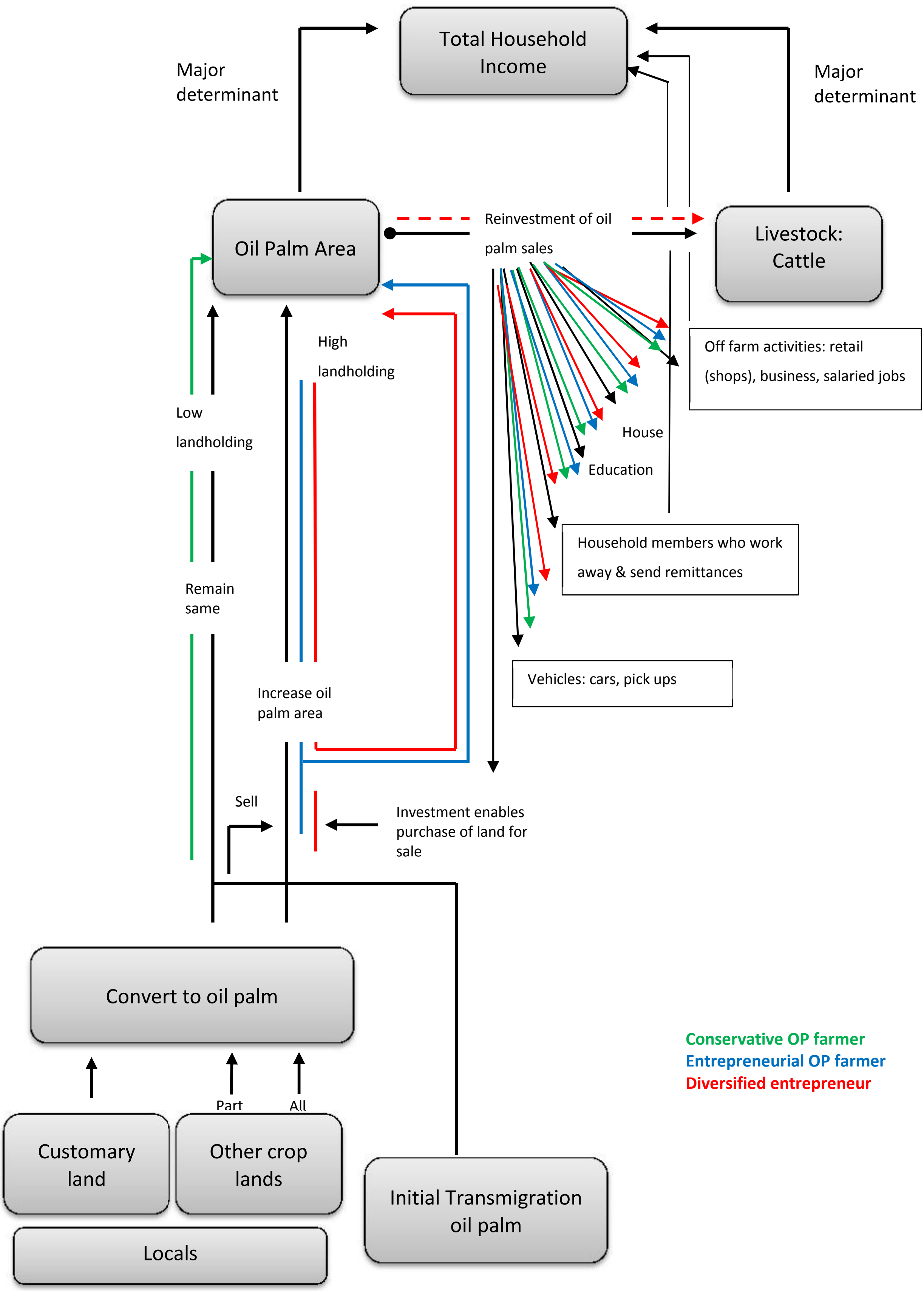


Figure 7.2. Various various ways of livelihood strategy development for oil palm-dependent households in Tapung

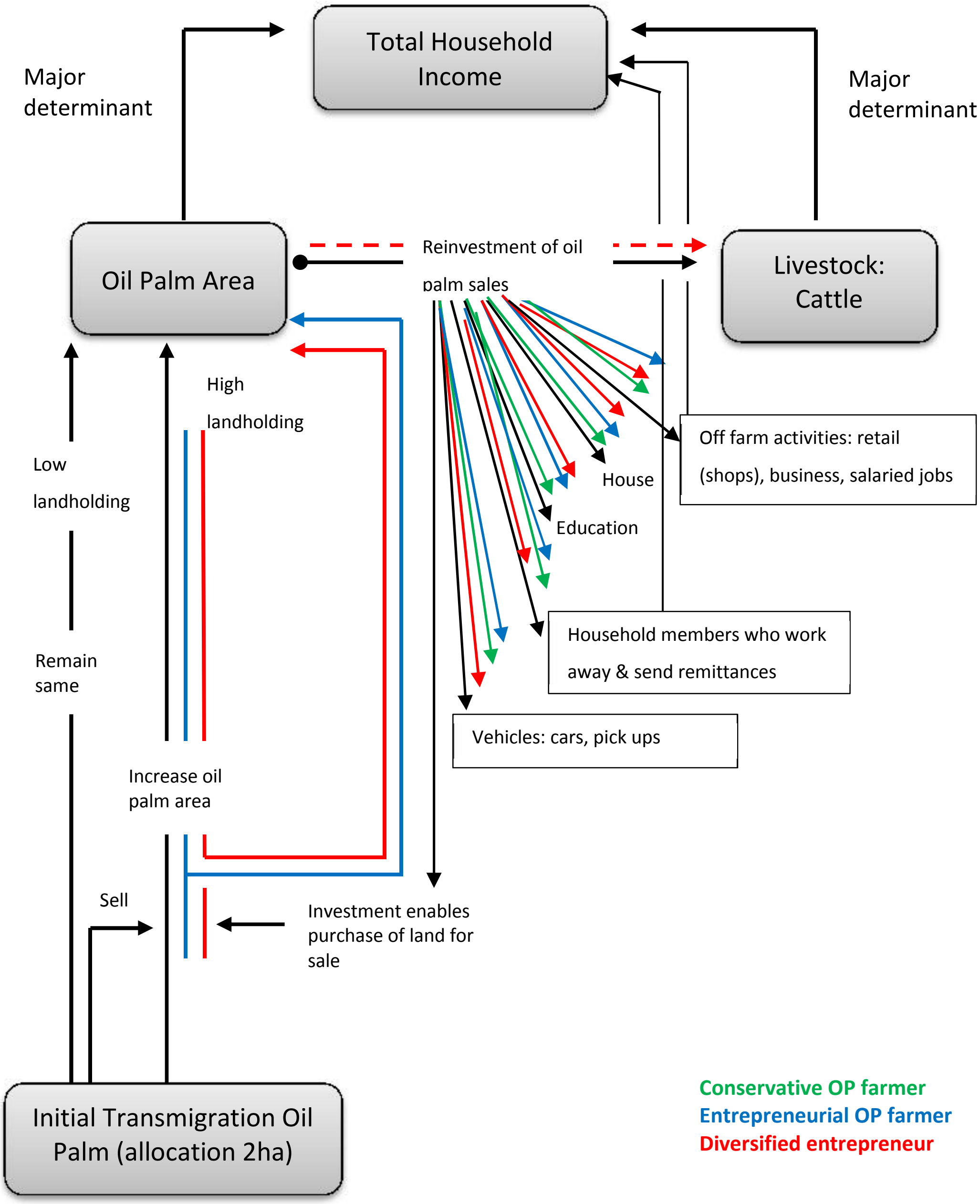


Figure 7.3. Various various ways of livelihood strategy development for oil palm-dependent households in Kerinci Kanan

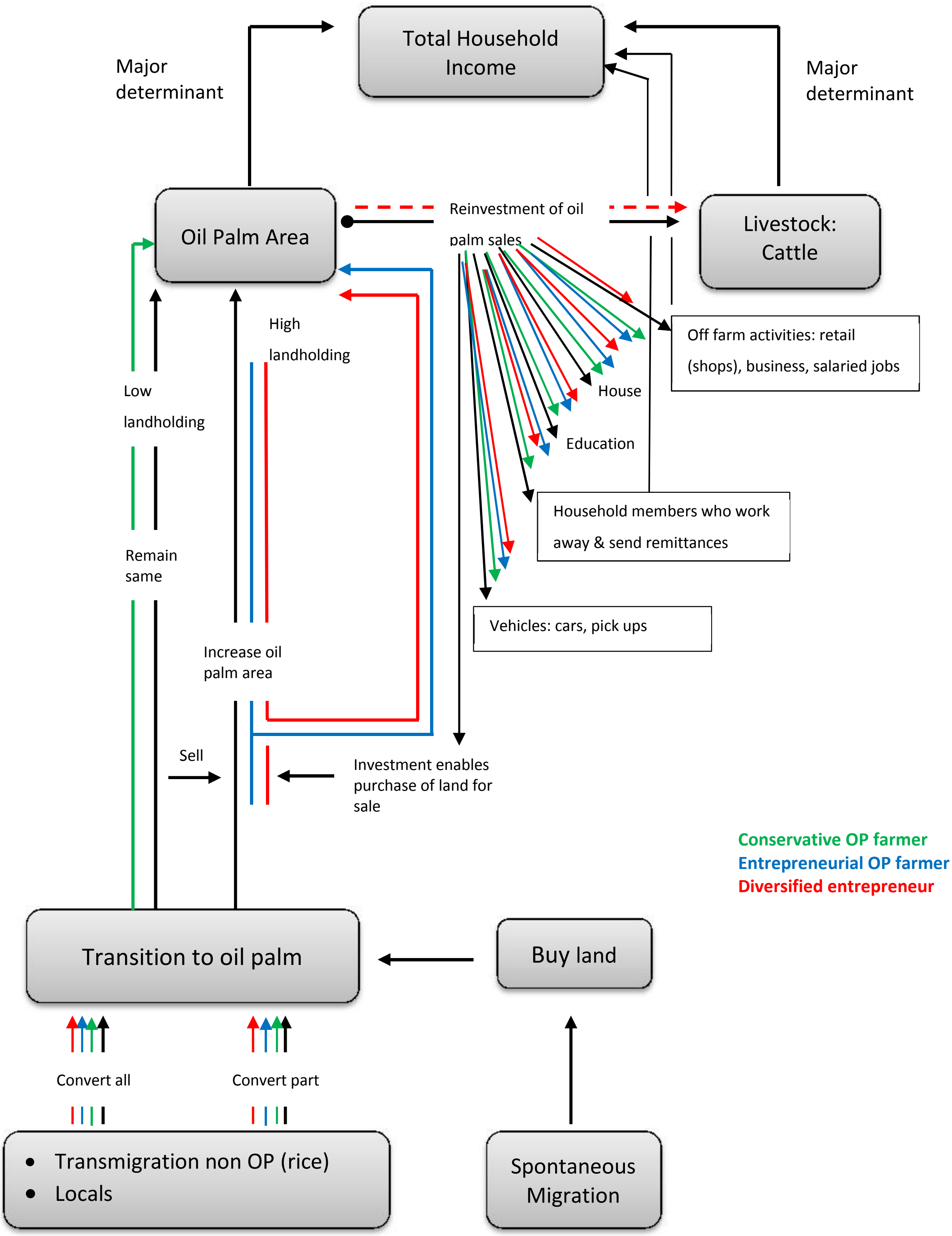


Figure 7.4. Various various ways of livelihood strategy development for oil palm-dependent households in Bunga Raya

As oil palms mature, they produce more fruit and hence generate more income. The income at the mature stage is in excess of household requirements and there is money to invest. The situation for investment is quite similar for all households in four study areas and I have identified three categorises of smallholders based on their attitudes to investment:

1. Conservative oil palm farmers;
2. Entrepreneurial oil palm farmers; and
3. Diversified entrepreneurs.

Conservative smallholders tend to have oil palm plantations that have remained more-or-less the same as their initial two-hectare allocation. Entrepreneurial smallholders invest much of their surplus income from oil palm sales in more land on which they grow oil palm, hence their landholdings are much larger than the original two-hectare plots. However, regardless of whether they are a conservative or an entrepreneurial farmer, oil palm makes a highly significantly contribution to total household incomes. These smallholders have developed a high dependency on oil palm in contrast to diversified entrepreneurial farmers.

Diversified entrepreneurs spread their investment into more land for oil palm, other crops, livestock and off-farm activities. Diversification is recognised as a key issue in rural livelihood strategies throughout the world (Ellis 2000a; Niehof 2004; Schroth & Ruf 2014). The regression models (Section 5.4.3) show that in addition to oil palm, other major determinants that contribute total household incomes include other farm activities - particularly cattle rearing - and the accumulation of household assets that can generate income such cars and pick-up trucks. Cattle rearing is an interesting case because all the examples in the households surveyed where feed lot-type operations that generate high returns per unit area of land compared to oil palm, while simultaneously not taking much land with potential for oil palm out of cultivation. Investment in vehicles, particularly pick ups reaps big benefits in rural areas as they are used to transport the farmers fruits (and hence avoid costs) while also generating income by transporting fruit, sacks of fertiliser and so on for farmers without transport. A further upside that they can used for family transport.

Reinvestment can also be used to advance livelihoods through improving housing conditions and educating children. Together with their parents, children can also contribute to total household incomes through on-farm activities and off-farm income-generating activities such as retailing and other businesses, and gaining salaried employment. Household members who work away can send remittances.

Diversification of activities in oil palm-dependent households can be critically important. It increases the level of “self-insurance” by farming families enabling then to reduce their vulnerability to environmental perturbations, market fluctuations and policy shifts (Barrett, Reardon & Webb 2001; Schroth & Ruf 2014). In Riau there is evidence to support this, with oil palm activities being balanced with other agricultural activities, in order to hedge against future shocks in the oil palm cultivation industry. However only the entrepreneurial farmers appear to recognise and respond in this way.

Though many studies (Barrett, Reardon & Webb 2001; Ellis 2000; Niehof 2004; Reardon et al. 2007; Schroth & Ruf 2014) argue the importance to diversification to rural, agrarian households in developing countries, there was unambiguous evidence as to the importance of diversification in the households sampled, both non-farm activities (Table 5.11) and other farm activities (Table 5.12), as well as diversified households tend to have larger flows of ES (higher total economic value from marketed ES) as depicted in Bunga Raya (Table 6.4). However, as this research is not employed a method of in-depth interview to oil palm farmers, hence the explicit survival strategy from diversification is not explored. This may be a failing of the questionnaire in pursuing this line of enquiry. So whilst some households do diversify the reasons for this, and its importance remain elusive and are a valid line of enquiry for future research in oil-palm landscapes.

7.2.2 Further comparisons between migrants and non-migrants in oil palm agriculture

In analysing households interviewed in Riau the first step taken by households, whether they are transmigrants or spontaneous migrants is that they chose oil palm farming as the means of improving their livelihoods. Migration itself can also be understood as a livelihood strategy that households undertake in combination with other strategies (McDowell & De Haan 1997).

Once household incomes grow and livelihoods improve because of the decision to grow oil palm, options for investment of accumulated capital open up. Agricultural extensification through the purchase of more land on which to cultivate oil palm cultivation, appears to be the next step that most farming families take on their way to more secure and improved livelihoods. This occurs because farmers tend to choose activities that they already familiar with, in this case growing oil palm. Although in some cases farmers have experience with other crops and livestock, or may have retained some land (if they not migrants) under say rubber. But oil palm provides smallholders a constant income throughout the year and this appeals to risk-adverse peasant farmers. This study confirms that oil palm has been used sustain and advances smallholder livelihood strategies regardless of whether they diversify or not.

Diversification to other activities, including other agricultural and off-farm activities is a further step that can be chosen by oil palm-dependent households. One of the important determinants of diversification for a household into other income-generating activities is incentives to diversify (Reardon et al. 2007). This may include pull factors such as higher payoffs and lower risks that some other activities, and push factors like seasonal or temporary declines in income due, for example, to weather events that put agriculture at risk. The push factors usually drive to secure in non-farm activities.

For the people that lived in the area before the oil palm boom, there is a tendency to adopt new agricultural activities when these activities have proven successful. Although some local farmers were allocated oil palm during the first establishment phase of NES-transmigration scheme, in general they tended to wait and see what oil palm would bring. Of particular concern to them appears to have been the three to five years between planting and obtaining the first harvest and many chose too continue with crops that were proven already. Such farmers are likely to adopt diversification strategies by increasing the area of land under more profitable crops (Schroth & Ruf 2014) but not necessarily abandoning other crops. In fact, in Riau is clear that the long-term residents adopted another strategy, which was that during the early years of NES-trans scheme, they sold their new land allocations.

Adjacency in agricultural landscapes is important. When oil palm plantations dominate the landscape, and appear to be lucrative business, a situation is set up where people in the area who are not migrants want to move into oil palm. They take the opportunity to convert their crop lands, especially land under rubber and rice, to oil palm (Feintrenie, Chong & Levang 2010). Local people who have been living in an area for a long time, also have the advantage that they can use land they have abandoned for oil palm (Rist, Feintrenie & Levang 2010; Suyanto et al. 2004).

7.3 ES and the Paradox of Oil Palm Landscapes

In chapter 2, I introduced the oil palm paradox. Oil palm has benefitted society across geographical scales that extend from an individual village in an oil palm producing regions to all countries at a global scale. It has been used by developing countries in some tropical regions as a vehicle to reduce poverty, by increasing farming opportunities for local people and to stimulate industrial development, and in providing a steady export income. However, the negative impact of oil palm cultivation in the tropics is also evident. Hence, the paradox that exists.

In Chapter 6, I have endeavoured to identify and assess the economic value of ES associated with oil palm landscapes. The key aspects of this part of my research are as follows.

1. To my knowledge, very few studies have investigated ES valuation in plantation landscapes, particularly oil palm. Using information gathered during a household survey, I have been able to identify the important ES provided by oil palm landscapes and estimate their economic value using a direct market approach. The use of a household survey as a method in ES is important because it is a well-accepted authoritative data collection tool in community-based studies, which can enable a researcher to quantitatively understand and measure the economic value of ES;
2. Oil palm landscapes in Riau generate high economic returns: on average of US$6,520 ha/year (range = US$2,970 – 7,729 ha/year) when traded and non-traded ES are combined;

3. My research shows that in addition to oil palm fruits, other key provisioning services are associated with oil palm landscapes. In the villages sampled in Riau these include nine provisioning services, which comprise seven crops (oil palm, rubber, coconut, bamboo, areca nut, cacao, and rice), and cattle and chickens. These ES were valued at US$2,263 – 5,489 ha/year depending on which villages was surveyed, with an average across the four villages of US$4,331 ha/year;
4. In an attempt to quantify the non-marketed ES provided in oil palm landscapes, I focused on groundwater recharge, soil erosion, carbon storage, and sacred forest values. I found the total economic value from these four ES is on average 33.6% of total economic value of ES in oil palm landscapes, and ranged between 23.8 – 52.1%; and
5. I also estimated the economic value of ES provided by oil palm landscapes in Riau Province through extrapolation. The total economic value of ES in oil palm landscapes in Riau is around US$ 15 billion/year, approximately a third of Riau's GDP in 2012.

I have explained the assumption and limitation of the economic valuation of ES in oil palm landscapes (Section 6.5.4) and identified some non-marketed ES that I did not include in the economic valuation study that need further research.

Despite these assumptions and omissions it is clear that ES provide benefits to human wellbeing, the importance of which has been recognised previously in the improvement of rural livelihoods and poverty alleviation (Fisher et al. 2013; Sandhu & Sandhu 2014). This is the case in Riau. Previous studies have acknowledged the high degree of dependence on ES in providing livelihoods for rural communities (Akwetaireho & Getzner 2010; Babulo et al. 2008; Bahuguna 2000; Dewi, Belcher & Puntodewo 2005). However, I would argue that there is a lack of attention on the importance of acknowledging ES approach in rural livelihoods, particularly in oil palm landscapes. The ES concept provides a meaningful framework with which to examine livelihoods of oil palm farming families. ES offers contextual information, as shown in Chapter 6, that oil palm cultivation has a high value in term of potential income returned in investment per hectare per year, which means smallholders depend heavily on oil palm cultivation for their livelihoods. However, oil palm is not the only agricultural activity which has a high value is provided in oil palm landscapes. Specifically, other crops notably rubber, coconut, cacao, areca nut, and rice together with livestock production such as cattle and chicken add the high value of ES in oil palm landscapes. Altogether, these ‘other’ provisioning services are valued at US$2,263 – 5,489 ha/year to communities I investigated.

Oil palm landscapes look like monocultures. While this may true when oil palm is grown on an estate, this is clearly not so for smallholder-dominated landscapes. As the smallholder area is always growing (in 2013 it covered more than 41% of total national’s oil palm area) this more heterogeneous landscapes provide more ES-related to be oil palm households in terms of income than that from oil palm alone. From the perspective of ES, households mostly care about provisioning services that their land generates, as these services generate direct benefits to their households. However, as this research shows, there are other provisioning services that are potentially profitable for smallholders.

Additionally, oil palm landscapes provide ES, that are not traded. These can reach half of the total economic value in some communities. They have value but no price tag. The use of money values for these ES does not however mean they can be sold in private markets. Until that is the case, they have to be seen as beneficial to effective land management and to be applied when decisions that involve economic incentives are needed (Costanza et al. 2014). At the present time the strength of the arguments around the oil palm paradox does not allow that to happen in oil palm landscapes. The use of ES valuation can also to assist in understanding of land managers preferences and showing the relative value given by the current generation, hence valuation can foster better decisions for resource allocation among competing land uses (de Groot et al. 2012). Therefore, this particular valuation study is important as it could make people appreciate the economic value of ES in oil palm landscapes and improve community understanding and awareness of ES provided by oil palm landscapes.

7.4 Integrating ES into Livelihoods Production in Oil Palm Landscapes

Having discussed the significant contribution of oil palm to livelihoods production (Chapter 5 and Section 7.2) and the importance of ES provided by oil palm landscapes (Chapter 6 and Section 7.3), I argue that developing a new framework that exploits the links between ES and livelihoods production is necessary (Figure 7.5). The framework is built on ES that I identified in oil palm landscapes, which comprise provisioning services, regulating services and cultural service. These ES provide the natural capital that forms part of the livelihood assets that support households. When oil palm farmers have secured access to land (natural capital), gradually they accumulate financial capital, physical capital, human capital and social capital. This capital influences livelihoods and outcomes, and is moderated by structures and processes in the oil palm industry, particularly oil palm mills (who buy fresh fruit bunches from smallholders and who provide extension services) and government policies in supporting the industry.

In Indonesia, the government recognises the importance of the oil palm industry in providing employment and in reducing poverty in the rural areas. However, the government considers that the industry could operate with only a limited set of government policies, such as price intervention:

> …the oil palm industry does not look to being [a] concern[s] of the government. This is because the private sector has managed it very well. Now, what the government [needs to] do is to control from regulation side (Government Officer – 1, February 2013).

I argue this view is incorrect, what my research demonstrates is that it is imperative for the government to look at oil palm landscapes from a wider perspective, and that implies a multiple policy environment.

From the analysis of interviews with stakeholders from government and non-governmental organisations, two main themes arose repeatedly in relation to livelihoods production and ES in the context of oil palm:

1. Support for smallholders; and
2. Oil palm expansion and sustainable development.

Government officials and NGOs identified support for smallholders as the key issue. One government officers went as far as to state that support for smallholders or oil palm farmers was essential to increase fruit quality, value and competitiveness in oil palm market:

> *Pemerintah juga memberikan dukungan dan support kepada petani kelapa sawit. Bimbingan teknis misalnya training of trainers dari propinsi, training terkait oil palm seperti bagaimana meningkatkan mutu, meningkatkan daya saing, distribusi, sehingga memberikan nilai tambah, merupakan bentuk peningkatan yang dapat dilakukan oleh kementerian pertanian. Dalam hal pengolahan produk ikutannya, ini lebih dilakukan oleh kementerian perindustrian.*
>
> The Government also gives encouragement and support to the palm oil farmer. Technical guidance, for example through training of the provincial trainers, including training on how to increase oil palm quality and how to improve its competitiveness and distribution, so it gives added value are parts of the improvement which can be provided by the Ministry of Agriculture. In terms of product manufacturing, it is done by the Ministry of Industry (Government Officer – 1, February 2013).

Another comment from a government official was:

> *Harus meningkatkan mutu yang mulai dari hulu sampai hilir, adanya good infrastructure facilities, good farming agriculture practices, good handling practices, good manufacturing practices, good distribution practices and good marketing practices.*
>
> There must be improvement from the start to the end, good infrastructure facilities, good farming agriculture practices, good handling practices, good manufacturing practices, good distribution practices and good marketing practices (Government Officer – 1, February 2013).

From the government side, expansion of oil palm is seen as a necessity in Indonesia. However, it needs to be controlled and planned, and also must meet the needs of specific sites in the community. This expansion must not harm the ecosystem either:

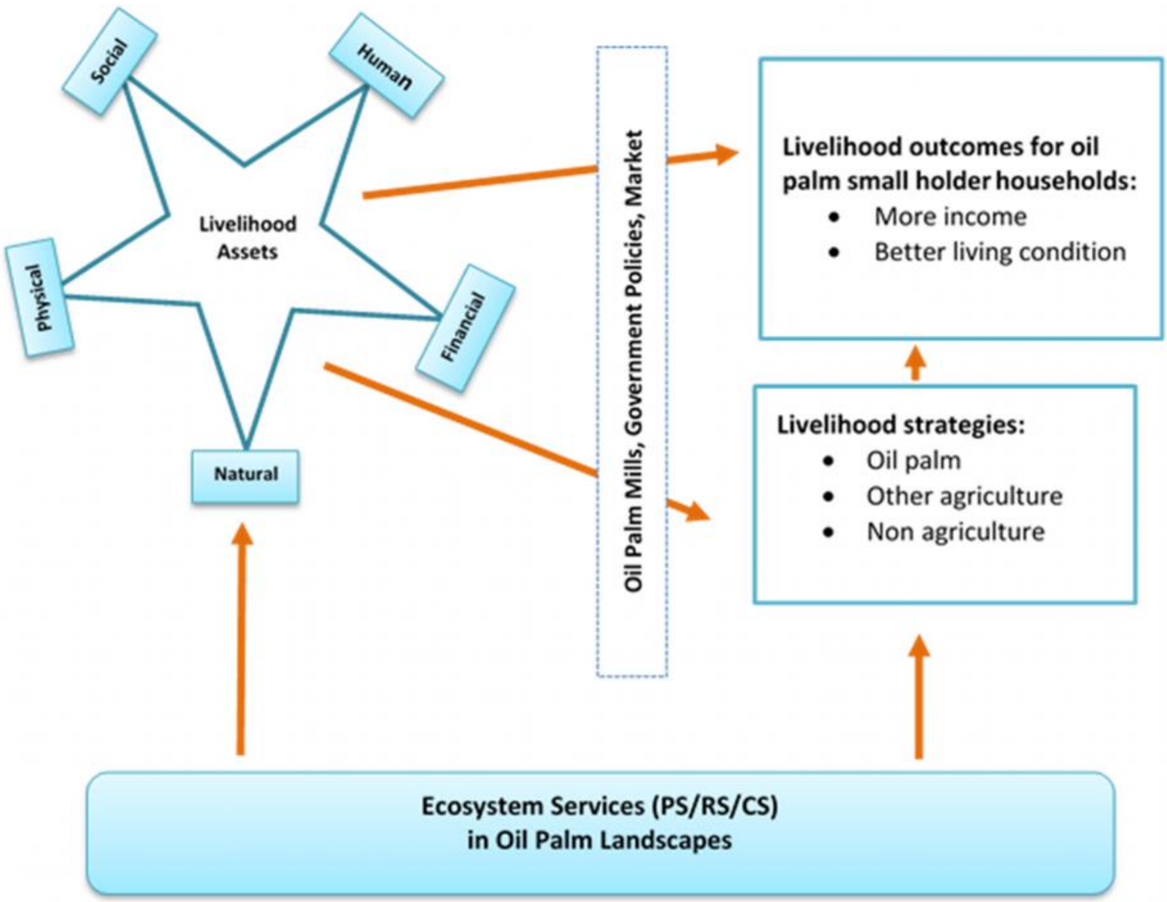
> *Ekspansi di dukung sesuai dengan kearifan lokal. Harus tepat guna, spesifikasi lokasi dan mempertimbangkan appropriate teknologi. Selama ekspansi prospektif, tidak mengganggu lingkungan. itu tidak masalah.*
>
> Expansion must have community support. It should be expedious, location specific and must consider the use of appropriate technology. As long as the future expansion doesn’t harm the environment, it’s not a problem (Government Officer – 1, February 2013).

> *Ekosistem kan ga ada di pikiran pengusaha. Ga ada. Ekosistem itu ada dalam pikiran para pengambil kebijakan.*
>
> The ecosystem is not thought about by business. It's not there. The ecosystem is in the thoughts of the policy makers (Researcher – 1 February 2013).

Sustainable oil palm development and its impact on the economy was also raised as an issue by one government officer, who commented it had a significant relationship with the global market:

> *…Yang namanya sustainable development itu bicara long term. Ini selalu diliat dari long term objectives. Nah apakah kalo kita bicara long term objectives dan kita tahu bahwa petani-petani yang sekarang menerima manfaat ekonomi dari kelapa sawit itu kan sebetulnya sangat tergantung pada kondisi global. Karena kelapa sawit kita memang bukan untuk konsumsi dalam negeri. Jadi harganya adalah harga global.*
>
> When we use the term sustainable development, we are talking long term. About long-term objectives. Well, if we're talking long-term objectives and we know the economic return from oil palm gained by farmers is actually very dependent on global conditions. This is because palm oil is really not for consumption in this country. So the price is actually the global price (Government Officer – 2, March 2013).
>
> *…sekarang itu mungkin pengalaman sawit kita kan belum sampai 30 tahun …sawit kita baru 10 an kali yah…iya ini kita baru 1 dekade dan itu belum bisa diukur dengan sustainability kan apakah asumsi global itu sama dengan yang akan datang.*
>
> Maybe our palm oil venture won't last for 30 years… our palms are only 10 years old aren't they …. Yes it's only been a decade and the sustainability is based on assumptions that the global demands will remain the same (Government Officer – 2, March 2013).

Figure 7.5 illustrates market demand and supply at national and global scales, and how it is affected by the strength of interactions between oil palm based-livelihood assets and livelihood strategies and outcomes. ES provide households choices of livelihoods strategies or activities, which then contribute to livelihood outcomes.



Note: PS: Provisioning Services; RS: Regulating Services; CS: Cultural Services

Figure 7.5. Integrated framework of ecosystem services and livelihoods production in oil palm landscapes

The increasing smallholder area means that there is an opportunity for more smallholders to improve their livelihoods. However, smallholders are very vulnerable to external shocks, which in turn affect their livelihoods. This is especially so in the households with high dependency on oil palm. This may be coming into play as my research is concluding especially as the global demand for palm oil has begun to slow down and, together with the declining global price of crude oil, may lead to the decrease in palm oil prices. This would have a direct effect on smallholder incomes. This study shows that oil palm cultivation is heavily dependent on fertilizer, which account for around 30% of the gross income (Section 5.4.1). Fertilizer prices are high, and if the purchasing power of smallholders falls they may be forced to use less fertilizer and yields would decline (Ghazoul 2015). From this study there is a clear message to government, which is to promote on-farm income diversification to incorporate other agricultural activities with relatively high net value in oil palm landscapes.

7.5 Summary of Chapter

This chapter explore the link between ES and livelihoods production in the oil palm landscapes. Integration of the ES approach to oil palm rural livelihoods is stressed. The high economic value of ES associated with oil palm landscapes provide an initial estimate of the potential ES that can be gained and maintained by the communities living in the oil palm landscapes. It is important to sustain livelihoods of oil palm-dependent households who are vulnerable to any external shocks. Integrating ES approach into rural livelihoods in oil palm landscapes indicates the importance of livelihoods strategies in income diversification, particularly in other on-farm activities.

CHAPTER 8:
CONCLUSIONS

8.1 Introduction

The final chapter summarises the study and presents the key findings in the context of the research objectives that were laid out in Chapter 1. In the next section the contributions the study will make to knowledge and practice are outlined. The fourth section makes recommendation concerning sustainable livelihoods and ES in oil palm landscapes. Finally, the chapter concludes by highlighting the overall context of the study.

8.2 Key Research Findings

The primary aim of the research is to investigate socio-economic and ecological services and dis-services for people living in oil palm-dominated landscapes in Riau Province in Sumatra. The specific objectives were to:

1. Assess livelihood patterns in the oil-palm dominated regions in Riau;
2. Characterise the ES underpinning oil palm-dominated farming systems and the associated households;
3. Examine the economic value of ES in these landscapes; and
4. Understand the impact of oil palm production has on rural livelihoods and ES in oil palm landscapes.

The research engaged with both the sustainable livelihood and the ES frameworks to achieve the above objectives. These frameworks were used because they are appropriate and enable conceptual models to be developed that are related to the study's objectives. The sustainable livelihood framework contains the main elements that influence people's livelihoods and is routinely used in assessing the contribution of different activities or strategies to try and achieve sustainable livelihoods. Combining the sustainable livelihood and ES frameworks is a strong research design element the study, because the ES framework integrates the ecological, social and economic dimensions of natural resources management and complements the livelihoods approach.

The following key findings are related to objective 1.

1. Income from oil palm cultivation dominates employment patterns and total household incomes in the vast majority of households sampled;
2. A range of other agricultural crops, other natural resource off-takes and non-agricultural activities were identified in the household survey as non-oil palm income streams; in particular, cattle rearing, growing and tapping rubber, coconut groves, and investing in vehicles that can be used for local transport;
3. Diversification of household livelihoods through reinvestment of capital is not commonplace across the households researched and many remain highly dependent on a single crop – oil palm; and
4. As a consequence, many households are in a 'high wealth-high dependency' position that exposes them to future risk, either in the context of economic boom-and-bust cycles in the oil palm industry or to other natural or synthetic products being substituted (in an economic sense) for oil palm.

This study also revealed that oil palm landscapes provide a range of ES. The key findings related to objectives 2 and 3 are the following.

1. 13 ES were identified and valued in the four villages studied. These are oil palm fruit, rubber, coconut, bamboo, areca nuts, cacao, rice, cattle, chicken, groundwater recharge, soil erosion, carbon storage and sacred forest groves;
2. The economic value is substantial averaging US$6,520 ha/year (range = US$ 2,970 – 7,729 ha/year) with the highest amount (average = US$1,707 ha/year; range = US$1,315 to 2,043 ha/year) coming from oil palm fruits;
3. The value of provisioning services per hectare within these oil palm landscapes increases on farms that diversify from oil palm by including other crops (especially tree crops) and livestock;
4. Approximately 23.8% to 52.1% of the total economic value of these oil palm

landscapes is provided by non-marketed ES (groundwater recharge, soil erosion, carbon storage, and sacred forest groves); and

5. The total economic value of ES generated by smallholders and companies operating in the oil palm landscapes across Riau Province is around US$ 15 billion annually, with a little over half (US$ 8.5 billion) originating on smallholder plantations.

The significant influence of oil palm production on rural livelihoods and ES in oil palm landscapes was revealed in Chapter 7 in to response objective 4. It is evident that the integration of the ES approach into the understanding of oil palm-dominated rural livelihoods provides wide-ranging findings. These include the observation that valuing oil palm landscapes using marketed and non-marketed ES further emphasises the importance of oil palm to farming livelihoods. This view was reinforced by stakeholders who, during interviews, generally acknowledged that the oil palm industry makes substantial contributions to their livelihoods.

8.3 Recommendations

The findings associated with the sustainability of oil palm production are a complex mix of socio-economic and environmental. Clearly they cannot solely be resolved without a much better understanding of how livelihood patterns and ES interact in oil palm landscapes. This study is a contribution towards that. If recommendations can be made at this stage, they are the following.

1. It is important to develop national strategies for oil palm expansion that integrate sustainable livelihoods with the full range of ES, not simply the provisioning service around oil palm fruits. Furthermore, these strategies must be constructed so that it is clear whether impacts are reduced, and they must be integrated into land use policy and coupled with effective regulatory systems;
2. Government should emphasise programs that inform oil palm-dependent households the implications of being too dependenct on oil palm cultivation and their vulnerability to external shocks. In fact, this study shows the potential economic value of other provisioning services could be used as the

basis for alternative livelihood strategies that reduce exposure to risk;

3. The assessment of ES shows the substantial benefits they may bring. This information should be used to improve land management in oil palm plantations, for example by introducing programs for the people in the oil palm landscapes to recognise and appreciate the importance of non-marketed ES. Strategic alliances between stakeholders are needed to enable successful efforts in this area. Thus, there are opportunities for identifying ways in which palm oil yield can be increased while minimising negative environmental externalities; and
4. This study emphasised livelihood patterns of the oil palm-dependent households.
5. In terms of future research,
    a. The impacts of structures, processes and shocks on livelihood outcomes would be an important follow up to this study;
    a. As would a comparison of these with rural households that are not dominated by oil palm in Indonesia; and
    b. In addition, the ES that were not included in the economic valuation need to be researched in oil palm landscapes.

8.4 Contributions of the Study

This study provides contribution to theory as well as to practice. The study contributes to knowledge in terms of fields of academic study and methods, as well as providing important case studies from Sumatra. This project (when published) will extend the academic literature in the fields of sustainable livelihoods and ES by applying them to oil palm landscapes. This study improves the understanding, relationships and construct between these two conceptual approaches. Incorporating an ES approach to a livelihoods framework provides significant and appropriate evidence in identifying alternatives of livelihoods patterns and strategies, which highlight potential livelihoods outcomes to households. ES provide natural capital, one of the initial and most utilised livelihood assets in rural areas. In this study, economic valuation of ES in oil palm-dominated landscapes reveals the high value of oil palm, and it suggests that households rely greatly on oil palm activities. However, crops and livestock production which increase the overall value of ES are also relevant. These other farming activities or strategies can be employed as ways to assure and enhance livelihood outcomes. I developed a questionnaire for a household survey, which is a methodological contribution as it was designed to assess the nexus between livelihoods and ES in oil palm-dependent households.

This case study, to the best of my knowledge, this study is one of the first that integrates sustainable livelihoods with the economic valuation of ES in oil palm landscapes. In addition, this study was undertaken in Riau Province, a polticial unit with a paucity of rural resource-based development-focused research. More broadly, this study will contribute to the understanding and development of oil palm rural livelihoods worldwide, and should also contribute to the wider field of plantation farming systems.

The research offers a practical contribution by providing useful information to farmers, buisnesses, NGOs and, especially, to the national and provincial governments. The information that the study yields can provide a framework and methodology for the government to evaluate contemporary and future impacts of oil palm landscapes on the local environment and local economy.

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LIST OF APPENDICES

APPENDIX 4A - CLASSIFICATION OF ECOSYSTEM SERVICES

	Ecosystem Services	Definition	Example
Regulating services			
1	Gas regulation	Regulation of atmospheric chemical composition	**CO_2/O_2 balance, O_2 for UVB, SOx levels**
2	Climate regulation	Regulation of global temperature, precipitation, and other biologically mediated climatic processes at global or local levels	**Greenhouse gas regulation,**
3	Disturbance regulation	Capacitance, damping and integrity of ecosystem response to environmental fluctuations	**Storm protection, flood control, drought recovery**
4	Water regulation	Regulation of hydrological flow	**Irrigation, milling transportation**
5	Water supply	Storage and retention of water	**Watersheds, reservoirs, aquifers**
6	Erosion control and sediment retention	Retention of soil within an ecosystem	**Erosion control, reduction of runoff**
7	Waste treatment	Recovery of mobile nutrients and removal or breakdown of excess or xenic nutrients and compounds	**Waste treatment, pollution control detoxification**
8	Refugia	Habitat for resident and transient production	**Nurseries, habitat for migratory species, regional habitats for locally harvested species**
Provisioning services			
9	Food production	That portion of gross primary production extractable as food	**Production of fish, crops, nuts, fruits**
10	Raw material	That portion of gross primary production extractable as raw material	**Production of lumber, fuel , or fodder**
11	Genetic resources	Sources of unique biological materials and products	**Products for materials science, resistance to plant pathogens and crop pests**
12	Ornamental resources	For display purpose	**Horticultural products, flowers etc**
13	Medicinal resources	Source of medicinal compounds	**Products used in medicines.**
Cultural services			
14	Aesthetic information	Associated landscapes	**Landscaping of farmland**
15	Recreation	Providing opportunities for recreational activities	**Eco-tourism, sport fishing, outdoor activities**
16	Cultural and artistic information	Providing opportunities for non-commercial uses	**Aesthetic, artistic, education spiritual, and/or scientific values,**
17	Spiritual and historic information	Source of historic and spiritual value	**Associated history of farmsteads**
18	Science and education information	Source of education and training	**Research and development**

Supporting services			
19	Pollination	Movement of floral gametes	**Reproduction of plant populations**
20	Biological control	Trophic-dynamic regulations of population	**Reduction of herbivory by top predators, control of prey species**
21	Carbon accumulation	Carbon sequestration by vegetation and soil	**Regulation of chemical composition**
22	Mineralization of plant nutrients	Storage, internal cycling, processing and acquisition of nutrients	**Nitrogen fixation**
23	Soil formation (maintenance of soil health)	Soil formation processes (Turning over of soil by earthworms	**Structure maintenance**
24	Nitrogen fixation	Storage and cycling	**Legumes fixing N**
25	Services provided by shelterbelts	Protection against wind erosion	**Windbreaks**

Source: Barbier (2007); Costanza et al. (1997); de Groot, Wilson and Boumans (2002); MEA (2005); Sandhu, Porter and Wratten (2013); Sandhu, Wratten and Cullen (2007).

APPENDIX 4B – INFORMATION SHEET

INFORMATION SHEET

Title: 'Valuing ecosystem services in the Indonesian palm oil industry'

Investigators:
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Flinders University
Ph: +61 8 82013560

Description of the study:
This study is part of the Ph.D project entitled '*Valuing ecosystem services in the Indonesian palm oil industry'.* This project will examine variations in the ecosystem service value in response to land use changes in the Indonesian palm oil industry. This project is supported by Flinders University School of the Environment.

Purpose of the study:
This project aims to investigate the importance of ecosystem services in the Indonesian palm oil industry and how land use changes affect ecosystem services which are an important component in developing Indonesia's palm oil-based economy.

What will I be asked to do?

Interview
You are invited to attend a one-on-one interview with the researcher who will ask a few questions about your views and experiences in oil palm plantations and palm oil industry that you deal with. The interview will take about 30 minutes. The interview will be recorded using a digital voice recorder. Once recorded, the interview will be transcribed (typed-up) and will be shown to the participants to revise their comments. The participation is voluntary.

Focus group discussion
You are invited to attend focus group discussion in a group comprising ten participants. The discussion topic is about the perceptions and experience in oil palm plantations and palm oil industry. The Focus group discussion takes about one hour. The focus discussion group will be recorded using a digital voice recorder. Once recorded, the focus groups discussion result will be transcribed (typed-up) and will be shown to the participants to revise their comments. The participation is voluntary.

What benefit will I gain from being involved in this study?
Being involved in the interview and focus group discussion, your sharing of viewpoints and experiences will improve the planning and delivery of future policy and programs of ecosystem services in the palm oil industry. Through this study, the researcher is very keen to offer valuable information to stakeholders as the basis for greater recognition of ecosystem services in the development of Indonesian palm oil industry.

Will I be identifiable by being involved in this study?
The interview data will be coded when we analyse, store and publish the data so that your identity will not be attached to it; i.e. it will be depersonalised. All data will be stored in a locked filing cabinet at Flinders University School of the Environment main office for at least seven years that only the researcher (Mr Ando Fahda Aulia) will have access to. Your comments will not be linked directly to you.

Are there any risks or discomforts if I am involved?
The researcher anticipates few risks from your involvement in this study. If you have any concerns regarding anticipated or actual risks or discomforts, please raise them with the researcher and you may withdraw at any time.

How do I agree to participate?
Participation is voluntary. You may answer 'no comment' or refuse to answer any questions and you are free to withdraw from the focus group at any time without effect or consequences. A consent form accompanies this information sheet. If you agree to participate please read and sign the form.

How will I receive feedback?
Outcomes from the project will be summarised and given to you by the researcher if you would like to see them.

Thank you for taking the time to read this information sheet and we hope that you will accept our invitation to be involved.

This research project has been approved by the Flinders University Social and Behavioural Research Ethics Committee (Project No. 5878). For more information regarding ethical approval of the project the Executive Officer of the Committee can be contacted by telephone on 8201 3116, by fax on 8201 2035 or by email human.researchethics@flinders.edu.au

LEMBAR INFORMASI

Judul: ‘Penilaian jasa ekosistem di industri kelapa sawit Indonesia’

Peneliti:
Ando Fahda Aulia
School of the Environment
Flinders University
Ph: +61 8 82013560

Deskripsi penelitian:
Kajian ini merupakan bagian dari studi doktoral yang berjudul ‘Penilaian jasa ekosistem di industri kelapa sawit Indonesia’. Penelitian akan menguji variasi-variasi dalam nilai jasa ekosistem sebagai akibat dari perubahan penggunaan lahan di industri kelapa sawit Indonesia. Studi ini didukung oleh Flinders University School of the Environment.

Tujuan penelitian:
Studi ini bertujuan untuk menyelidiki pentingnya jasa ekosistem di industri kelapa sawit Indonesia dan bagaimana perubahan tata guna lahan mempengaruhi jasa ekosistem, yang merupakan komponen utama dalam pengembangan ekonomi Indonesia yang berbasiskan kelapa sawit.

Saya akan diminta untuk melakukan apa?
Wawancara
Anda akan diundang dalam wawancara individu dengan peneliti yang akan menanyakan beberapa pertanyaan akan pendapat dan pengalaman anda dalam perkebunan kelapa sawit dan industri kelapa sawit dimana anda terlibat didalamnya. Wawancara akan berlangsung selama kurang lebih 30 menit. Wawancara akan direkam. Setelah itu, wawancara akan ditranskripkan dan akan ditunjukkan kepada anda. Partisipasi bersifat sukarela.

Diskusi kelompok
Anda akan diundang untuk menghadiri diskusi kelompok yang terdiri dari sepuluh peserta. Topik diskusi adalah tentang persepsi dan pengalaman di perkebunan kelapa sawit dan industri kelapa sawit. Diskusi kelompok akan berlangsung selama kurang lebih satu jam. Diskusi kelompok akan direkam. Setelah itu, diskusi kelompok akan ditranskripkan dan akan ditunjukkan kepada anda. Partisipasi bersifat sukarela.

Apa manfaat saya terlibat dalam penelitian ini?
Dengan keikutsertaan dalam wawancara dan diskusi kelompok, berbagi pendapat dan pengalaman anda akan meningkatkan perencanaan dan penyediaan kebijakan dan program di masa depan akan jasa ekosistem di industri kelapa sawit. Melalui studi ini, peneliti sangat antusias untuk dapat memberikan informasi yang berharga kepada para pemangku kepentingan sebagai dasar penggunaan jasa ekosistem yang lebih besar dalam pengembangan industri kelapa sawit Indonesia.

Apakah identitas saya akan terlihat dalam keikutsertaan saya ini?
Data wawancara, termasuk nama anda, akan di-kode-kan dalam analisis, penyimpanan dan publikasinya sehingga identitas anda tidak akan terungkap. Wawancara akan ditranskripkan dan disimpan sebagai *file*. Semua informasi yang teridentifikasi akan dihilangkan, sehingga pendapat anda tidak akan terhubung secara langsung ke anda. Semua data akan disimpan dalam lemari terkunci di kantor utama Flinders University School of the Environment selama tujuh tahun dimana hanya peneliti (Ando Fahda Aulia) yang memiliki aksesnya.

Apakah ada risiko atau ketidaknyamanan jika saya terlibat?
Peneliti melihat sangat kecil kemungkinan risiko dari keikutsertaan anda dalam studi ini. Jika anda merasa ada risiko atau ketidaknyamanan yang dapat diantisipasi sebelumnya, mohon dapat menyampaikannya kepada peneliti dan anda dapat kapan saja menarik diri dari keikutsertaannya dalam penelitian ini tanpa ada konsekuensi apapun.

Bagaimana saya setuju untuk berpartisipasi?
Partisipasi anda bersifat sukarela. Anda dapat menjawab 'tidak bersedia berkomentar' atau menolak untuk menjawab pertanyaan dan anda dapat menarik diri kapan saja dari wawancara tanpa ada konsekuensi apapun. Formulir persetujuan untuk berpartisipasi menyertai lembar informasi ini. Jika anda setuju untuk berpartisipasi, mohon dapat membaca dan menandatangani formulir tersebut.

Bagaimana saya bisa mengetahui hasilnya?
Hasil penelitian akan dibuat kesimpulannya dan anda dapat melihatnya apabila menginginkannya.

Terima kasih anda telah meluangkan waktunya untuk membaca lembar informasi ini dan kami berharap kesediaan anda untuk bekerja sama dalam penelitian ini.

This research project has been approved by the Flinders University Social and Behavioural Research Ethics Committee (Project No. 5878). For more information regarding ethical approval of the project the Executive Officer of the Committee can be contacted by telephone on 8201 3116, by fax on 8201 2035 or by email human.researchethics@flinders.edu.au

APPENDIX 4C – LETTER OF INTRODUCTION

Letter of Introduction

Dear All,

This letter is to introduce Mr. Ando Fahda Aulia, a lecturer of the Economics Department of Riau University who is currently studying in a Doctor of Philosophy program at Flinders University in South Australia. The title of the research is "Valuing ecosystem services in the Indonesian palm oil industry". His research aims at investigating the impacts of land use changes to ecosystem services in the Indonesian palm oil industry. The study has been approved by the Flinders University Social and Behavioural Research Ethics Committee and is supervised by me, Professor Andrew Millington and Dr. Harpinder Sandhu from School of the Environment. It will lead to the production of a PhD thesis and/or other academic publications on the above-mentioned subject.

Ando would like to conduct a research at various places in Riau and Jakarta for about four months. During that time, he would be most grateful if you would to assist in this project, by granting an interview and/or focus group discussion and accessing all documents, which covers certain aspect of this topic. I hope you can assist by agreeing to participate in a 30-60 minute interview and/or discussion with him upon request.

Ando would like to audio-record the interviews. At any time during the interviews you are free to stop the discussion and can choose not to answer any questions that you do not wish to. You will be given the summary of your interview for confirmation about the accuracy of the information you provided. Please be assured that all the information provided will be kept strictly confidential. Ando will be the only person to listen to the audio-recordings or to read the interview transcripts. None of the information in the report of Ando's thesis or other publications will reveal your identity or that of the community.

Participation in this study is voluntary. Please be informed that it is still possible for you to withdraw from the study at any time and without any consequences.

Finally, if you have any questions or concerns regarding this study, please feel free to contact me on +61 8 82017577 or email andrew.millington@flinders.edu.au or Dr. Harpinder Sandhu on +61 8 82012845 or email harpinder.sandhu@flinders.edu.au. Ando can be contacted locally at this number: +62 823 9165 1168 or email ando.aulia@flinders.edu.au.

Thank you for considering our request.

Yours faithfully,

Professor Andrew C. Millington
Dean
School of the Environment

This research project has been approved by the Flinders University Social and Behavioural Research Ethics Committee (Project Number 5878). For more information regarding ethical approval of the project the Executive Officer of the Committee can be contacted by telephone on 8201 3116, by fax on 8201 2035 or by email human.researchethics@flinders.edu.au

Surat Pengantar

Kepada Yth:
Saudara – saudara sekalian,

Surat ini adalah untuk meminta kesediaan anda untuk berpartisipasi dalam wawancara yang akan dilakukan oleh Ando Fahda Aulia. Beliau adalah seorang dosen Jurusan Ilmu Ekonomi di Universitas Riau yang sedang menempuh pendidikan Doktor (Ph.D) di Flinders University, Australia Selatan. Penelitiannya berjudul "Penilaian jasa ekosistem di industri kelapa sawit Indonesia. Tujuan penelitian dia adalah untuk mengkaji dampak perubahan tata guna lahan terhadap jasa ekosistem di industri kelapa sawit Indonesia. Penelitian ini telah disetujui oleh Komite Etik Penelitian Sosial dan Perilaku Flinders University. Saya, Professor Andrew C. Millington dan Dr. Harpinder Sandhu membimbing Ando dalam melakukan penelitian ini. Penelitian ini nantinya akan menghasilkan sebuah disertasi Ph.D dan/atau publikasi ilmiah yang berkenaan dengan judul tersebut di atas.

Ando akan melakukan penelitian di beberapa lokasi di Riau dan Jakarta selama kurang lebih 4 bulan. Dalam rentang waktu tersebut, dia akan meminta kesediaan anda untuk melakukan wawancara dan/atau diskusi kelompok, serta mengakses semua dokumen yang berhubungan deng topik diatas. Saya berharap anda dapat membantu dengan bersedia berpartisipasi dalam wawancara dan/atau diskusi selama kurang lebih 30 sampai 60 menit bersamanya.

Ando akan merekam wawancara/diskusi dengan saudara. Namun ketika wawancara/diskusi sedang berlangsung, saudara dapat menghentikannya kapanpun dan juga dapat memilih untuk tidak menjawab pertanyaan yang tidak saudara inginkan. Kesimpulan tentang wawancara/diskusi ini akan disampaikan kepada saudara untuk tetap menjaga tingkat validitas informasi yang saudara sampaikan. Semua informasi yang disampaikan akan dijaga kerahasiaannya. Ando adalah satu-satunya pihak yang mendengar rekaman atau membaca hasil rekaman wawancara tersebut. Identitas saudara tidak akan dicantumkan dalam disertasi hasil penelitiannya.

Partisipasi saudara dalam penelitian ini adalah bersifat sukarela. Perlu diingat sekali lagi bahwa saudara dapat kapan saja mengundurkan diri dari keikutsertaannya dalam penelitian ini tanpa ada konsekuensi apapun.

Akhirnya bila ada pertanyaan dan keluhan yang berkenaan dengan penelitian ini, silakan menghubungi saya melalui +61 8 82017577 atau email: andrew.millington@flinders.edu.au atau Dr. Harpinder Sandhu melalui +61 8 82012845 atau email harpinder.sandhu@flinders.edu.au. Ando dapat dihubungi di tempat melalui telepon no. +62 823 9165 1168, atau melalui email ando.aulia@flinders.edu.au.

Terima kasih atas perhatian dan bantuan saudara.

Salam hormat,

Professor Andrew C. Millington
Dean
School of the Environment

Penelitian ini telah disetujui oleh Komite Etik Penelitian Sosial dan Perilaku Flinders University (Nomor Penelitian 5878). Untuk informasi lebih lanjut mengenai persetujuan penelitian ini, silakan menghubungi Executive Officer Komite Etik melalui nomor telepon +61 8 8201 3116, fax +61 8 8201 2035 atau email human.researchethics@flinders.edu.au

APPENDIX 4D – CONSENT FORM

CONSENT FORM FOR PARTICIPATION IN RESEARCH

(by interview)

Valuing ecosystem services in the Indonesian palm oil industry

I ……...……..

being over the age of 18 years hereby consent to participate as requested in the Letter of Introduction and Information Sheet for the research project on ecosystem services and land use changes in the Indonesian palm oil industry.

I have read the information provided.
Details of procedures and any risks have been explained to my satisfaction.
I agree to audio/video recording of my information and participation.
4. I am aware that I should retain a copy of the Information Sheet and Consent Form for future reference.
5. I understand that:
I may not directly benefit from taking part in this research.
I am free to withdraw from the project at any time and am free to decline to answer particular questions.
While the information gained in this study will be published as explained, I will not be identified, and individual information will remain confidential.
Whether I participate or not, or withdraw after participating, will have no effect on any treatment or service that is being provided to me.
I may ask that the recording/observation be stopped at any time, and that I may withdraw at any time from the session or the research without disadvantage.
6. I agree/do not agree* to the tape/transcript* being made available to other researchers who are not members of this research team, but who are judged by the research team to be doing related research, on condition that my identity is not revealed. ** delete as appropriate*
7. I have had the opportunity to discuss taking part in this research with a family member or friend.

Participant's signature……………………………………Date…………………...

I certify that I have explained the study to the volunteer and consider that she/he understands what is involved and freely consents to participation.

Researcher's name…………………………………………………………..................

Researcher's signature…………………………………..Date…………………….

NB: Two signed copies should be obtained. The copy retained by the researcher may then be used for authorisation of Items 8 and 9, as appropriate.

8. I, the participant whose signature appears below, have read a transcript of my participation and agree to its use by the researcher as explained.

Participant's signature…………………………………Date…………………...

FORMULIR PERNYATAAN KESEDIAAN DAN KESANGGUPAN UNTUK BERPERAN SERTA DALAM PENELITIAN

(Wawancara)

Penilaian jasa ekosistem di industri kelapa sawit Indonesia

Saya yang bernama.. berusia di atas 18 tahun dengan ini menyatakan kesediaan untuk berperan serta dalam proyek penelitian tentang jasa ekosistem dan tata guna lahan di industri kepala sawit Indonesia.

Saya telah membaca semua informasi yang diberikan terkait dengan penelitian tersebut.
Prosedur dan resiko yang mungkin timbul dari penelitian tersebut telah dijelaskan kepada saya dan saya memahaminya.
Saya setuju bahwa informasi yang saya berikan akan direkam.
Saya mengerti bahwa saya harus menyimpan formulir ini jika diperlukan suatu saat nanti.
Saya mengerti bahwa:
Secara langsung saya tidak akan mendapatkan keuntungan apapun dari penelitian ini.
Saya bebas untuk mundur dari penelitian ini kapanpun dan berhak untuk tidak menjawab pertanyaan yang tidak saya inginkan.
Informasi dan peran serta saya dalam penelitian ini akan dijaga kerahasiaannya.
Apakah saya akan berpartisipasi atau tidak dalam penelitian ini tidak akan berpengaruh apapun pada perlakuan atau pelayanan yang saya terima.
Saya berhak untuk meminta rekaman wawancara dihentikan kapanpun dan mengundurkan diri kapanpun tanpa ada konsekuensi apapun.
Saya **setuju/tidak setuju*** hasil rekaman wawancara saya diserahkan kepada peneliti/orang lain yang bukan anggota dari penelitian ini yang melakukan penelitian yang berkenaan dengan penelitian ini dengan syarat bahwa identitas saya akan dijaga kerahasiaannya.
Saya telah mendapatkan kesempatan untuk mendiskusikan bersama keluarga atau teman tentang keterlibatan saya dalam penelitian ini.

Tanda tangan peserta: .... Tanggal: ....

Saya menyatakan bahwa saya telah menjelaskan tentang penelitian ini kepada calon peserta dan meyakini bahwa yang bersangkutan memahami dan dengan suka rela menyatakan kesediaanya untuk berperan serta.

Nama peneliti: .... Tanggal: ....

Tanda tangan peneliti: .... Tanggal: ....

Catatan: Dua lembar formulir ini yang telah ditanda tangani harus diterima. Lembaran yang diterima oleh peneliti digunakan untuk pengesahan poin nomor 8 dan 9.

8. Saya, peserta penelitian, yang bertanda tangan di bawah ini telah membaca hasil wawancara saya dan setuju untuk penggunaan hasil wawancara tersebut seperti yang dijelaskan oleh peneliti.

Tanda tangan peserta: .... Tanggal: ....

APPENDIX 4E – QUESTIONNAIRES

Riau Province (Sumatera): Rural livelihoods survey

<u>Questionnaire for individual farmers</u>

Enumerator: ______________________________ Date (D/M/Y): ____/____/20____ Time ____:____ to ____:____
District: ____________________________ Sub-district: _________________________Village: ___________________________ Block: ________________________
GPS Coordinates **ONLY IF INTERVIEWED AT FARM**: Latitude __________________ ; Longitude _____________________

Pre-interview guide

Researcher (interviewer) introducing himself

> Good morning/afternoon. My name is Ando Fahda Aulia. I am conducting a study about farming families, farms and farming in Riau Province for my PhD research at Flinders University in Adelaide, Australia. I would like to interview you for this research if that is possible. This interview is for my research only and it will be confidential.

> In this interview I want to find out about how you farm, how your farming activities fit into the livelihoods of your household/family, why you moved to this area (if you are a migrant) and what types of farming and other economic activities occurred here before oil palm cultivation (if you and your family have lived here a long time)

Clarification of the participation

Have you received and read the information sheet regarding to this study?

(If **YES** – start the interview – sign the consent form)

(If **NO** – provides the participants with the information sheet –then sign the consent form)

Observed HH characteristics:

CONSTRUCTION: all wood, wood/brick, unfinished brick, finished brick, fancy finish ROOF: zinc, roof til WINDOW: shutter, glass

SATELLITE TV: yes, no SHOP/BUSINESS ATTACHED: yes, no THROUGH ROAD: on through road, on side road/track

Background information or profile of respondent and household (HH)						
B.1	Name:			B.2 Are you the head of the HH, if not what is your relationship to head of HH?		Yes/No,
B.3	How old are you?	<20	20 – 30	30 – 40	40 – 50	>50
B.4	Where were you born?					
B.5	*Gender:*	Male/Female				
B.6	Ethnicity:	Malay	Javanese	Sundanese	Minangese	Other:
B.7	Highest level of education:	None	Primary	Jr High	High	College or University
B.8	Marital status:	Single	Married	Divorced	Widowed	
B.9	How many children do you have?					
B.10	How many children are living in your house at the present time?					
B.11	For children not living at home, where do they live? (name of town/village)	a.	b.	c.	d.	e.

<table>
<tr><td>B.12</td><td>How many adults live in your house at the present time?</td><td colspan="3">Males:</td><td colspan="2">Females:</td></tr>
<tr><td>B.13</td><td>Haw many dependents live in your house? (dependent – children, elder)</td><td colspan="5">Calculate by adding no. children at home (B10) and any adults at home not working (B12- D2/D3)</td></tr>
<tr><td>B.14</td><td>In which village is your house located?</td><td colspan="5"></td></tr>
<tr><td>B.15</td><td>How long have you lived in this village?</td><td>< 1 years</td><td>1 - 5 years</td><td>5 – 10 years</td><td>10 – 15 years</td><td>>15 years</td></tr>
<tr><td>B.16</td><td>Have you ever lived anywhere else?
If yes, where & when (years)?</td><td colspan="5"></td></tr>
<tr><td>B.17</td><td>Why did you move to this village? or
Why did you move back to this village if from here originally? (all reasons)</td><td colspan="5"></td></tr>
<tr><td>B.18</td><td>Do you own the land you are farming at the present time?</td><td colspan="3">Yes</td><td colspan="2">No</td></tr>
<tr><td colspan="7">The following questions are about oil palm cultivation (<u>for other main crops substitute main crop where underlined</u>)</td></tr>
<tr><td>C.1</td><td>In which village(s) do you own land <u>with OPs?</u> (village, district)</td><td>A:</td><td>B:</td><td>C:</td><td>D:</td><td>E:</td></tr>
<tr><td>C.2</td><td>How many years have you cultivated <u>OP on</u> Farm #?</td><td>A:</td><td>B:</td><td>C:</td><td>D:</td><td>E:</td></tr>
<tr><td>C.3</td><td>Why did you start to <u>cultivate OP</u> on Farm #?</td><td colspan="5"></td></tr>
<tr><td>C.4</td><td>What is the area of Farm #?</td><td colspan="5"></td></tr>
</table>

C.5	Do you own Farm #?	Yes/No. If yes, is Farm # owned by an individual or family (where do they live ....) If no, is the farm owned by a business (name of business ....)				
C.6	Is Farm # part of a cooperative?	Yes/No. If yes, which cooperative?				
C.7	Do you follow a set of management guidelines on Farm #?	If yes, whose management guidelines? If no, why?				
C.8	What variety(ies) of OP do you grow on Farm #?					
C.9	What types of landscape/soil are on Farm #	Hilly/Steep slopes	Gentle slopes	Mainly level (not swamp)	Swamp	Other:
C.10	How old are the trees in Farm #?	<3 years	3 – 5	5 – 10	10 – 25	>25 **ONLY TREE CROPS**
C.11	Approx what amount did you harvest in tonnes last year (or last month)	t/yr: t or kg/mo:				
C.12	How much did you earn from palm fruit sales from Farm # last year?	Rp				
C.13	How were you paid?	Cooperative	Middleman	Other:		
C.14	Did you clear Farm # yourself and/or with family members initially?	Yes	No	If no: who did?		
C.15	Do you test the soil on Farm #?	Yes	If yes: how often?			No
C.16	Do you employ people to work on Farm # (if yes, complete C17-19)	Yes	C.17 Number permanent:	C.18 Do they live on farm?	C.19 Number temporary (when?)	No

C.20	How often do you do fertilize?		
C.21	What types of fertilizers do you use?		
C.22	What are the recommended doses of the fertilizers you use?		
C.23	What are the costs of each type of fertilizer used per 50 kg sack?		
C.24	How often do you do weed/clear ground vegetation?		
C.25	What are the major pests on this farm?		
C.26	How do you control pests on this farm?		
C.27	What animals, birds, insects etc. pollinate OP flowers on this farm?		
C.28	What other things do you do to maintain oil palms?		
C.29	What machinery do you use in oil palm cultivation?		
Repeat for other oil palm farms at this point (new C sheets)			
The next sets of questions are about you and other members of your household (HH) that are living with you at the present time.			
D.1	Is oil palm the only source of income for HH?	Yes	No
D.2	If no, what are the other sources of income for HH members (*prompts* –		

	other farm activities, shop, business, salary job – eg teacher)	***If other types of farming go to section E***					
D.3	Which other members of your HH have jobs or work on farm (No of each)	Males:	Females:	Children:			
D.4	What is the proportion of total HH (all members) income from oil palm farming?	<20%	20 – 40%	40-60%	60-80%	>80%	
D.5	Staple food: Where do you get your daily staple food? (define staple – bulk, rice)	Own farm	Shop (Nr. Village)	Weekly market	Shop (Nr. big town)	Other:	
D.6	What is the proportion of daily food in grown or collected by you and HH?	<10%	10-25%	25 –50%	50 – 75%	>75%	
D.7	What fuel do you use for cooking?	Wood	Kerosene	Gas 3 kg	Gas 12kg	Other:	
D.8	If wood used for cooking, answer D9-11	D.9 Buy from?	D.10 Collect, how much week/month?	D. 11 Which land do you collect wood from?			
D.12	Do you collect and sell wood to others for cooking? Yes/No, if yes D13-16	D.13 Collect own land Yes/No	D.14 Collect from other land: which land?	D.15 How much sold/month?	D.16 Wood sales last year (month)? Rp.		
D 17	Where do you get your drinking water?	River	Well wo pump	Well w pump	Piped supply	Buy	Other
D.18	Do you own any of…? write on type	Bicycle ScooterMotorbike Becak Motor Car/Taxi Oplet Pick up Truck Other					
D.19	How much did you spend for school fees for HH last month?	Rp:	D.13	How much did you spend on transportation last month?	Rp:		

E1. Other crops grown on farm # (n.b. crops can be for food or other uses; crops can be field crops or individual trees (NOT plantations), include FLOWERS grown and sold. COMPLETE ONLY FOR FARMS IN VILLAGE WHERE MAIN HOUSE LOCATED AND AROUND MAIN HOUSE								
What other crops do you grow? (write below)	Approx. area or no. of trees	Which months is this crop harvested in?	In the last 12 mo … what was the approx amount harvested ?	… % used by household (not sold or exchanged)	… % exchanged for other food or goods	… % sold	… cash from sales (Rp)	Do you own the land this crop is grown on?
E1	E2	E3	E4	E5	E6	E7	E8	E9
E10	E11	E12	E13	E14	E15	E16	E17	E18

Repeat for other farms

E2. Livestock					
What animals do your rear?	Approx. number (at present time)	What are these animals for? (e.g., eggs, meat, sale etc.)	How much (eggs, individuals etc) do you consume in HH each year?	How many units (eggs, individual animals) do you seel each year?	What is income from sales?
Cattle	E100	E101	E102	E103	E104
Buffalo					
Goats					
Chickens					
Ducks					
Geese					
Hunting dogs					
Cats					
Songbirds					
Game cocks					

E3. Plantations/Tree Crops (not individual or scattered trees)						
Do you cultivate?	Approx. area	Number of trees	Is it grown on your land? Y/N	If N, who owns land?	What % of harvest did you consumer last yr?	What was income from sales last year? Rp
E200 Rubber Yes/No	E201	E202	E203	E204	E205	E206
E207 Bamboo Yes/No						
E214 Timber plantation for construction wood or furniture (write in wood type(s)) Yes/No						
E22Firewood plantation (write in wood type) Yes/No						
E228 Coconut Yes/No						
E235						
E242						

E. 4 Collecting on farm or in other areas						
Do you collect…?	What do you collect?	Amount collected per month/year	Collected from your land? Y/N	If no, who owns this land?	What % of amount collected did your HH consume last year?	What was your income from this product last year? Rp?
E300 Honey Yes/No	E301	E302	E303	E304	E305	E306
E310 Walet Yes/No	E311	E312	E313	E314	E315	E316
Plants or parts of trees (e.g. bamboo, for basket making, food, cooking herbs): list by name: E400						
Animals (incl. insects) (food, medicine, ceremonies, song birds etc): list by name: E500						

Now the final set of questions about the village you live in or have your main farm in								
F.1	Is there any natural forest nearby? Yes/No	F.2	If yes, is it a sacred grove? Yes/No		F.3	If yes, How far is it to nearest natural forest/sacred grove?		Distance *or*: Walking time:
F.4	Do you have a name for this type of forest it is?							
F.5	Do animals from the forest (or other areas) affect your farm, other people's farms or people in your village. Explain, if yes.							
F.6	Do other people in the village hunt or trap animals on farms, or forest and natural vegetation. Explain, if yes (which animals, where, what)							
F.7	How far is your farm from nearest anak sungai or sungai?	Distance *or*: Walking time						
F.8	In the last 10 years has the anak sungai/sungai flooded your land?	Yes, every year		7-9 times, 4-6 times, 1-3 times				No
F.9	Does your farming affect the anak sungai or sungai?	Yes	No	If yes what?				
F.10	Do you know of any historical significance of the land you farm?	Yes	No	What?				
F.11	Have there been any natural disasters in area the last 10 yrs?	Landslide	Flood	Fire	Severe storm	Earthquake	Other	
F.12	If you use well/river water for any HH tasks has quality changed 10 yrs?	Better		Worse			No difference	

F.13	What do you not see in this surrounding countryside that you used to see before oil palms were cultivated? (e.g., animals, birds, types of farming, hunting etc.)	

Riau Province: questionnaire for organisations with interests in the oil palm industry

A. Pre-interview guide

A.1. Researcher (interviewer) introducing himself

Good morning/afternoon. My name is Ando Fahda Aulia. I am conducting a study about farming families, farms and farming in Riau Province for my PhD research at Flinders University in Adelaide, Australia. I would like to interview you for this research if that is possible. This interview is for my research only and it will be confidential.

A.2. Introducing the purpose of the interview

I want to find out in what ways your organisation is involved in the oil palm industry (in Riau Province, but also more generally) and to seek your organisations position(s) on a number of issues associated with the oil palm industry. I also am interviewing individual farmers in seven locations in Riau Province.

A.3. Clarification of the participation

Have you received and read the information sheet regarding to this study? (If **YES** – start the interview – sign the consent form)

(If **NO** – provides the participants with the information sheet –then sign the consent form)

Name of organisation:	
Address:	
Interviewee name:	

Position and what that job entails	
How long have you been in this institution and position?	

OPENING QUESTIONS:

- What are the core businesses of your organisations? (is there a web site or a brochure)
- What do you see as the benefits of the palm oil industry – for Indonesia, Riau, the districts in which your COMPANY/ORGANISATION works, and individual farmers?

THESE QUESTIONS FOR COMPANY OR GOVT OIL PALM BUSINESS ONLY

What are your activities in Riau Province (do you own land, mills etc; number of workers on plantations, mills; do you work with cooperatives etc, how long has your COMPANY/ORGANISATION worked in Riau? – LAND TENURE AND MANAGEMENT PRACTICES – questions come from what you have found out from farmer interviews)?

- Beyond your obligations to shareholders or government etc, what does your COMPANY/ORGANISATION do to maximise the benefits at these different scales (national, provincial, district and individual). If they can provide concrete examples that would be good, and any publicity, leaflets etc.
- Has your COMPANY/ORGANISATION experienced any opposition to OP cultivation nationally, in Riau, districts in Riau or from individuals and/or organisations. Explain.
- Have your plantations (or those of people that sell to your mills) experienced any changes in yield (other things) due to climate change, changes in flooding regimes, clearance of forests nearby or generally in Sumatera?
- Is your COMPANY/ORGANSIATION doing anything to value it’s assets in Riau in the light of actual or potential environmental change?

- Are your mills/plantations certified by RSPO or ISPO? What are the benefits of certification to your COMPANY/ORGANISATION? What are your COMPANIES/ORGANISATIONS views on the future of certification?
- In your view, what are the biggest threats to the oil palm industry (in Riau, but also could consider Indonesia) in the next 5-10 years?

THESE QUESTIONS FOR COMMUNITY & RURAL DEVELOPMENT AND CONSERVATION NGOs (incl. GOVT CONSERVATION AD DEVELOPMENT AGENCIES)

- What are your activities in Riau Province (maybe based on questions that arise from what you have found out from farmer interviews)?
- Is your ORGANISATION opposed to further expansion OP cultivation in Riau, (or elsewhere in SE Asia)? and/or Does it have a policy aimed at converting oil palm plantations to other land uses? Explain.
- What does your ORGANISATION do to maximise/conserve conservation benefits in the face of oil palm expansion?

(CONSERVATION NGO ONLY)

- What does your ORGANISATION do to promote rural and community and alleviate poverty in the face of oil palm expansion?

(ALL NGOs)

- What are the main types of environmental change facing Sumatera (and specifically Riau) (e.g., forest loss, climate change changes in flooding regimes etc)? Try and find specific things, e.g. areas now flooded more frequently along particular rivers, loss of particularly important forests, local/island-wide species extinction?
- Does your ORGANSIATION use any concepts like natural endowments, natural capital, or ecosystem service valuation in its work in

- Sumatera. If so, how?
- What is your ORGANISATION'S position on RSPO or ISPO certification?
- What is your ORGANISATION'S view of further Transmigration in Indonesia?
- In your view, what are the biggest threats to the oil palm industry and the rural environment/population (in Riau, but also could consider Indonesia) in the next 5-10 years?

THESE QUESTIONS FOR ALL ORGANISATIONS

- In what ways do you think the oil palm industry is improving the livelihoods of people in rural areas, and what can be done to improve this?
- Are there any local particular issues (in the place where they are interviewed – if in, say, a mill in Riau, or in Riau – if in, say, an office in Jakarta) about palm oil industry?

APPENDIX 4F – ETHICS APPROVAL

Ando Aulia

From: Human Research Ethics
Sent: Wednesday, 31 October 2012 10:45 AM
To: Ando Aulia
Subject: 5878 SBREC - Final approval notice

Dear Ando Fahda,

The Chair of the Social and Behavioural Research Ethics Committee (SBREC) at Flinders University considered your response to conditional approval out of session and your project has now been granted final ethics approval. Your ethics final approval notice can be found below.

FINAL APPROVAL NOTICE

Project No.: **5878**

Project Title: Evaluating ecosystem services in the Indonesian palm oil industry

Principal Researcher: Mr Ando Fahda Aulia

Email: ando.aulia@flinders.edu.au

Address: School of the Environment

Approval Date:

31 October 2012		Ethics Approval Expiry Date:	**30 April 2015**

The above proposed project has been **approved** on the basis of the information contained in the application, its attachments and the information subsequently provided.

RESPONSIBILITIES OF RESEARCHERS AND SUPERVISORS

1. Participant Documentation

Please note that it is the responsibility of researchers and supervisors, in the case of student projects, to ensure that:

- all participant documents are checked for spelling, grammatical, numbering and formatting errors. The Committee does not accept any responsibility for the above mentioned errors.

- the Flinders University logo is included on all participant documentation (e.g., letters of Introduction, information Sheets, consent forms, debriefing information and questionnaires – with the exception of purchased research tools) and the current Flinders University letterhead is included in the header of all letters of introduction. The Flinders University international logo/letterhead should be used and documentation should contain international dialling codes for all telephone and fax numbers listed for all research to be conducted overseas.

- the SBREC contact details, listed below, are included in the footer of all letters of introduction and information sheets.

2. Annual Progress / Final Reports

In order to comply with the monitoring requirements of the *National Statement on Ethical Conduct in Human Research (March 2007)* an annual progress report must be submitted each year on the **31 October** (approval anniversary date) for the duration of the ethics approval using the annual progress / final report pro forma. *Please retain this notice for reference when completing annual progress or final reports.*

If the project is completed *before* ethics approval has expired please ensure a final report is submitted immediately. If ethics approval for your project expires please submit either (1) a final report; or (2) an extension of time request and an annual report. Your first report is due on **31 October 2013** or on completion of the project, whichever is the earliest.

3. Modifications to Project

Modifications to the project must not proceed until approval has been obtained from the Ethics Committee. Such matters include:

- proposed changes to the research protocol;
- proposed changes to participant recruitment methods;
- amendments to participant documentation and/or research tools;
- extension of ethics approval expiry date; and
- changes to the research team (addition, removals, supervisor changes).

To notify the Committee of any proposed modifications to the project please submit a Modification Request Form to the Executive Officer. Please note that extension of time requests should be submitted prior to the Ethics Approval Expiry Date listed on this notice.

Change of Contact Details

Please ensure that you notify the Committee if either your mailing or email address changes to ensure that correspondence relating to this project can be sent to you. A modification request is not required to change your contact details.

4. Adverse Events and/or Complaints

Researchers should advise the Executive Officer of the Ethics Committee on 08 8201-3116 or human.researchethics@flinders.edu.au immediately if:

- any complaints regarding the research are received;

- a serious or unexpected adverse event occurs that effects participants;
- an unforseen event occurs that may affect the ethical acceptability of the project.

Joanne Petty Administrative Support *on behalf of*
Andrea Fiegert, Executive Officer
Social and Behavioural Research Ethics Committee

Andrea Fiegert (nee Mather)
Executive Officer, Social and Behavioural Research Ethics Committee
Research Services Office |Union Building Basement
Flinders University
Sturt Road, Bedford Park | South Australia | 5042

GPO Box 2100 | Adelaide SA 5001
P: +61 8 8201-3116 | F: +61 8 8201-2035 |Web: Social and Behavioural Research Ethics Committee

PEMERINTAH PROPINSI RIAU
BADAN KESATUAN BANGSA POLITIK DAN PERLINDUNGAN MASYARAKAT

Jalan Cut Nyak Dien II/2, Telepon (0761) 23740, 38736 Faximile (0761) 38736

PEKANBARU Kode Pos : 28126

REKOMENDASI

Nomor : 070/BKBPPM/6822/2012

TENTANG

PELAKSANAAN KEGIATAN PENELITIAN DAN PENGUMPULAN DATA DESERTASI

Kepala Badan Kesatuan Bangsa Politik dan Perlindungan Masyarakat, setelah membaca surat Permohonan Rekomendasi Riset dari : **Dekan Flinders University Adelaide, Australia,** dengan ini memberikan rekomendasi kepada :

1. Nama	:	**ANDO FAHDA AULIA**
2. N I M	:	-
3. Program Studi	:	Ilmu Lingkungan
4. Konsentrasi	:	-
5. Jenjang	:	S3
6. Judul Penelitian	:	**PENILAIAN JASA EKOSISTEM DI INDUSTRI KELAPA SAWIT INDONESIA**
7. Lokasi Penelitian	:	1. DINAS PERKEBUNAN PROVINSI RIAU 2. DINAS KEHUTANAN PROVINSI RIAU 3. BADAN LINGKUNGAN HIDUP PROVINSI RIAU 4. BAPPEDA PROVINSI RIAU 5. KABUPATEN ROHUL 6. KABUPATEN KAMPAR 7. KABUPATEN INDRAGIRI HULU 8. KABUPATEN SIAK

Dengan Ketentuan sebagai berikut :

1. Tidak melakukan kegiatan yang menyimpang dari ketentuan yang telah ditetapkan yang tidak ada hubungan dengan kegiatan ini.
2. Pelaksanaan Kegiatan Penelitian dan Pengumpulan Data ini berlangsung selama 3 (tiga) bulan terhitung mulai tanggal rekomendasi ini dibuat.

Demikian Rekomendasi ini diberikan, agar dapat dipergunakan sebagimana mestinya dan kepada pihak yang terkait diharapkan untuk dapat memberikan kemudahan dan membantu kelancaran kegiatan Penelitian dan Pengumpulan Data ini dan terima kasih.

DIBUAT DI : PEKANBARU
PADA TANGGAL : 30 November 2012

KEPALA BADAN KESATUAN BANGSA POLITIK DAN PERLINDUNGAN MASYARAKAT

DASWANTO, S.IP
Pembina Tingkat I
NIP. 19620101 198503 1 024

Tembusan :
Disampaikan Kepada Yth :
1. Kepala Dinas Perkebunan Provinsi Riau di Pekanbaru
2. Kepala Dinas Kehutanan Provinsi Riau di Pekanbaru
3. Kepala Badan Lingkungan Hidup Provinsi Riau di Pekanbaru
4. Kepala BAPPEDA Provinsi Riau di Pekanbaru
5. Bupati Rokan Hulu
   Up. Kakan Kesbang dan Linmas di Pasir Pengarayan
6. Bupati Kampar
   Up. Kaban Kesbang Pemberdayaan di Bangkinang
7. Bupati Indragiri Hulu
   Up. Kaban Kesbangpol dan Linmas di Rengat
8. Bupati Siak
   Up. Kaban Kesbangpol dan Linmas di Siak
9. Dekan Flinder University Australia di Adelaide
10. Yang Bersangkutan

APPENDIX 5A – RESULTS OF EACH VILLAGE CORRELATION ANALYSES

Kendall's tau_b		All		Ujung Batu		Tapung		Kerinci Kanan		Bunga Raya	
		233OPNetIncomeYrUSD	237TotalHHIncomeYrUSD	233OPNetIncomeYrUSD	237TotalHHIncomeYrUSD	233OPNetIncomeYrUSD	237TotalHHIncomeYrUSD	233OPNetIncomeYrUSD	237TotalHHIncomeYrUSD	233OPNetIncomeYrUSD	237TotalHHIncomeYrUSD
8SumHouse2:structure of house	Correlation Coefficient	.246**	.204*	.166	.071	.054	.162	.504*	.504*	.219	.188
	Sig. (2-tailed)	.008	.027	.518	.782	.771	.384	.020	.020	.168	.236
	N	73	73	12	12	20	20	15	15	26	26
9Age	Correlation Coefficient	.151	.139	.068	-.171	.323	.273	.024	.024	.073	.050
	Sig. (2-tailed)	.095	.127	.774	.472	.076	.134	.912	.912	.647	.754
	N	73	73	12	12	20	20	15	15	26	26
11AMalay	Correlation Coefficient	.228*	.209*	.165	.055	.363	.399*	-.052	-.052	-.130	-.130
	Sig. (2-tailed)	.019	.031	.519	.830	.059	.038	.817	.817	.435	.435
	N	73	73	12	12	20	20	15	15	26	26
11BJavanese	Correlation Coefficient	-.162	-.120	.187	.104	-.316	-.316	-.115	-.115	.055	.192
	Sig. (2-tailed)	.095	.216	.465	.685	.099	.099	.610	.610	.739	.249
	N	73	73	12	12	20	20	15	15	26	26
12Educ	Correlation Coefficient	.252**	.253**	.139	.453	.242	.304	.678**	.678**	.093	-.019
	Sig. (2-tailed)	.005	.005	.560	.058	.178	.091	.002	.002	.549	.905
	N	73	73	12	12	20	20	15	15	26	26
14Children	Correlation Coefficient	.076	.064	-.118	-.287	.088	-.018	-.088	-.110	.044	.003
	Sig. (2-tailed)	.375	.459	.614	.220	.612	.919	.672	.596	.769	.982
	N	73	73	12	12	20	20	15	15	26	26
20DependentsOP	Correlation Coefficient	.222*	.179*	.179	.082	.224	.141	.499*	.431*	-.098	-.063
	Sig. (2-tailed)	.011	.039	.439	.725	.199	.417	.017	.039	.518	.678
	N	73	73	12	12	20	20	15	15	26	26
21HouseholdSize	Correlation Coefficient	.227**	.189*	.183	.050	.168	.096	.507*	.462*	-.028	.007
	Sig. (2-tailed)	.009	.029	.435	.831	.336	.583	.015	.026	.855	.964
	N	73	73	12	12	20	20	15	15	26	26
22YearsVillage	Correlation Coefficient	.337**	.258**	.146	-.229	.389*	.289	.413	.470*	.306*	.253
	Sig. (2-tailed)	.000	.005	.559	.369	.040	.126	.061	.033	.049	.104
	N	73	73	12	12	20	20	15	15	26	26
23LiveElsewhere	Correlation Coefficient	-.205*	-.172	-.165	-.055	-.197	-.211			-.112	-.048
	Sig. (2-tailed)	.034	.076	.519	.830	.305	.271			.501	.773
	N	73	73	12	12	20	20	15	15	26	26
24ANotMigrant	Correlation Coefficient	.273**	.215*	-.111	-.260	.342	.312			.142	-.024
	Sig. (2-tailed)	.005	.027	.664	.311	.075	.104			.394	.887
	N	73	73	12	12	20	20	15	15	26	26
24BTransmigrant	Correlation Coefficient	.154	.154	.260	.260	.216	.183	.469*	.524*	-.166	-.211
	Sig. (2-tailed)	.112	.112	.311	.311	.260	.340	.037	.020	.317	.205
	N	73	73	12	12	20	20	15	15	26	26
24CEconomic	Correlation Coefficient	-.240*	-.266**	-.566*	-.522*	-.363	-.399*	-.239	-.345	.028	-.009
	Sig. (2-tailed)	.013	.006	.027	.042	.059	.038	.289	.126	.868	.956
	N	73	73	12	12	20	20	15	15	26	26
24DFollowFamily	Correlation Coefficient	-.119	-.058	.451	.492	-.216	-.216	-.235	-.177	-.030	.151
	Sig. (2-tailed)	.220	.548	.078	.055	.260	.260	.296	.433	.856	.364
	N	73	73	12	12	20	20	15	15	26	26
25OwnLand	Correlation Coefficient	.215*	.221*	.165	-.055	.435*	.435*	.383	.383	-.255	-.255
	Sig. (2-tailed)	.027	.022	.519	.830	.023	.023	.090	.090	.125	.125
	N	73	73	12	12	20	20	15	15	26	26
27YearsCultivateOP	Correlation Coefficient	.293**	.248**	.094	.019	.317	.334	.356	.356	.114	.084
	Sig. (2-tailed)	.001	.007	.698	.938	.091	.075	.106	.106	.467	.589
	N	73	73	12	12	20	20	15	15	26	26
28ATransmigrant	Correlation Coefficient	.292**	.230*	.408	.408	.206	.174	.313	.261	.166	.100
	Sig. (2-tailed)	.003	.018	.111	.111	.284	.364	.165	.247	.317	.549
	N	73	73	12	12	20	20	15	15	26	26
28BMajorityNearby	Correlation Coefficient	-.115	-.126	-.354	-.520*	.236	.163	.104	.104	-.168	-.188
	Sig. (2-tailed)	.235	.192	.167	.042	.219	.395	.643	.643	.312	.260
	N	73	73	12	12	20	20	15	15	26	26
28COtherCropFailed	Correlation Coefficient	-.078	-.058	-.186	.037	-.216	-.216			.059	-.047
	Sig. (2-tailed)	.422	.547	.469	.885	.260	.260			.722	.776

	N	73	73	12	12	20	20	15	15	26	26
28DGoodIncome	Correlation Coefficient	-.075	-.019	.174	.305	-.222	-.133	-.365	-.313	.098	.192
	Sig. (2-tailed)	.436	.841	.497	.234	.247	.487	.105	.165	.555	.249
	N	73	73	12	12	20	20	15	15	26	26
29AreaOwnedHa	Correlation Coefficient	.618**	.577**	.462	.249	.661**	.637**	.638**	.638**	.475**	.428**
	Sig. (2-tailed)	.000	.000	.054	.299	.000	.000	.002	.002	.002	.004
	N	73	73	12	12	20	20	15	15	26	26
30OPFarmOwner	Correlation Coefficient	-.253**	-.268**	-.134	.027	-.435*	-.435*	-.383	-.383	-.064	-.145
	Sig. (2-tailed)	.008	.005	.593	.915	.023	.023	.090	.090	.697	.376
	N	73	73	12	12	20	20	15	15	26	26
31CoopMember	Correlation Coefficient	.310**	.241*	.408	.408	.023	.053	.383	.383		
	Sig. (2-tailed)	.001	.013	.111	.111	.905	.782	.090	.090		
	N	73	73	12	12	20	20	15	15	26	26
32FollowGuidelines	Correlation Coefficient	.063	.020	.408	.408	-.117	-.117			-.012	.166
	Sig. (2-tailed)	.518	.833	.111	.111	.544	.544			.943	.320
	N	73	73	12	12	20	20	15	15	26	26
35TreeAge	Correlation Coefficient	.347**	.280**	.206	.056	.429*	.329	.529*	.529*	.041	.019
	Sig. (2-tailed)	.000	.002	.394	.816	.023	.082	.014	.014	.793	.905
	N	73	73	12	12	20	20	15	15	26	26
36FreqHarvestMonth	Correlation Coefficient	.252**	.222*	.205	.041	.342	.326	.383	.383	-.255	-.255
	Sig. (2-tailed)	.006	.016	.407	.868	.064	.078	.090	.090	.125	.125
	N	73	73	12	12	20	20	15	15	26	26
37AmountHarvestYear	Correlation Coefficient	.361**	.346**	.425	.263	.564**	.564**	.443*	.467*	-.221	-.330*
	Sig. (2-tailed)	.000	.000	.083	.283	.001	.001	.037	.028	.177	.044
	N	73	73	12	12	20	20	15	15	26	26
38AverageSalesYear	Correlation Coefficient	.310**	.277**	.304	.101	.360*	.417*	.239	.266	-.102	-.222
	Sig. (2-tailed)	.001	.002	.215	.679	.036	.015	.277	.228	.530	.170
	N	73	73	12	12	20	20	15	15	26	26
42EmployPeople	Correlation Coefficient	.437**	.416**	.239	.202	.528**	.528**	.496*	.496*	.240	.080
	Sig. (2-tailed)	.000	.000	.330	.410	.005	.005	.022	.022	.143	.625
	N	73	73	12	12	20	20	15	15	26	26
43NoPermanent	Correlation Coefficient	.543**	.549**	.357	.469	.548**	.596**	.490*	.511*	.455**	.389**
	Sig. (2-tailed)	.000	.000	.141	.053	.002	.001	.017	.013	.002	.008
	N	73	73	12	12	20	20	15	15	26	26
46FreqFertiliseYear	Correlation Coefficient	.314**	.302**	.369	.404	.368*	.428*	.221	.199	.223	.097
	Sig. (2-tailed)	.000	.000	.124	.092	.037	.015	.294	.345	.142	.521
	N	73	73	12	12	20	20	15	15	26	26
47NPK	Correlation Coefficient	.117	.142	.164	0.000	.079	.152	.331	.355	-.137	-.195
	Sig. (2-tailed)	.207	.126	.507	1.000	.669	.415	.124	.099	.403	.234
	N	73	73	12	12	20	20	15	15	26	26
48NPKDose	Correlation Coefficient	.051	.081	.081	.081	-.127	-.047	.158	.222	-.052	-.080
	Sig. (2-tailed)	.571	.369	.749	.749	.491	.796	.474	.316	.727	.592
	N	73	73	12	12	20	20	15	15	26	26
49NPKCostUSD	Correlation Coefficient	.011	.040	.081	.081	-.165	-.087	.130	.195	-.226	-.240
	Sig. (2-tailed)	.904	.660	.749	.749	.367	.636	.564	.386	.130	.108
	N	73	73	12	12	20	20	15	15	26	26
50Urea	Correlation Coefficient	.267**	.253**	.288	.173	.299	.334	.239	.239	.153	.107
	Sig. (2-tailed)	.004	.007	.241	.482	.111	.075	.277	.277	.345	.511
	N	73	73	12	12	20	20	15	15	26	26
51UreaDose	Correlation Coefficient	.326**	.297**	.389	.423	.310	.332*	.192	.192	.276	.216
	Sig. (2-tailed)	.000	.000	.097	.071	.066	.049	.369	.369	.059	.138
	N	73	73	12	12	20	20	15	15	26	26
52UreaCostUSD	Correlation Coefficient	.269**	.226**	.230	.263	0.000	.044	.179	.179	.291*	.194
	Sig. (2-tailed)	.001	.007	.317	.253	1.000	.793	.406	.406	.044	.180
	N	73	73	12	12	20	20	15	15	26	26
53TSP	Correlation Coefficient	.407**	.373**	.260	.186	.411*	.443*	.322	.297	.344*	.280
	Sig. (2-tailed)	.000	.000	.289	.449	.028	.018	.138	.171	.033	.083
	N	73	73	12	12	20	20	15	15	26	26
54TSPDose	Correlation Coefficient	.393**	.354**	.280	.359	.313	.313	.340	.295	.429**	.370*

	Sig. (2-tailed)	.000	.000	.249	.138	.064	.064	.111	.167	.005	.015
	N	73	73	12	12	20	20	15	15	26	26
55TSPCostUSD	Correlation Coefficient	.304**	.274**	.280	.359	.200	.271	.198	.149	.281	.230
	Sig. (2-tailed)	.001	.002	.249	.138	.248	.118	.367	.499	.063	.129
	N	73	73	12	12	20	20	15	15	26	26
56KCL	Correlation Coefficient	.306**	.323**	.288	.173	.411*	.443*	.239	.239	.162	.291
	Sig. (2-tailed)	.001	.001	.241	.482	.028	.018	.277	.277	.317	.072
	N	73	73	12	12	20	20	15	15	26	26
57KCLDose	Correlation Coefficient	.281**	.321**	.448	.481*	.334*	.334*	.272	.250	.171	.385*
	Sig. (2-tailed)	.001	.000	.053	.038	.048	.048	.203	.243	.256	.011
	N	73	73	12	12	20	20	15	15	26	26
58KCLCostUSD	Correlation Coefficient	.263**	.288**	.249	.282	.266	.344	.064	.064	.242	.378*
	Sig. (2-tailed)	.003	.001	.283	.223	.139	.056	.773	.773	.107	.012
	N	73	73	12	12	20	20	15	15	26	26
59Dolomite	Correlation Coefficient	.198*	.205*	.165	-.055	.472*	.445*	.239	.239	-.057	-.081
	Sig. (2-tailed)	.033	.027	.519	.830	.011	.017	.277	.277	.726	.617
	N	73	73	12	12	20	20	15	15	26	26
60DolomiteDose	Correlation Coefficient	.094	.125			.376*	.350	-.104	-.104	.024	.010
	Sig. (2-tailed)	.283	.155			.036	.050	.610	.610	.870	.944
	N	73	73	12	12	20	20	15	15	26	26
61DolomiteCostUSD	Correlation Coefficient	.226*	.209*			.344	.305	.292	.292	.007	-.059
	Sig. (2-tailed)	.011	.019			.055	.089	.184	.184	.962	.704
	N	73	73	12	12	20	20	15	15	26	26
62Borate	Correlation Coefficient	.324**	.275**	.165	-.055	.364*	.323	.318	.318	-.112	-.096
	Sig. (2-tailed)	.001	.003	.519	.830	.050	.081	.137	.137	.501	.564
	N	73	73	12	12	20	20	15	15	26	26
63BorateDose	Correlation Coefficient	.280**	.222*			.238	.226	.239	.239		
	Sig. (2-tailed)	.003	.017			.173	.196	.277	.277		
	N	73	73	12	12	20	20	15	15	26	26
64BorateCostUSD	Correlation Coefficient	.260**	.199*			.135	.109	.276	.276		
	Sig. (2-tailed)	.006	.036			.456	.546	.221	.221		
	N	73	73	12	12	20	20	15	15	26	26
65Manure	Correlation Coefficient	.251**	.257**	.165	-.055	.435*	.435*	.452*	.452*	-.112	-.096
	Sig. (2-tailed)	.009	.008	.519	.830	.023	.023	.040	.040	.501	.564
	N	73	73	12	12	20	20	15	15	26	26
66ManureDose	Correlation Coefficient	.129	.152					.313	.313		
	Sig. (2-tailed)	.184	.117					.165	.165		
	N	73	73	12	12	20	20	15	15	26	26
67ManureCostUSD	Correlation Coefficient	.129	.152					.313	.313		
	Sig. (2-tailed)	.184	.117					.165	.165		
	N	73	73	12	12	20	20	15	15	26	26
68FreqWeedYear	Correlation Coefficient	.073	.100	.194	.032	.209	.269	.204	.182	-.129	-.031
	Sig. (2-tailed)	.399	.251	.400	.888	.235	.127	.326	.380	.396	.837
	N	73	73	12	12	20	20	15	15	26	26
69PestRats	Correlation Coefficient	.232*	.220*	.297	.114	.225	.239	.308	.308	-.059	-.059
	Sig. (2-tailed)	.012	.018	.235	.648	.225	.198	.153	.153	.717	.717
	N	73	73	12	12	20	20	15	15	26	26
70PestPigs	Correlation Coefficient	.183	.195*	.123	-.041	.246	.246	.545*	.545*	-.174	-.174
	Sig. (2-tailed)	.051	.038	.619	.868	.189	.189	.012	.012	.286	.286
	N	73	73	12	12	20	20	15	15	26	26
71PestFireWorm	Correlation Coefficient	.193*	.230*	.186	.074	.383*	.397*	.227	.250	-.026	.184
	Sig. (2-tailed)	.038	.013	.449	.762	.040	.033	.288	.243	.872	.258
	N	73	73	12	12	20	20	15	15	26	26
72PestBetties	Correlation Coefficient	.125	.138	.206	.023	.528**	.528**	.452*	.452*	-.048	-.176
	Sig. (2-tailed)	.179	.139	.411	.927	.005	.005	.040	.040	.766	.276
	N	73	73	12	12	20	20	15	15	26	26
73PestPorcupines	Correlation Coefficient	.222*	.221*	.297	.114	.269	.309	.383	.383	-.112	-.096
	Sig. (2-tailed)	.021	.021	.235	.648	.155	.102	.090	.090	.501	.564
	N	73	73	12	12	20	20	15	15	26	26

79Pollination	Correlation Coefficient	.149	.212*	.041	-.041	.256	.242	.452*	.452*	-.243	-.128
	Sig. (2-tailed)	.110	.023	.868	.868	.168	.191	.040	.040	.137	.435
	N	73	73	12	12	20	20	15	15	26	26
80FreqPrunYear	Correlation Coefficient	-.047	.009	-.052	-.190	.268	.307	.266	.266	-.341*	-.320*
	Sig. (2-tailed)	.598	.921	.828	.425	.139	.090	.215	.215	.025	.035
	N	73	73	12	12	20	20	15	15	26	26
81MachineGrassStrimmer	Correlation Coefficient	.285**	.260**	.334	.186	.508**	.476*	.544*	.568**	.045	-.015
	Sig. (2-tailed)	.002	.005	.173	.449	.007	.011	.011	.008	.785	.928
	N	73	73	12	12	20	20	15	15	26	26
82OPOnlyIncome	Correlation Coefficient	-.129	-.185	-.055	-.275	-.316	-.316	.088	.029		
	Sig. (2-tailed)	.183	.056	.830	.283	.099	.099	.695	.896		
	N	73	73	12	12	20	20	15	15	26	26
83OthFarmActIncome	Correlation Coefficient	.101	.159	.123	.082	.430*	.343	.078	.130	.012	.035
	Sig. (2-tailed)	.297	.100	.631	.749	.025	.074	.728	.563	.943	.831
	N	73	73	12	12	20	20	15	15	26	26
84ShopIncome	Correlation Coefficient	-.059	.008	-.603*	-.312	.145	.266	.353	.412	0.000	.048
	Sig. (2-tailed)	.545	.931	.019	.223	.450	.166	.117	.068	1.000	.773
	N	73	73	12	12	20	20	15	15	26	26
85BusinessIncome	Correlation Coefficient	.185	.210*	.062	.187	.334	.377*	.186	.239	-.013	.058
	Sig. (2-tailed)	.057	.030	.808	.465	.082	.049	.409	.289	.936	.726
	N	73	73	12	12	20	20	15	15	26	26
86SalaryJobIncome	Correlation Coefficient	.165	.110	.174	.087	.053	-.038	.195	.130	-.020	-.142
	Sig. (2-tailed)	.088	.254	.497	.734	.782	.843	.386	.564	.903	.394
	N	73	73	12	12	20	20	15	15	26	26
87OtherHHWorkFarm	Correlation Coefficient	.010	.023	.220	.110	-.290	-.242	.028	.083	.234	.234
	Sig. (2-tailed)	.917	.812	.390	.667	.131	.208	.903	.713	.160	.160
	N	73	73	12	12	20	20	15	15	26	26
88A_%OPIncome	Correlation Coefficient	-.025	-.210*	0.000	-.304	-.106	-.269	-.029	-.147	-.059	-.322*
	Sig. (2-tailed)	.783	.023	1.000	.212	.573	.153	.896	.514	.706	.038
	N	73	73	12	12	20	20	15	15	26	26
90%FoodOwnGrown	Correlation Coefficient	-.071	-.050					-.365	-.365	.046	.046
	Sig. (2-tailed)	.460	.602					.105	.105	.779	.779
	N	73	73	12	12	20	20	15	15	26	26
91FuelwoodCooking	Correlation Coefficient	-.246*	-.279**	-.312	-.687**	0.000	0.000	-.059	0.000	-.106	-.118
	Sig. (2-tailed)	.011	.004	.223	.007	1.000	1.000	.794	1.000	.522	.477
	N	73	73	12	12	20	20	15	15	26	26
92OtherFuelCooking	Correlation Coefficient	.399**	.368**	.432	.507*	.302	.245	.151	.104	.293	.276
	Sig. (2-tailed)	.000	.000	.075	.036	.109	.192	.483	.627	.066	.083
	N	73	73	12	12	20	20	15	15	26	26
94DrinkWater	Correlation Coefficient	.104	.168	.533*	.462	-.021	.007	.100	.100	-.089	-.071
	Sig. (2-tailed)	.251	.063	.028	.057	.911	.970	.633	.633	.585	.667
	N	73	73	12	12	20	20	15	15	26	26
95NoScooter	Correlation Coefficient	.339**	.372**	.299	.299	.252	.240	.375	.418*	.104	.239
	Sig. (2-tailed)	.000	.000	.213	.213	.147	.167	.069	.043	.484	.109
	N	73	73	12	12	20	20	15	15	26	26
96NoCar	Correlation Coefficient	.343**	.316**	.111	-.037	.222	.281	.225	.282	.503**	.472**
	Sig. (2-tailed)	.000	.001	.664	.885	.247	.143	.303	.198	.002	.004
	N	73	73	12	12	20	20	15	15	26	26
97NoPickUp	Correlation Coefficient	.413**	.385**	.111	-.037	.330	.259	.498*	.498*	.440**	.463**
	Sig. (2-tailed)	.000	.000	.664	.885	.080	.168	.027	.027	.007	.005
	N	73	73	12	12	20	20	15	15	26	26
98NoTruck	Correlation Coefficient	.375**	.360**	.403	.295	.320	.320	.507*	.507*	.270	.281
	Sig. (2-tailed)	.000	.000	.109	.240	.082	.082	.022	.022	.093	.081
	N	73	73	12	12	20	20	15	15	26	26
99SchoolExpenseYearUSD	Correlation Coefficient	.268**	.239**	.284	.107	.312	.312	.193	.116	.082	.225
	Sig. (2-tailed)	.001	.004	.234	.655	.058	.058	.321	.551	.573	.120
	N	73	73	12	12	20	20	15	15	26	26
100TransportExpenseYearUSD	Correlation Coefficient	.471**	.454**	.473*	.351	.490**	.423*	.265	.265	.302*	.358*
	Sig. (2-tailed)	.000	.000	.033	.114	.004	.012	.178	.178	.032	.011

	N	73	73	12	12	20	20	15	15	26	26
209Individual	Correlation Coefficient	.086	.113	.165	-.055	.285	.301	.304	.304	-.255	-.255
	Sig. (2-tailed)	.377	.245	.519	.830	.138	.117	.178	.178	.125	.125
	N	73	73	12	12	20	20	15	15	26	26
210NESTrans	Correlation Coefficient	.360**	.324**	.408	.408	.237	.158	.607**	.607**		
	Sig. (2-tailed)	.000	.001	.111	.111	.216	.409	.007	.007		
	N	73	73	12	12	20	20	15	15	26	26
211NESCoopFullManaged	Correlation Coefficient	.299**	.258**			.158	.206				
	Sig. (2-tailed)	.002	.008			.409	.284				
	N	73	73	12	12	20	20	15	15	26	26
212NESCoopPartlyManaged	Correlation Coefficient	.309**	.291**			.284	.386*				
	Sig. (2-tailed)	.001	.003			.138	.044				
	N	73	73	12	12	20	20	15	15	26	26
213OPProductiveLandAreaHa	Correlation Coefficient	.643**	.601**	.520*	.331	.546**	.589**	.631**	.611**	.607**	.513**
	Sig. (2-tailed)	.000	.000	.022	.144	.001	.000	.001	.002	.000	.000
	N	73	73	12	12	20	20	15	15	26	26
214OPAvgProdHaYrTonnes	Correlation Coefficient	.250**	.225**	.400	.369	.544**	.501**	.259	.239	-.076	-.165
	Sig. (2-tailed)	.002	.006	.073	.098	.001	.002	.191	.228	.594	.248
	N	73	73	12	12	20	20	15	15	26	26
215OPAvgPriceTonnesUSD	Correlation Coefficient	.363**	.307**	.497*	.272	.259	.174	.486*	.507*	-.040	-.062
	Sig. (2-tailed)	.000	.000	.030	.233	.112	.284	.016	.012	.794	.686
	N	73	73	12	12	20	20	15	15	26	26
216OPGrossIncomeYrUSD	Correlation Coefficient	.774**	.710**	.708**	.554*	.836**	.772**	.716**	.696**	.735**	.545**
	Sig. (2-tailed)	.000	.000	.002	.013	.000	.000	.000	.000	.000	.000
	N	73	73	12	12	20	20	15	15	26	26
217OPGrossIncomeHaYrUSD	Correlation Coefficient	.334**	.313**	.443*	.412	.533**	.470**	.473*	.453*	-.050	-.124
	Sig. (2-tailed)	.000	.000	.046	.063	.001	.004	.016	.021	.724	.377
	N	73	73	12	12	20	20	15	15	26	26
219OPHarvestCostYrUSD	Correlation Coefficient	.647**	.624**	.559*	.679**	.706**	.663**	.679**	.658**	.593**	.445**
	Sig. (2-tailed)	.000	.000	.021	.005	.000	.000	.001	.001	.000	.002
	N	73	73	12	12	20	20	15	15	26	26
221OPFertilizingLabourYrUSD	Correlation Coefficient	.489**	.484**	.280	.280	.374*	.385*	.635**	.635**	.443**	.388*
	Sig. (2-tailed)	.000	.000	.249	.249	.026	.022	.003	.003	.004	.011
	N	73	73	12	12	20	20	15	15	26	26
223OPTotalFertilizerCostYrUSD	Correlation Coefficient	.613**	.589**	.461*	.362	.565**	.544**	.657**	.638**	.518**	.499**
	Sig. (2-tailed)	.000	.000	.046	.116	.001	.001	.001	.001	.000	.000
	N	73	73	12	12	20	20	15	15	26	26
225OPFertilizerCostHaYrUSD	Correlation Coefficient	.363**	.344**	.164	.197	.248	.227	.481*	.461*	.173	.179
	Sig. (2-tailed)	.000	.000	.475	.391	.127	.163	.014	.019	.217	.201
	N	73	73	12	12	20	20	15	15	26	26
227OPWeedingCostYrUSD	Correlation Coefficient	.575**	.597**	.540*	.477*	.599**	.663**	.552**	.599**	.568**	.531**
	Sig. (2-tailed)	.000	.000	.017	.036	.000	.000	.008	.004	.000	.000
	N	73	73	12	12	20	20	15	15	26	26
229OPPruningCostYrUSD	Correlation Coefficient	.545**	.528**	.510*	.510*	.515**	.472**	.458*	.505*	.455**	.364*
	Sig. (2-tailed)	.000	.000	.042	.042	.002	.004	.028	.016	.002	.015
	N	73	73	12	12	20	20	15	15	26	26
231OPTotalCostRealYrUSD	Correlation Coefficient	.659**	.627**	.509*	.445*	.607**	.586**	.657**	.638**	.616**	.450**
	Sig. (2-tailed)	.000	.000	.025	.050	.000	.000	.001	.001	.000	.001
	N	73	73	12	12	20	20	15	15	26	26
232OPTotCostHaYrUSD	Correlation Coefficient	.425**	.394**	.445*	.445*	.343*	.322*	.539**	.520**	.210	.092
	Sig. (2-tailed)	.000	.000	.050	.050	.036	.048	.006	.008	.134	.508
	N	73	73	12	12	20	20	15	15	26	26
233OPNetIncomeYrUSD	Correlation Coefficient	1.000	.834**	1.000	.697**	1.000	.895**	1.000	.924**	1.000	.711**
	Sig. (2-tailed)		.000		.002		.000		.000		.000
	N	73	73	12	12	20	20	15	15	26	26
234OPNetIncomeHaYrUSD	Correlation Coefficient	.220**	.211**	.504*	.412	.459**	.396*	.343	.363	-.169	-.237
	Sig. (2-tailed)	.006	.008	.023	.063	.005	.015	.080	.064	.225	.090
	N	73	73	12	12	20	20	15	15	26	26
235TotalOtherAgricIncomeYrUSD	Correlation Coefficient	.260**	.347**	.225	.315	.452*	.384*	.403	.454*	.197	.255

	Sig. (2-tailed)	.003	.000	.363	.202	.011	.032	.057	.032	.167	.075
	N	73	73	12	12	20	20	15	15	26	26
236TotalHHAgricIncomeYrUSD	Correlation Coefficient	.882**	.852**	1.000**	.697**	1.000**	.895**	.962**	.962**	.735**	.705**
	Sig. (2-tailed)	.000	.000		.002		.000	.000	.000	.000	.000
	N	73	73	12	12	20	20	15	15	26	26
237TotalHHIncomeYrUSD	Correlation Coefficient	.834**	1.000	.697**	1.000	.895**	1.000	.924**	1.000	.711**	1.000
	Sig. (2-tailed)	.000		.002		.000		.000		.000	
	N	73	73	12	12	20	20	15	15	26	26
101Rubber	Correlation Coefficient	.184	.196*			.301	.317			.201	.038
	Sig. (2-tailed)	.058	.043			.117	.099			.228	.817
	N	73	73	12	12	20	20	15	15	26	26
102RubberAreaHa	Correlation Coefficient	.201*	.209*			.317	.317			.232	.111
	Sig. (2-tailed)	.028	.022			.083	.083			.124	.463
	N	73	73	12	12	20	20	15	15	26	26
103RubberProdKgYear	Correlation Coefficient	.161	.180			.395*	.375*			.222	.092
	Sig. (2-tailed)	.089	.058			.036	.045			.169	.566
	N	71	71	12	12	20	20	15	15	24	24
104RubberSalesIncomeYearUSD	Correlation Coefficient	.175	.203*			.395*	.375*			.244	.170
	Sig. (2-tailed)	.062	.030			.036	.045			.118	.277
	N	72	72	12	12	20	20	15	15	25	25
105RubberNetIncomeYearUSD	Correlation Coefficient	.182	.201*			.395*	.375*			.236	.131
	Sig. (2-tailed)	.050	.030			.036	.045			.121	.389
	N	73	73	12	12	20	20	15	15	26	26
106ArecaNut	Correlation Coefficient	.009	.069			.290	.218	.209	.209	-.316	-.219
	Sig. (2-tailed)	.924	.478			.131	.257	.355	.355	.058	.188
	N	73	73	12	12	20	20	15	15	26	26
107ArecaNutNoTree	Correlation Coefficient	.009	.062			.296	.208	.209	.209	-.229	-.173
	Sig. (2-tailed)	.919	.503			.112	.261	.355	.355	.141	.265
	N	73	73	12	12	20	20	15	15	26	26
109ArecaNutProdKgYear	Correlation Coefficient	-.104	-.002			.083	.017			-.243	-.081
	Sig. (2-tailed)	.275	.986			.665	.931			.125	.609
	N	73	73	12	12	20	20	15	15	26	26
110ArecaNutSalesIncomeYearUSD	Correlation Coefficient	-.129	-.036			.083	.017			-.271	-.161
	Sig. (2-tailed)	.170	.700			.665	.931			.083	.303
	N	73	73	12	12	20	20	15	15	26	26
111Cacao	Correlation Coefficient	-.022	-.039	.111	-.037	.051	-.010			-.166	-.166
	Sig. (2-tailed)	.818	.685	.664	.885	.791	.958			.320	.320
	N	73	73	12	12	20	20	15	15	26	26
112CacaoNoTree	Correlation Coefficient	-.022	-.035	.111	-.037	.079	.020			-.144	-.144
	Sig. (2-tailed)	.819	.711	.664	.885	.674	.916			.377	.377
	N	73	73	12	12	20	20	15	15	26	26
114CacaoProdKgYear	Correlation Coefficient	.001	-.007	.111	-.037	.012	-.012			-.026	-.026
	Sig. (2-tailed)	.992	.944	.664	.885	.950	.950			.873	.873
	N	73	73	12	12	20	20	15	15	26	26
115CacaoIncomeYearUSD	Correlation Coefficient	.001	-.007	.111	-.037	.012	-.012			-.026	-.026
	Sig. (2-tailed)	.992	.944	.664	.885	.950	.950			.873	.873
	N	73	73	12	12	20	20	15	15	26	26
116Rice	Correlation Coefficient	.016	.070							.060	.100
	Sig. (2-tailed)	.868	.470							.718	.547
	N	73	73	12	12	20	20	15	15	26	26
117RiceAreaHa	Correlation Coefficient	.016	.070							.060	.100
	Sig. (2-tailed)	.868	.470							.718	.547
	N	73	73	12	12	20	20	15	15	26	26
119RiceProdKgYear	Correlation Coefficient	.012	.065							.039	.078
	Sig. (2-tailed)	.901	.496							.810	.631
	N	73	73	12	12	20	20	15	15	26	26
120RiceIncomeYearUSD	Correlation Coefficient	.020	.074							.078	.118
	Sig. (2-tailed)	.835	.445							.631	.471
	N	73	73	12	12	20	20	15	15	26	26

121Bamboo	Correlation Coefficient	.170	.153			.152	.132				
	Sig. (2-tailed)	.080	.113			.427	.491				
	N	73	73	12	12	20	20	15	15	26	26
122BambooNoTree	Correlation Coefficient	.171	.155			.169	.149				
	Sig. (2-tailed)	.075	.107			.370	.429				
	N	73	73	12	12	20	20	15	15	26	26
123Coconut	Correlation Coefficient	.300**	.276**	.123	.041	.226	.260	0.000	0.000	.445**	.531**
	Sig. (2-tailed)	.002	.004	.631	.873	.239	.176	1.000	1.000	.007	.001
	N	73	73	12	12	20	20	15	15	26	26
124CoconutNoTree	Correlation Coefficient	.337**	.296**	.259	.190	.177	.111	.010	-.073	.484**	.521**
	Sig. (2-tailed)	.000	.001	.269	.418	.292	.511	.959	.720	.002	.001
	N	73	73	12	12	20	20	15	15	26	26
125CoconutSold	Correlation Coefficient	.313**	.288**	.123	.041	.285	.300	.089	.089	.445**	.531**
	Sig. (2-tailed)	.001	.003	.631	.873	.131	.111	.686	.686	.007	.001
	N	73	73	12	12	20	20	15	15	26	26
126CoconutProdSoldNoEach	Correlation Coefficient	.148	.139			.216	.183	.209	.209		
	Sig. (2-tailed)	.124	.151			.260	.340	.355	.355		
	N	73	73	12	12	20	20	15	15	26	26
128CoconutIncomeYearUSD	Correlation Coefficient	.148	.139			.216	.183	.209	.209		
	Sig. (2-tailed)	.124	.151			.260	.340	.355	.355		
	N	73	73	12	12	20	20	15	15	26	26
129JackFruit	Correlation Coefficient	.063	.068	-.055	-.055	-.099	-.038	.098	.033	.088	.044
	Sig. (2-tailed)	.516	.486	.830	.830	.606	.843	.665	.885	.598	.792
	N	73	73	12	12	20	20	15	15	26	26
130JackfruitNoTree	Correlation Coefficient	.034	.035	-.081	-.081	-.120	-.092	.098	.033	.020	-.043
	Sig. (2-tailed)	.715	.706	.749	.749	.512	.616	.665	.885	.899	.780
	N	73	73	12	12	20	20	15	15	26	26
131Mango	Correlation Coefficient	.190*	.237*	-.021	-.062	.111	.142	.497*	.497*	.041	.071
	Sig. (2-tailed)	.050	.014	.935	.808	.564	.458	.027	.027	.808	.670
	N	73	73	12	12	20	20	15	15	26	26
132MangoNoTree	Correlation Coefficient	.170	.224*	-.037	0.000	-.058	-.104	.452*	.452*	.137	.157
	Sig. (2-tailed)	.050	.010	.877	1.000	.738	.547	.036	.036	.354	.288
	N	73	73	12	12	20	20	15	15	26	26
133Banana	Correlation Coefficient	.093	.046	.305	-.087	-.127	-.174	.183	.183	.222	.176
	Sig. (2-tailed)	.335	.634	.234	.734	.509	.364	.418	.418	.182	.291
	N	73	73	12	12	20	20	15	15	26	26
134BananaNoTree	Correlation Coefficient	.168*	.122	.208	-.080	-.104	-.150	.262	.262	.243	.117
	Sig. (2-tailed)	.049	.151	.362	.726	.547	.384	.205	.205	.100	.430
	N	73	73	12	12	20	20	15	15	26	26
135Papaya	Correlation Coefficient	-.059	-.007	-.071	-.166	-.047	-.095	-.156	-.261	-.105	.009
	Sig. (2-tailed)	.544	.941	.782	.518	.805	.621	.487	.247	.527	.958
	N	73	73	12	12	20	20	15	15	26	26
136PapayaNoTree	Correlation Coefficient	-.056	-.015	-.023	-.114	-.053	-.098	-.156	-.261	-.075	-.043
	Sig. (2-tailed)	.543	.874	.927	.648	.776	.598	.487	.247	.630	.780
	N	73	73	12	12	20	20	15	15	26	26
137Rambutan	Correlation Coefficient	.103	.077	.044	.131	-.133	-.148	.235	.235	.060	.009
	Sig. (2-tailed)	.289	.427	.865	.610	.487	.440	.298	.298	.719	.959
	N	73	73	12	12	20	20	15	15	26	26
138RambutanNoTree	Correlation Coefficient	.133	.116	.104	.187	-.146	-.169	.290	.266	.133	.074
	Sig. (2-tailed)	.134	.189	.677	.453	.398	.327	.172	.208	.385	.629
	N	73	73	12	12	20	20	15	15	26	26
139Cassava	Correlation Coefficient	.009	.039	-.024	.024	-.305	-.305	-.235	-.235	.137	.248
	Sig. (2-tailed)	.929	.689	.926	.926	.112	.112	.298	.298	.411	.136
	N	73	73	12	12	20	20	15	15	26	26
140CassavaNoTree	Correlation Coefficient	.049	.089	.023	.023	-.172	-.196	-.136	-.136	.151	.219
	Sig. (2-tailed)	.584	.317	.927	.927	.328	.264	.515	.515	.331	.159
	N	73	73	12	12	20	20	15	15	26	26
141Guava	Correlation Coefficient	.078	.053	.261	.261	.112	.071	-.029	-.088	.092	-.018
	Sig. (2-tailed)	.420	.582	.309	.309	.560	.711	.896	.695	.579	.912

	N	73	73	12	12	20	20	15	15	26	26
142GuavaNoTree	Correlation Coefficient	.078	.057	.270	.270	.110	.070	-.014	-.070	.095	-.009
	Sig. (2-tailed)	.404	.544	.275	.275	.562	.712	.949	.748	.549	.957
	N	73	73	12	12	20	20	15	15	26	26
143RoseApple	Correlation Coefficient	-.059	-.072	-.334	-.334					.166	.100
	Sig. (2-tailed)	.543	.457	.192	.192					.317	.549
	N	73	73	12	12	20	20	15	15	26	26
144RoseAppleNoTree	Correlation Coefficient	-.060	-.073	-.334	-.334					.166	.100
	Sig. (2-tailed)	.532	.447	.192	.192					.317	.549
	N	73	73	12	12	20	20	15	15	26	26
145Durian	Correlation Coefficient	.018	.022	.220	.110	.132	.112	-.077	-.153	-.067	-.112
	Sig. (2-tailed)	.852	.821	.390	.667	.491	.560	.734	.497	.686	.500
	N	73	73	12	12	20	20	15	15	26	26
146DurianNoTree	Correlation Coefficient	.037	.043	.242	.134	.110	.110	-.077	-.153	.029	-.037
	Sig. (2-tailed)	.692	.644	.336	.593	.562	.562	.734	.497	.855	.814
	N	73	73	12	12	20	20	15	15	26	26
147Cattle	Correlation Coefficient	.449**	.440**	.408	.408	.144	.099	.498*	.498*	.327*	.354*
	Sig. (2-tailed)	.000	.000	.111	.111	.452	.606	.027	.027	.049	.033
	N	73	73	12	12	20	20	15	15	26	26
148CattleNoPresent	Correlation Coefficient	.458**	.450**	.408	.408	.090	.076	.470*	.470*	.340*	.353*
	Sig. (2-tailed)	.000	.000	.111	.111	.618	.673	.034	.034	.037	.031
	N	73	73	12	12	20	20	15	15	26	26
149CattleSold	Correlation Coefficient	.412**	.426**	.408	.408	.435*	.435*	.498*	.498*	.144	.144
	Sig. (2-tailed)	.000	.000	.111	.111	.023	.023	.027	.027	.386	.386
	N	73	73	12	12	20	20	15	15	26	26
150CattleSoldNo	Correlation Coefficient	.412**	.427**	.408	.408	.417*	.417*	.470*	.470*	.144	.144
	Sig. (2-tailed)	.000	.000	.111	.111	.028	.028	.034	.034	.386	.386
	N	73	73	12	12	20	20	15	15	26	26
151CattleSalesIncomeYearUSD	Correlation Coefficient	.413**	.427**	.408	.408	.417*	.417*	.470*	.470*	.144	.144
	Sig. (2-tailed)	.000	.000	.111	.111	.028	.028	.034	.034	.386	.386
	N	73	73	12	12	20	20	15	15	26	26
152Buffalo	Correlation Coefficient	.183	.195			.316	.316			.144	.144
	Sig. (2-tailed)	.121	.098			.099	.099			.386	.386
	N	73	73	12	12	20	20	15	15	26	26
153BuffaloNoPresent	Correlation Coefficient	.184	.196			.316	.316			.144	.144
	Sig. (2-tailed)	.118	.096			.099	.099			.386	.386
	N	73	73	12	12	20	20	15	15	26	26
154BuffaloSold	Correlation Coefficient	.183	.195			.316	.316			.144	.144
	Sig. (2-tailed)	.121	.098			.099	.099			.386	.386
	N	73	73	12	12	20	20	15	15	26	26
155BuffaloSoldNo	Correlation Coefficient	.184	.196			.316	.316			.144	.144
	Sig. (2-tailed)	.118	.096			.099	.099			.386	.386
	N	73	73	12	12	20	20	15	15	26	26
156BuffaloSalesIncomeUSD	Correlation Coefficient	.184	.196			.316	.316			.144	.144
	Sig. (2-tailed)	.118	.096			.099	.099			.386	.386
	N	73	73	12	12	20	20	15	15	26	26
157Goat	Correlation Coefficient	.064	.087	.261	.071	.266	.218			.060	.060
	Sig. (2-tailed)	.589	.464	.309	.782	.166	.257			.720	.720
	N	73	73	12	12	20	20	15	15	26	26
158GoatNoPresent	Correlation Coefficient	.077	.102	.225	.045	.274	.227			.073	.094
	Sig. (2-tailed)	.518	.392	.363	.856	.148	.232			.651	.561
	N	73	73	12	12	20	20	15	15	26	26
159GoatSold	Correlation Coefficient	.134	.169			.266	.218			-.016	.064
	Sig. (2-tailed)	.257	.154			.166	.257			.923	.700
	N	73	73	12	12	20	20	15	15	26	26
160GoatSoldNo	Correlation Coefficient	.138	.173			.274	.227			-.008	.071
	Sig. (2-tailed)	.243	.144			.148	.232			.962	.665
	N	73	73	12	12	20	20	15	15	26	26
161GoatSalesIncomeUSD	Correlation Coefficient	.140	.174			.274	.227			-.008	.071

	Sig. (2-tailed)	.238	.142			.148	.232			.962	.665
	N	73	73	12	12	20	20	15	15	26	26
162Chicken	Correlation Coefficient	-.121	-.061	.392	.479	-.345	-.345	-.083	-.028	0.000	.046
	Sig. (2-tailed)	.308	.608	.126	.062	.073	.073	.713	.903	1.000	.781
	N	73	73	12	12	20	20	15	15	26	26
163ChickenNoPresent	Correlation Coefficient	-.087	-.012	.319	.399	-.330	-.330	.071	.071	.036	.095
	Sig. (2-tailed)	.463	.922	.187	.099	.075	.075	.723	.723	.805	.515
	N	73	73	12	12	20	20	15	15	26	26
164ChichkenSold	Correlation Coefficient	-.235*	-.075	-.186	.037			-.115	-.038	-.254	-.038
	Sig. (2-tailed)	.045	.529	.469	.885			.610	.865	.126	.820
	N	73	73	12	12	20	20	15	15	26	26
165ChichkenSoldNo	Correlation Coefficient	-.241*	-.081	-.186	.037			-.131	-.056	-.270	-.042
	Sig. (2-tailed)	.040	.497	.469	.885			.554	.800	.093	.796
	N	73	73	12	12	20	20	15	15	26	26
166ChickenSalesIncomeUSD	Correlation Coefficient	-.242*	-.081	-.186	.037			-.131	-.056	-.270	-.042
	Sig. (2-tailed)	.039	.496	.469	.885			.554	.800	.093	.796
	N	73	73	12	12	20	20	15	15	26	26
167ChickenEgg	Correlation Coefficient	.139	.109	.261	.355	-.036	-.036	.235	.235	.159	.053
	Sig. (2-tailed)	.242	.360	.309	.166	.850	.850	.296	.296	.340	.751
	N	73	73	12	12	20	20	15	15	26	26
168ChickenEggNo	Correlation Coefficient	.147	.114	.315	.405	-.087	-.087	.276	.276	.176	.050
	Sig. (2-tailed)	.215	.338	.202	.101	.640	.640	.200	.200	.268	.755
	N	73	73	12	12	20	20	15	15	26	26
169ChichkenEggSold	Correlation Coefficient	.112	.078							.189	.122
	Sig. (2-tailed)	.346	.510							.257	.463
	N	73	73	12	12	20	20	15	15	26	26
170CHickenEggSoldNo	Correlation Coefficient	.112	.078							.189	.122
	Sig. (2-tailed)	.346	.510							.257	.463
	N	73	73	12	12	20	20	15	15	26	26
171ChickenEggSalesIncomeUSD	Correlation Coefficient	.112	.078							.189	.122
	Sig. (2-tailed)	.346	.510							.257	.463
	N	73	73	12	12	20	20	15	15	26	26
172Dog	Correlation Coefficient	-.064	-.092			-.283	-.283	.156	.156		
	Sig. (2-tailed)	.592	.441			.140	.140	.487	.487		
	N	73	73	12	12	20	20	15	15	26	26
173DogNo	Correlation Coefficient	-.064	-.092			-.283	-.283	.156	.156		
	Sig. (2-tailed)	.592	.441			.140	.140	.487	.487		
	N	73	73	12	12	20	20	15	15	26	26
174Cat	Correlation Coefficient	-.097	-.129	-.037	-.186	.036	-.036	-.115	-.191	-.167	-.219
	Sig. (2-tailed)	.415	.276	.885	.469	.850	.850	.610	.396	.317	.188
	N	73	73	12	12	20	20	15	15	26	26
175CatNo	Correlation Coefficient	-.064	-.095	-.037	-.186	.079	.009	-.094	-.169	-.090	-.139
	Sig. (2-tailed)	.590	.423	.885	.469	.673	.963	.672	.446	.573	.383
	N	73	73	12	12	20	20	15	15	26	26
176SongBird	Correlation Coefficient	-.180	-.171	.260	.260			-.391	-.443*	-.102	-.102
	Sig. (2-tailed)	.128	.149	.311	.311			.083	.049	.541	.541
	N	73	73	12	12	20	20	15	15	26	26
177SongBirdNo	Correlation Coefficient	-.162	-.156	.260	.260			-.296	-.340	-.047	-.056
	Sig. (2-tailed)	.172	.187	.311	.311			.154	.101	.765	.724
	N	73	73	12	12	20	20	15	15	26	26
238OwnOtherEstateCrops	Correlation Coefficient	.219	.194	.187	.021	.127	.163	0.000	0.000	.189	.179
	Sig. (2-tailed)	.062	.100	.465	.935	.508	.395	1.000	1.000	.255	.283
	N	73	73	12	12	20	20	15	15	26	26
239OtherEstateCropsNoTree	Correlation Coefficient	.358**	.362**	.315	.183	.349*	.327*	.042	-.042	.358*	.264
	Sig. (2-tailed)	.002	.002	.174	.431	.034	.047	.838	.838	.012	.063
	N	73	73	12	12	20	20	15	15	26	26
240OwnStapleFoodCrops	Correlation Coefficient	-.012	.038	-.024	.024	-.305	-.305	-.235	-.235	.081	.218
	Sig. (2-tailed)	.921	.750	.926	.926	.112	.112	.298	.298	.626	.191
	N	73	73	12	12	20	20	15	15	26	26

241StapleFoodAreaHa	Correlation Coefficient	.031	.091	.023	.023	-.172	-.196	-.136	-.136	.104	.191
	Sig. (2-tailed)	.797	.442	.927	.927	.328	.264	.515	.515	.491	.209
	N	73	73	12	12	20	20	15	15	26	26
242OwnFruitTrees	Correlation Coefficient	.068	.020	.495	.165			0.000	0.000	-.192	-.240
	Sig. (2-tailed)	.565	.867	.053	.519			1.000	1.000	.248	.149
	N	73	73	12	12	20	20	15	15	26	26
243FruitsNoTree	Correlation Coefficient	.233*	.212	.185	-.123	-.098	-.131	.304	.265	.168	.056
	Sig. (2-tailed)	.047	.072	.408	.582	.556	.432	.122	.178	.233	.691
	N	73	73	12	12	20	20	15	15	26	26
244OwnLivestock	Correlation Coefficient	.089	.136	.369	.287	-.051	-.066	.325	.390	.120	.168
	Sig. (2-tailed)	.455	.251	.150	.262	.790	.732	.149	.083	.470	.312
	N	73	73	12	12	20	20	15	15	26	26
245LivestockNoPresent	Correlation Coefficient	.171	.242*	.259	.259	-.069	-.106	.507**	.507**	.126	.177
	Sig. (2-tailed)	.148	.039	.269	.269	.695	.544	.010	.010	.384	.219
	N	73	73	12	12	20	20	15	15	26	26
246OwnPets	Correlation Coefficient	-.231*	-.245*	.165	.055	.036	-.036	-.359	-.414	-.307	-.324
	Sig. (2-tailed)	.049	.037	.519	.830	.850	.850	.111	.066	.065	.052
	N	73	73	12	12	20	20	15	15	26	26
247PetsNoPresent	Correlation Coefficient	-.181	-.196	.134	.027	.061	-.009	-.288	-.329	-.154	-.168
	Sig. (2-tailed)	.125	.096	.593	.915	.743	.963	.154	.103	.314	.272
	N	73	73	12	12	20	20	15	15	26	26
178NaturalForestNearby	Correlation Coefficient	.321**	.298**	-.186	.037	.250	.298	.268	.268	.186	.091
	Sig. (2-tailed)	.001	.002	.469	.885	.187	.116	.234	.234	.264	.586
	N	73	73	12	12	20	20	15	15	26	26
179DistanceNaturalForestKm	Correlation Coefficient	.246**	.233**	-.186	.037	.058	.069	.282	.282	.146	.113
	Sig. (2-tailed)	.006	.009	.469	.885	.738	.688	.204	.204	.347	.465
	N	73	73	12	12	20	20	15	15	26	26
180SacredGrove	Correlation Coefficient	-.014	-.014			-.207	-.136				
	Sig. (2-tailed)	.881	.881			.262	.463				
	N	73	73	12	12	20	20	15	15	26	26
181AnimalsAffectFarm	Correlation Coefficient	-.145	-.101	.037	.186	-.063	-.047			-.277	-.277
	Sig. (2-tailed)	.133	.297	.885	.469	.741	.805			.096	.096
	N	73	73	12	12	20	20	15	15	26	26
182MonkeysFarm	Correlation Coefficient	-.085	-.096	-.354	-.312	-.059	-.044	.193	.138	-.157	-.324
	Sig. (2-tailed)	.378	.321	.167	.223	.758	.817	.391	.540	.345	.052
	N	73	73	12	12	20	20	15	15	26	26
183PigsFarm	Correlation Coefficient	.020	-.022	.437	.270	.133	.148	-.500*	-.500*	.103	-.114
	Sig. (2-tailed)	.838	.819	.088	.291	.487	.440	.026	.026	.537	.495
	N	73	73	12	12	20	20	15	15	26	26
184PorcupinesFarm	Correlation Coefficient	.174	.162			.030	.091			.189	.122
	Sig. (2-tailed)	.073	.094			.874	.634			.257	.463
	N	73	73	12	12	20	20	15	15	26	26
185ElephantsFarm	Correlation Coefficient	.207*	.199*			-.054	0.000	.365	.365		
	Sig. (2-tailed)	.032	.040			.777	1.000	.105	.105		
	N	73	73	12	12	20	20	15	15	26	26
186LizardsFarm	Correlation Coefficient	-.110	-.120	.037	-.111						
	Sig. (2-tailed)	.255	.217	.885	.664						
	N	73	73	12	12	20	20	15	15	26	26
187RatsFarm	Correlation Coefficient	-.070	-.079			-.314	-.314	-.052	-.052	-.038	-.092
	Sig. (2-tailed)	.469	.417			.101	.101	.817	.817	.820	.580
	N	73	73	12	12	20	20	15	15	26	26
188DeersFarm	Correlation Coefficient	-.129	-.138			-.316	-.316				
	Sig. (2-tailed)	.184	.155			.099	.099				
	N	73	73	12	12	20	20	15	15	26	26
189TigersFarm	Correlation Coefficient	.141	.147			.283	.283			.144	.144
	Sig. (2-tailed)	.146	.128			.140	.140			.386	.386
	N	73	73	12	12	20	20	15	15	26	26
190CivetsFarm	Correlation Coefficient	-.097	.110							-.189	.211
	Sig. (2-tailed)	.319	.255							.257	.205

	N	73	73	12	12	20	20	15	15	26	26
191TrenggilingPangolinsFarm	Correlation Coefficient	-.037	-.078	.186	.111						
	Sig. (2-tailed)	.704	.420	.469	.664						
	N	73	73	12	12	20	20	15	15	26	26
192AnimalHunted	Correlation Coefficient	.125	.182	.131	.392	.062	.080	.052	.052	.020	.073
	Sig. (2-tailed)	.193	.058	.610	.126	.742	.672	.817	.817	.904	.659
	N	73	73	12	12	20	20	15	15	26	26
193PigsHunted	Correlation Coefficient	.056	.133	.131	.392	.062	.080	-.313	-.261	.020	.073
	Sig. (2-tailed)	.564	.168	.610	.126	.742	.672	.165	.247	.904	.659
	N	73	73	12	12	20	20	15	15	26	26
194MonkeysHunted	Correlation Coefficient	.070	.060			.283	.283	0.000	0.000		
	Sig. (2-tailed)	.468	.532			.140	.140	1.000	1.000		
	N	73	73	12	12	20	20	15	15	26	26
195BirdsHunted	Correlation Coefficient	.210*	.163	.308	.166	-.049	-.091	.235	.235	.332*	.255
	Sig. (2-tailed)	.029	.090	.229	.518	.794	.628	.298	.298	.046	.126
	N	73	73	12	12	20	20	15	15	26	26
196SnakesHunted	Correlation Coefficient	.028	.114							.103	.189
	Sig. (2-tailed)	.776	.238							.537	.255
	N	73	73	12	12	20	20	15	15	26	26
197DeersHunted	Correlation Coefficient	.147	.152			-.036	.036	.209	.209	.114	.114
	Sig. (2-tailed)	.129	.116			.850	.850	.355	.355	.495	.495
	N	73	73	12	12	20	20	15	15	26	26
198AyamHutanJunglefowl	Correlation Coefficient	-.110	-.121			-.316	-.316	0.000	0.000	-.100	-.122
	Sig. (2-tailed)	.255	.211			.099	.099	1.000	1.000	.549	.463
	N	73	73	12	12	20	20	15	15	26	26
199DistanceFarmToRiverKm	Correlation Coefficient	.018	-.018	.118	.254	-.062	-.017	.379	.338	.143	.027
	Sig. (2-tailed)	.827	.827	.614	.279	.716	.921	.060	.093	.337	.855
	N	73	73	12	12	20	20	15	15	26	26
200FrequentFlood10years	Correlation Coefficient	-.082	-.136	-.330	-.220	-.025	.025			-.065	-.164
	Sig. (2-tailed)	.390	.154	.197	.390	.896	.896			.739	.318
	N	73	73	12	12	20	20	15	15	26	26
201FarmAffectRiver	Correlation Coefficient	.103	.064	-.062	-.062	.105	.147	.074	.074	.120	.028
	Sig. (2-tailed)	.284	.505	.808	.808	.576	.434	.735	.735	.470	.868
	N	73	73	12	12	20	20	15	15	26	26
202HistoricalLand	Correlation Coefficient	.140	.188*	.213	.261	.307	.334	.443*	.443*	-.096	-.175
	Sig. (2-tailed)	.140	.049	.405	.309	.098	.072	.045	.045	.562	.292
	N	73	73	12	12	20	20	15	15	26	26
203Landslide	Correlation Coefficient	.026	.033	.110	.275	-.024	-.048				
	Sig. (2-tailed)	.790	.734	.667	.283	.900	.801				
	N	73	73	12	12	20	20	15	15	26	26
204Flood	Correlation Coefficient	-.183	-.140	-.111	.037	-.415*	-.385*	0.000	-.077	.077	.128
	Sig. (2-tailed)	.059	.148	.664	.885	.031	.045	1.000	.734	.643	.440
	N	73	73	12	12	20	20	15	15	26	26
205Fire	Correlation Coefficient	.033	.114	.334	.334			.313	.313	.022	.103
	Sig. (2-tailed)	.734	.241	.192	.192			.165	.165	.893	.535
	N	73	73	12	12	20	20	15	15	26	26
206Storm	Correlation Coefficient	-.120	-.129	-.037	-.186						
	Sig. (2-tailed)	.217	.184	.885	.469						
	N	73	73	12	12	20	20	15	15	26	26
207Earthquake	Correlation Coefficient	.016	.013					0.000	0.000		
	Sig. (2-tailed)	.866	.892					1.000	1.000		
	N	73	73	12	12	20	20	15	15	26	26
208RiverWaterQuality	Correlation Coefficient	-.112	-.141	-.603*	-.687**	-.073	-.105	.293	.293	.033	.033
	Sig. (2-tailed)	.238	.136	.016	.006	.698	.575	.194	.194	.841	.841
	N	73	73	12	12	20	20	15	15	26	26

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

APPENDIX 5B – RESULTS OF REGRESSION MODEL USING FORCED ENTRY METHOD

Enter Method

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.888[a]	.789	.713	17847.3551	2.292

a. Predictors: (Constant), 178NaturalForestNearby, 22YearsVillage, 84ShopIncome, 83OthFarmActIncome, 85BusinessIncome, 21HouseholdSize, 91FuelwoodCooking, 239OtherEstateCropsNoTree, 245LivestockNoPresent, 46FreqFertiliseYear, 12Educ, 210NESTrans, 97NoPickUp, 212NESCoopPartlyManaged, 213OPProductiveLandAreaHa, 215OPAvgPriceTonnesUSD, 100TransportExpenseYearUSD, 36FreqHarvestMonth, 35TreeAge

b. Dependent Variable: 237TotalHHIncomeYrUSD

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	63166292359.988	19	3324541703.157	10.437	.000[b]
	Residual	16881988396.288	53	318528082.949		
	Total	80048280756.275	72			

a. Dependent Variable: 237TotalHHIncomeYrUSD

b. Predictors: (Constant), 178NaturalForestNearby, 22YearsVillage, 84ShopIncome, 83OthFarmActIncome, 85BusinessIncome, 21HouseholdSize, 91FuelwoodCooking, 239OtherEstateCropsNoTree, 245LivestockNoPresent, 46FreqFertiliseYear, 12Educ, 210NESTrans, 97NoPickUp, 212NESCoopPartlyManaged, 213OPProductiveLandAreaHa, 215OPAvgPriceTonnesUSD, 100TransportExpenseYearUSD, 36FreqHarvestMonth, 35TreeAge

Coefficientsa

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
	B	Std. Error	Beta			Tolerance	VIF
(Constant)	26822.142	20885.615		1.284	.205		
12Educ	707.160	2438.721	.023	.290	.773	.639	1.564
21HouseholdSize	-2585.113	1805.864	-.126	-1.432	.158	.515	1.940
22YearsVillage	-878.563	3008.970	-.026	-.292	.771	.491	2.037
35TreeAge	1993.125	3841.373	.081	.519	.606	.165	6.054
36FreqHarvestMonth	773.239	5190.321	.021	.149	.882	.205	4.887
46FreqFertiliseYear	-545.066	1361.268	-.034	-.400	.690	.555	1.801
83OthFarmActIncome	-662.535	5124.291	-.010	-.129	.898	.703	1.423

84ShopIncome	-150.652	6009.239	-.002	-.025	.980	.826	1.211
85BusinessIncome	-4105.719	5296.704	-.061	-.775	.442	.642	1.556
91FuelwoodCooking	-8618.066	5379.584	-.114	-1.602	.115	.783	1.277
97NoPickUp	10435.442	5289.719	.175	1.973	.054	.505	1.978
100TransportExpenseYearUSD	3.611	1.345	.256	2.684	.010	.436	2.295
210NESTrans	19836.374	7823.518	.222	2.535	.014	.519	1.927
212NESCoopPartlyManaged	-6967.696	8131.548	-.075	-.857	.395	.516	1.939
213OPProductiveLandAreaHa	824.247	111.608	.628	7.385	.000	.549	1.820
215OPAvgPriceTonnesUSD	-193.887	150.117	-.206	-1.292	.202	.156	6.424
239OtherEstateCropsNoTree	.758	1.728	.032	.439	.663	.762	1.313
245LivestockNoPresent	134.901	118.375	.095	1.140	.260	.573	1.744
178NaturalForestNearby	-895.197	5054.841	-.014	-.177	.860	.628	1.591

a. Dependent Variable: 237TotalHHIncomeYrUSD

APPENDIX 5C – RESULTS OF REGRESSION MODEL USING STEPWISE METHOD

Model Summary[d]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Square Change	F Change	df1	df2	Sig. F Change	
1	.829[a]	.687	.682	18797.9671	.687	155.532	1	71	.000	
2	.849[b]	.721	.713	17849.6893	.035	8.744	1	70	.004	
3	.859[c]	.737	.726	17462.6024	.016	4.138	1	69	.046	2.235

a. Predictors: (Constant), 213OPProductiveLandAreaHa

b. Predictors: (Constant), 213OPProductiveLandAreaHa, 97NoPickUp

c. Predictors: (Constant), 213OPProductiveLandAreaHa, 97NoPickUp, 245LivestockNoPresent

d. Dependent Variable: 237TotalHHIncomeYrUSD

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	54959467475.234	1	54959467475.234	155.532	.000[b]
	Residual	25088813281.041	71	353363567.339		
	Total	80048280756.275	72			
2	Regression	57745482072.966	2	28872741036.483	90.621	.000[c]
	Residual	22302798683.310	70	318611409.762		
	Total	80048280756.275	72			
3	Regression	59007249495.801	3	19669083165.267	64.501	.000[d]
	Residual	21041031260.475	69	304942482.036		
	Total	80048280756.275	72			

a. Dependent Variable: 237TotalHHIncomeYrUSD

b. Predictors: (Constant), 213OPProductiveLandAreaHa

c. Predictors: (Constant), 213OPProductiveLandAreaHa, 97NoPickUp

d. Predictors: (Constant), 213OPProductiveLandAreaHa, 97NoPickUp, 245LivestockNoPresent

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	5011.881	2413.102		2.077	.041		
	213OPProductiveLandAreaHa	1086.719	87.138	.829	12.471	.000	1.000	1.000
2	(Constant)	3006.529	2389.619		1.258	.213		

	213OPProductiveLandAreaHa	962.649	92.772	.734	10.377	.000	.795	1.257
	97NoPickUp	12470.751	4217.271	.209	2.957	.004	.795	1.257
3	(Constant)	1172.108	2505.708		.468	.641		
	213OPProductiveLandAreaHa	887.709	97.952	.677	9.063	.000	.683	1.464
	97NoPickUp	12554.915	4126.024	.211	3.043	.003	.795	1.257
	245LivestockNoPresent	195.632	96.174	.138	2.034	.046	.832	1.203

a. Dependent Variable: 237TotalHHIncomeYrUSD

Excluded Variables[a]

Model		Beta In	t	Sig.	Partial Correlation	Collinearity Statistics
						Tolerance
1	12Educ	-.005[b]	-.071	.944	-.008	.974
	21HouseholdSize	.093[b]	1.366	.176	.161	.937
	22YearsVillage	.011[b]	.160	.874	.019	.967
	35TreeAge	-.009[b]	-.136	.892	-.016	.954
	36FreqHarvestMonth	-.024[b]	-.349	.728	-.042	.963
	46FreqFertiliseYear	-.038[b]	-.556	.580	-.066	.954
	83OthFarmActIncome	.036[b]	.537	.593	.064	.967
	84ShopIncome	.023[b]	.337	.737	.040	.957
	85BusinessIncome	.051[b]	.729	.469	.087	.924
	91FuelwoodCooking	-.033[b]	-.494	.623	-.059	.993
	97NoPickUp	.209[b]	2.957	.004	.333	.795
	100TransportExpenseYearUSD	.197[b]	2.908	.005	.328	.866
	210NESTrans	.101[b]	1.444	.153	.170	.892
	212NESCoopPartlyManaged	.009[b]	.130	.897	.016	.981
	215OPAvgPriceTonnesUSD	-.042[b]	-.616	.540	-.073	.947
	239OtherEstateCropsNoTree	.056[b]	.840	.404	.100	.983
	245LivestockNoPresent	.136[b]	1.895	.062	.221	.832
	178NaturalForestNearby	-.022[b]	-.313	.755	-.037	.942
2	12Educ	-.009[c]	-.146	.885	-.018	.973
	21HouseholdSize	.037[c]	.534	.595	.064	.847
	22YearsVillage	-.008[c]	-.122	.903	-.015	.957
	35TreeAge	-.010[c]	-.153	.879	-.018	.954
	36FreqHarvestMonth	.001[c]	.009	.993	.001	.947
	46FreqFertiliseYear	-.027[c]	-.418	.677	-.050	.951
	83OthFarmActIncome	.025[c]	.389	.699	.047	.963
	84ShopIncome	.023[c]	.358	.721	.043	.957
	85BusinessIncome	.014[c]	.202	.840	.024	.890
	91FuelwoodCooking	-.051[c]	-.799	.427	-.096	.984
	100TransportExpenseYearUSD	.136[c]	1.835	.071	.216	.702
	210NESTrans	.109[c]	1.654	.103	.195	.890

	212NESCoopPartlyManaged	-.039[c]	-.589	.558	-.071	.924
	215OPAvgPriceTonnesUSD	-.033[c]	-.509	.612	-.061	.945
	239OtherEstateCropsNoTree	.004[c]	.058	.954	.007	.905
	245LivestockNoPresent	.138[c]	2.034	.046	.238	.832
	178NaturalForestNearby	-.045[c]	-.690	.492	-.083	.928
3	12Educ	-.006[d]	-.092	.927	-.011	.973
	21HouseholdSize	.009[d]	.131	.896	.016	.811
	22YearsVillage	.002[d]	.036	.971	.004	.951
	35TreeAge	-.020[d]	-.307	.760	-.037	.948
	36FreqHarvestMonth	-.010[d]	-.153	.879	-.019	.941
	46FreqFertiliseYear	-.017[d]	-.269	.789	-.033	.945
	83OthFarmActIncome	-.005[d]	-.071	.944	-.009	.912
	84ShopIncome	.004[d]	.065	.948	.008	.936
	85BusinessIncome	.020[d]	.296	.768	.036	.888
	91FuelwoodCooking	-.063[d]	-1.014	.314	-.122	.976
	100TransportExpenseYearUSD	.115[d]	1.564	.122	.186	.685
	210NESTrans	.104[d]	1.602	.114	.191	.888
	212NESCoopPartlyManaged	-.020[d]	-.310	.757	-.038	.905
	215OPAvgPriceTonnesUSD	-.027[d]	-.426	.671	-.052	.943
	239OtherEstateCropsNoTree	.004[d]	.066	.947	.008	.905
	178NaturalForestNearby	-.047[d]	-.735	.465	-.089	.928

a. Dependent Variable: 237TotalHHIncomeYrUSD

b. Predictors in the Model: (Constant), 213OPProductiveLandAreaHa

c. Predictors in the Model: (Constant), 213OPProductiveLandAreaHa, 97NoPickUp

d. Predictors in the Model: (Constant), 213OPProductiveLandAreaHa, 97NoPickUp, 245LivestockNoPresent

APPENDIX 5D – RESULTS OF REGRESSION MODEL USING STEPWISE METHOD IN EACH FOUR STUDY AREAS

Results of Multiple Linear Regression in Each Study Area
Stepwise Method
Ujung Batu

Model Summary[a,f]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Square Change	F Change	df1	df2	Sig. F Change	
1	.997[b]	.995	.994	1902.1225	.995	1901.285	1	10	.000	
2	.999[c]	.998	.997	1327.1513	.003	11.542	1	9	.008	
3	.999[d]	.999	.998	1006.0646	.001	7.661	1	8	.024	
4	1.000[e]	1.000	.999	699.3793	.001	9.555	1	7	.018	1.653

a. Sub District = Ujung Batu

b. Predictors: (Constant), 210NESTrans

c. Predictors: (Constant), 210NESTrans, 91FuelwoodCooking

d. Predictors: (Constant), 210NESTrans, 91FuelwoodCooking, 213OPProductiveLandAreaHa

e. Predictors: (Constant), 210NESTrans, 91FuelwoodCooking, 213OPProductiveLandAreaHa, 84ShopIncome

f. Dependent Variable: 237TotalHHIncomeYrUSD

ANOVA[a,b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	6878983223.189	1	6878983223.189	1901.285	.000[c]
	Residual	36180698.408	10	3618069.841		
	Total	6915163921.597	11			
2	Regression	6899311946.287	2	3449655973.144	1958.551	.000[d]
	Residual	15851975.310	9	1761330.590		
	Total	6915163921.597	11			
3	Regression	6907066593.116	3	2302355531.039	2274.682	.000[e]
	Residual	8097328.481	8	1012166.060		
	Total	6915163921.597	11			
4	Regression	6911740001.730	4	1727935000.433	3532.660	.000[f]
	Residual	3423919.867	7	489131.410		
	Total	6915163921.597	11			

a. Sub District = Ujung Batu

b. Dependent Variable: 237TotalHHIncomeYrUSD

c. Predictors: (Constant), 210NESTrans

d. Predictors: (Constant), 210NESTrans, 91FuelwoodCooking

e. Predictors: (Constant), 210NESTrans, 91FuelwoodCooking, 213OPProductiveLandAreaHa

f. Predictors: (Constant), 210NESTrans, 91FuelwoodCooking, 213OPProductiveLandAreaHa, 84ShopIncome

Coefficients[a,b]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	-83939.399	2221.200		-37.790	.000		
	210NESTrans	86627.625	1986.702	.997	43.604	.000	1.000	1.000
2	(Constant)	-77516.669	2444.574		-31.710	.000		
	210NESTrans	84829.260	1483.800	.977	57.170	.000	.873	1.146
	91FuelwoodCooking	-2826.001	831.836	-.058	-3.397	.008	.873	1.146
3	(Constant)	-61532.908	6064.688		-10.146	.000		
	210NESTrans	67969.677	6194.031	.783	10.973	.000	.029	34.746
	91FuelwoodCooking	-2925.527	631.609	-.060	-4.632	.002	.870	1.150
	213OPProductiveLandAreaHa	557.342	201.357	.196	2.768	.024	.029	34.352
4	(Constant)	-59992.197	4245.312		-14.131	.000		
	210NESTrans	68565.595	4310.177	.789	15.908	.000	.029	34.816
	91FuelwoodCooking	-3012.274	439.967	-.062	-6.847	.000	.866	1.154
	213OPProductiveLandAreaHa	515.854	140.618	.182	3.668	.008	.029	34.667
	84ShopIncome	-1318.186	426.454	-.027	-3.091	.018	.922	1.084

a. Sub District = Ujung Batu

b. Dependent Variable: 237TotalHHIncomeYrUSD

Excluded Variables[a,b]

Model		Beta In	t	Sig.	Partial Correlation	Collinearity Statistics		
						Tolerance	VIF	Minimum Tolerance
1	12Educ	.041[c]	1.897	.090	.534	.909	1.100	.909
	21HouseholdSize	.020[c]	.842	.422	.270	.986	1.014	.986
	22YearsVillage	-.013[c]	-.524	.613	-.172	.970	1.031	.970
	35TreeAge	.008[c]	.308	.765	.102	.958	1.044	.958
	36FreqHarvestMonth	.003[c]	.111	.914	.037	.961	1.041	.961
	46FreqFertiliseYear	.041[c]	1.616	.141	.474	.690	1.450	.690
	83OthFarmActIncome	-.005[c]	-.194	.850	-.065	.909	1.100	.909
	84ShopIncome	-.026[c]	-1.118	.292	-.349	.935	1.069	.935
	85BusinessIncome	-.010[c]	-.399	.699	-.132	.873	1.146	.873

	91FuelwoodCooking	-.058[c]	-3.397	.008	-.750	.873	1.146	.873
	97NoPickUp	-.001[c]	-.021	.983	-.007	.992	1.008	.992
	100TransportExpenseYearUSD	.024[c]	1.032	.329	.325	.985	1.015	.985
	213OPProductiveLandAreaHa	.178[c]	1.387	.199	.420	.029	34.240	.029
	215OPAvgPriceTonnesUSD	.014[c]	.557	.591	.182	.939	1.065	.939
	239OtherEstateCropsNoTree	.016[c]	.507	.625	.167	.560	1.787	.560
	245LivestockNoPresent	.001[c]	.057	.956	.019	.846	1.182	.846
	178NaturalForestNearby	.001[c]	.059	.954	.020	.992	1.008	.992
2	12Educ	.019[d]	1.006	.344	.335	.726	1.377	.697
	21HouseholdSize	.023[d]	1.513	.169	.472	.983	1.017	.858
	22YearsVillage	.032[d]	1.725	.123	.521	.623	1.605	.561
	35TreeAge	.012[d]	.717	.494	.246	.952	1.051	.831
	36FreqHarvestMonth	.014[d]	.842	.424	.285	.923	1.083	.816
	46FreqFertiliseYear	.012[d]	.511	.623	.178	.520	1.924	.520
	83OthFarmActIncome	-.009[d]	-.506	.626	-.176	.905	1.105	.813
	84ShopIncome	-.030[d]	-2.162	.063	-.607	.931	1.075	.813
	85BusinessIncome	.000[d]	.009	.993	.003	.845	1.184	.738
	97NoPickUp	.013[d]	.786	.455	.268	.935	1.069	.823
	100TransportExpenseYearUSD	.026[d]	1.781	.113	.533	.984	1.016	.859
	213OPProductiveLandAreaHa	.196[d]	2.768	.024	.699	.029	34.352	.029
	215OPAvgPriceTonnesUSD	.019[d]	1.146	.285	.376	.932	1.073	.813
	239OtherEstateCropsNoTree	.024[d]	1.130	.291	.371	.554	1.806	.497
	245LivestockNoPresent	-.026[d]	-1.483	.176	-.464	.710	1.408	.710
	178NaturalForestNearby	-.026[d]	-1.584	.152	-.489	.818	1.222	.720
3	12Educ	.007[e]	.429	.681	.160	.650	1.539	.026
	21HouseholdSize	-.002[e]	-.089	.931	-.034	.503	1.988	.015
	22YearsVillage	.007[e]	.327	.753	.123	.361	2.773	.017
	35TreeAge	-.003[e]	-.174	.867	-.066	.790	1.266	.024
	36FreqHarvestMonth	-.013[e]	-.784	.459	-.284	.554	1.805	.017
	46FreqFertiliseYear	-.017[e]	-.864	.416	-.310	.377	2.652	.021
	83OthFarmActIncome	-.027[e]	-2.472	.043	-.683	.767	1.304	.025
	84ShopIncome	-.027[e]	-3.091	.018	-.760	.922	1.084	.029
	85BusinessIncome	-.004[e]	-.311	.765	-.117	.832	1.202	.029
	97NoPickUp	-.017[e]	-1.047	.330	-.368	.523	1.913	.016
	100TransportExpenseYearUSD	-.007[e]	-.296	.776	-.111	.313	3.194	.009
	215OPAvgPriceTonnesUSD	-.007[e]	-.421	.686	-.157	.528	1.893	.017
	239OtherEstateCropsNoTree	-.016[e]	-.673	.523	-.246	.276	3.623	.015
	245LivestockNoPresent	-.021[e]	-1.528	.170	-.500	.692	1.445	.028
	178NaturalForestNearby	-.020[e]	-1.619	.149	-.522	.794	1.260	.028
4	12Educ	.019[f]	2.068	.084	.645	.586	1.707	.025
	21HouseholdSize	.010[f]	.788	.461	.306	.459	2.178	.014
	22YearsVillage	-.006[f]	-.360	.731	-.145	.332	3.011	.017
	35TreeAge	-.003[f]	-.318	.761	-.129	.790	1.266	.024

36FreqHarvestMonth	-.013[f]	-1.143	.297	-.423	.554	1.805	.017
46FreqFertiliseYear	-.012[f]	-.825	.441	-.319	.370	2.704	.021
83OthFarmActIncome	-.019[f]	-2.441	.050	-.706	.684	1.461	.023
85BusinessIncome	.012[f]	1.220	.268	.446	.635	1.576	.028
97NoPickUp	.006[f]	.372	.723	.150	.342	2.926	.012
100TransportExpenseYearUSD	.023[f]	1.383	.216	.492	.232	4.308	.007
215OPAvgPriceTonnesUSD	-.014[f]	-1.202	.275	-.441	.514	1.946	.016
239OtherEstateCropsNoTree	.011[f]	.569	.590	.226	.209	4.786	.012
245LivestockNoPresent	-.013[f]	-1.317	.236	-.474	.642	1.557	.028
178NaturalForestNearby	-.011[f]	-1.169	.287	-.431	.702	1.425	.028

a. Sub District = Ujung Batu

b. Dependent Variable: 237TotalHHIncomeYrUSD

c. Predictors in the Model: (Constant), 210NESTrans

d. Predictors in the Model: (Constant), 210NESTrans, 91FuelwoodCooking

e. Predictors in the Model: (Constant), 210NESTrans, 91FuelwoodCooking, 213OPProductiveLandAreaHa

f. Predictors in the Model: (Constant), 210NESTrans, 91FuelwoodCooking, 213OPProductiveLandAreaHa, 84ShopIncome

Results of Multiple Linear Regression in Each Study Area
Stepwise Method
Tapung

Model Summary[a,d]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics		Durbin-Watson
					R Square Change	F Change	
1	.889[b]	.790	.778	11094.7708	.790	67.519	
2	.956[c]	.914	.904	7305.9741	.124	24.510	2.220

a. Sub District = Tapung

b. Predictors: (Constant), 213OPProductiveLandAreaHa

c. Predictors: (Constant), 213OPProductiveLandAreaHa, 100TransportExpenseYearUSD

d. Dependent Variable: 237TotalHHIncomeYrUSD

ANOVA[a,b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	8311194590.583	1	8311194590.583	67.519	.000[c]
	Residual	2215690896.276	18	123093938.682		
	Total	10526885486.860	19			
2	Regression	9619472099.131	2	4809736049.566	90.108	.000[d]
	Residual	907413387.728	17	53377258.102		
	Total	10526885486.860	19			

a. Sub District = Tapung

b. Dependent Variable: 237TotalHHIncomeYrUSD

c. Predictors: (Constant), 213OPProductiveLandAreaHa

d. Predictors: (Constant), 213OPProductiveLandAreaHa, 100TransportExpenseYearUSD

Coefficients[a,b]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	145.831	3365.842		.043	.966		
	213OPProductiveLandAreaHa	1347.107	163.941	.889	8.217	.000	1.000	1.000
2	(Constant)	821.779	2220.629		.370	.716		

213OPProductiveLandAreaHa	899.917	140.761	.594	6.393	.000	.588	1.700
100TransportExpenseYearUSD	2.735	.553	.460	4.951	.000	.588	1.700

a. Sub District = Tapung

b. Dependent Variable: 237TotalHHIncomeYrUSD

Excluded Variables[a,b]

Model		Beta In	t	Sig.	Partial Correlation	Collinearity Statistics Tolerance
1	12Educ	-.051[c]	-.457	.653	-.110	.994
	21HouseholdSize	.150[c]	1.324	.203	.306	.871
	22YearsVillage	-.027[c]	-.237	.816	-.057	.921
	35TreeAge	-.027[c]	-.228	.822	-.055	.900
	36FreqHarvestMonth	.093[c]	.853	.405	.203	.999
	46FreqFertiliseYear	-.021[c]	-.155	.879	-.037	.660
	83OthFarmActIncome	.144[c]	1.306	.209	.302	.924
	84ShopIncome	-.063[c]	-.543	.594	-.131	.900
	85BusinessIncome	-.063[c]	-.492	.629	-.118	.736
	91FuelwoodCooking	.121[c]	1.023	.320	.241	.833
	97NoPickUp	-.053[c]	-.357	.725	-.086	.553
	100TransportExpenseYearUSD	.460[c]	4.951	.000	.768	.588
	210NESTrans	-.109[c]	-.992	.335	-.234	.972
	212NESCoopPartlyManaged	.026[c]	.211	.836	.051	.826
	215OPAvgPriceTonnesUSD	.050[c]	.448	.660	.108	.984
	239OtherEstateCropsNoTree	.086[c]	.789	.441	.188	1.000
	245LivestockNoPresent	.274[c]	2.721	.015	.551	.849
	178NaturalForestNearby	.001[c]	.013	.990	.003	.949
2	12Educ	.016[d]	.212	.835	.053	.959
	21HouseholdSize	-.050[d]	-.562	.582	-.139	.654
	22YearsVillage	-.036[d]	-.478	.639	-.119	.920
	35TreeAge	-.018[d]	-.238	.815	-.059	.899
	36FreqHarvestMonth	.101[d]	1.471	.161	.345	.998
	46FreqFertiliseYear	.065[d]	.718	.483	.177	.636
	83OthFarmActIncome	.056[d]	.727	.478	.179	.866
	84ShopIncome	.100[d]	1.242	.232	.297	.758
	85BusinessIncome	.027[d]	.306	.764	.076	.702
	91FuelwoodCooking	.071[d]	.891	.386	.217	.818
	97NoPickUp	-.103[d]	-1.079	.296	-.261	.547
	210NESTrans	.014[d]	.174	.864	.044	.861

212NESCoopPartlyManaged	.004[d]	.055	.957	.014	.823
215OPAvgPriceTonnesUSD	.050[d]	.681	.506	.168	.984
239OtherEstateCropsNoTree	.053[d]	.728	.477	.179	.991
245LivestockNoPresent	.077[d]	.805	.433	.197	.560
178NaturalForestNearby	.016[d]	.218	.830	.054	.947

a. Sub District = Tapung

b. Dependent Variable: 237TotalHHIncomeYrUSD

c. Predictors in the Model: (Constant), 213OPProductiveLandAreaHa

d. Predictors in the Model: (Constant), 213OPProductiveLandAreaHa, 100TransportExpenseYearUSD

Results of Multiple Linear Regression in Each Study Area
Stepwise Method
Kerinci Kanan

Model Summary[a,g]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics		Durbin-Watson
					R Square Change	F Change	
1	.956[b]	.914	.907	16721.8460	.914	137.745	
2	.999[c]	.998	.997	2820.3731	.084	444.982	
3	1.000[d]	.999	.999	1951.2940	.001	14.070	
4	1.000[e]	.999	.999	1563.8726	.000	7.125	
5	1.000[f]	1.000	.999	1303.9597	.000	5.384	1.778

a. Sub District = Kerinci Kanan

b. Predictors: (Constant), 213OPProductiveLandAreaHa

c. Predictors: (Constant), 213OPProductiveLandAreaHa, 97NoPickUp

d. Predictors: (Constant), 213OPProductiveLandAreaHa, 97NoPickUp, 12Educ

e. Predictors: (Constant), 213OPProductiveLandAreaHa, 97NoPickUp, 12Educ, 85BusinessIncome

f. Predictors: (Constant), 213OPProductiveLandAreaHa, 97NoPickUp, 12Educ, 85BusinessIncome, 91FuelwoodCooking

g. Dependent Variable: 237TotalHHIncomeYrUSD

ANOVA[a,b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	38516197802.803	1	38516197802.803	137.745	.000[c]
	Residual	3635061738.412	13	279620133.724		
	Total	42151259541.215	14			
2	Regression	42055805488.619	2	21027902744.310	2643.521	.000[d]
	Residual	95454052.596	12	7954504.383		
	Total	42151259541.215	14			
3	Regression	42109376508.368	3	14036458836.123	3686.482	.000[e]
	Residual	41883032.848	11	3807548.441		
	Total	42151259541.215	14			
4	Regression	42126802566.943	4	10531700641.736	4306.216	.000[f]
	Residual	24456974.272	10	2445697.427		
	Total	42151259541.215	14			
5	Regression	42135956742.762	5	8427191348.552	4956.265	.000[g]
	Residual	15302798.453	9	1700310.939		
	Total	42151259541.215	14			

a. Sub District = Kerinci Kanan

b. Dependent Variable: 237TotalHHIncomeYrUSD

c. Predictors: (Constant), 213OPProductiveLandAreaHa

d. Predictors: (Constant), 213OPProductiveLandAreaHa, 97NoPickUp

e. Predictors: (Constant), 213OPProductiveLandAreaHa, 97NoPickUp, 12Educ

f. Predictors: (Constant), 213OPProductiveLandAreaHa, 97NoPickUp, 12Educ, 85BusinessIncome

g. Predictors: (Constant), 213OPProductiveLandAreaHa, 97NoPickUp, 12Educ, 85BusinessIncome, 91FuelwoodCooking

Coefficients[a,b]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	5876.767	4592.197		1.280	.223		
	213OPProductiveLandAreaHa	1108.188	94.423	.956	11.736	.000	1.000	1.000
2	(Constant)	3139.796	785.330		3.998	.002		
	213OPProductiveLandAreaHa	706.421	24.827	.609	28.454	.000	.411	2.430
	97NoPickUp	70446.809	3339.568	.452	21.095	.000	.411	2.430
3	(Constant)	-4485.812	2104.330		-2.132	.056		
	213OPProductiveLandAreaHa	722.389	17.696	.623	40.821	.000	.388	2.580
	97NoPickUp	64882.305	2745.753	.416	23.630	.000	.291	3.432
	12Educ	3285.003	875.777	.044	3.751	.003	.642	1.558
4	(Constant)	-8079.545	2157.993		-3.744	.004		
	213OPProductiveLandAreaHa	724.040	14.196	.625	51.002	.000	.387	2.584
	97NoPickUp	62815.680	2332.816	.403	26.927	.000	.259	3.857
	12Educ	3414.822	703.578	.046	4.854	.001	.639	1.565
	85BusinessIncome	2515.512	942.385	.023	2.669	.024	.765	1.307
5	(Constant)	-8012.240	1799.572		-4.452	.002		
	213OPProductiveLandAreaHa	728.564	11.996	.628	60.732	.000	.377	2.655
	97NoPickUp	60199.873	2248.192	.386	26.777	.000	.194	5.153
	12Educ	4242.975	686.688	.057	6.179	.000	.466	2.145
	85BusinessIncome	3208.528	840.612	.030	3.817	.004	.668	1.496
	91FuelwoodCooking	-2215.645	954.893	-.018	-2.320	.045	.636	1.573

a. Sub District = Kerinci Kanan

b. Dependent Variable: 237TotalHHIncomeYrUSD

Excluded Variables[a,b]

Model		Beta In	t	Sig.	Partial Correlation	Collinearity Statistics
						Tolerance
1	12Educ	.196[c]	2.850	.015	.635	.907

	21HouseholdSize	.277[c]	4.270	.001	.777	.679
	22YearsVillage	.028[c]	.326	.750	.094	.968
	35TreeAge	.081[c]	.970	.351	.270	.945
	36FreqHarvestMonth	.035[c]	.406	.692	.116	.952
	46FreqFertiliseYear	-.056[c]	-.674	.513	-.191	.991
	83OthFarmActIncome	.079[c]	.921	.375	.257	.925
	84ShopIncome	.172[c]	2.024	.066	.504	.740
	85BusinessIncome	.126[c]	1.519	.155	.401	.875
	91FuelwoodCooking	-.036[c]	-.415	.685	-.119	.969
	97NoPickUp	.452[c]	21.095	.000	.987	.411
	100TransportExpenseYearUSD	.361[c]	10.045	.000	.945	.591
	210NESTrans	.150[c]	1.793	.098	.460	.812
	215OPAvgPriceTonnesUSD	.035[c]	.387	.706	.111	.890
	239OtherEstateCropsNoTree	-.076[c]	-.892	.390	-.249	.920
	245LivestockNoPresent	.400[c]	9.992	.000	.945	.481
	178NaturalForestNearby	-.055[c]	-.495	.629	-.142	.570
2	12Educ	.044[d]	3.751	.003	.749	.642
	21HouseholdSize	.020[d]	.741	.474	.218	.283
	22YearsVillage	.001[d]	.046	.964	.014	.960
	35TreeAge	.005[d]	.333	.745	.100	.882
	36FreqHarvestMonth	.002[d]	.159	.876	.048	.941
	46FreqFertiliseYear	.004[d]	.253	.805	.076	.949
	83OthFarmActIncome	.002[d]	.151	.883	.045	.865
	84ShopIncome	.018[d]	.994	.342	.287	.577
	85BusinessIncome	.020[d]	1.339	.207	.374	.769
	91FuelwoodCooking	.012[d]	.812	.434	.238	.944
	100TransportExpenseYearUSD	-.005[d]	-.079	.939	-.024	.047
	210NESTrans	.031[d]	2.118	.058	.538	.692
	215OPAvgPriceTonnesUSD	.010[d]	.662	.522	.196	.884
	239OtherEstateCropsNoTree	.012[d]	.766	.460	.225	.844
	245LivestockNoPresent	.028[d]	.419	.683	.125	.046
	178NaturalForestNearby	.008[d]	.444	.666	.133	.555
3	21HouseholdSize	.014[e]	.754	.468	.232	.281
	22YearsVillage	-.011[e]	-1.045	.320	-.314	.882
	35TreeAge	-.011[e]	-1.002	.340	-.302	.755
	36FreqHarvestMonth	-.012[e]	-1.150	.277	-.342	.827
	46FreqFertiliseYear	-.010[e]	-.955	.362	-.289	.838
	83OthFarmActIncome	.011[e]	1.061	.314	.318	.826
	84ShopIncome	.012[e]	.920	.379	.279	.566
	85BusinessIncome	.023[e]	2.669	.024	.645	.765
	91FuelwoodCooking	-.008[e]	-.672	.517	-.208	.728
	100TransportExpenseYearUSD	-.003[e]	-.072	.944	-.023	.047
	210NESTrans	.019[e]	1.701	.120	.474	.620

	215OPAvgPriceTonnesUSD	-.005[e]	-.471	.648	-.147	.755
	239OtherEstateCropsNoTree	.009[e]	.829	.426	.254	.839
	245LivestockNoPresent	.002[e]	.050	.961	.016	.045
	178NaturalForestNearby	.019[e]	1.518	.160	.433	.533
4	21HouseholdSize	.019[f]	1.388	.199	.420	.276
	22YearsVillage	-.002[f]	-.175	.865	-.058	.723
	35TreeAge	.007[f]	.593	.568	.194	.442
	36FreqHarvestMonth	.005[f]	.432	.676	.142	.470
	46FreqFertiliseYear	.003[f]	.253	.806	.084	.600
	83OthFarmActIncome	.003[f]	.310	.764	.103	.706
	84ShopIncome	.007[f]	.641	.538	.209	.545
	91FuelwoodCooking	-.018[f]	-2.320	.045	-.612	.636
	100TransportExpenseYearUSD	.009[f]	.254	.805	.084	.046
	210NESTrans	.018[f]	2.099	.065	.573	.618
	215OPAvgPriceTonnesUSD	.013[f]	1.258	.240	.387	.487
	239OtherEstateCropsNoTree	.010[f]	1.249	.243	.384	.836
	245LivestockNoPresent	.037[f]	.978	.354	.310	.040
	178NaturalForestNearby	.008[f]	.668	.521	.217	.430
5	21HouseholdSize	.015[g]	1.276	.238	.411	.268
	22YearsVillage	.002[g]	.285	.783	.100	.688
	35TreeAge	-.003[g]	-.274	.791	-.096	.360
	36FreqHarvestMonth	-.005[g]	-.501	.630	-.174	.381
	46FreqFertiliseYear	-.006[g]	-.626	.549	-.216	.507
	83OthFarmActIncome	.004[g]	.488	.639	.170	.704
	84ShopIncome	-.005[g]	-.443	.669	-.155	.401
	100TransportExpenseYearUSD	-.025[g]	-.739	.481	-.253	.038
	210NESTrans	.015[g]	2.092	.070	.595	.598
	215OPAvgPriceTonnesUSD	.006[g]	.610	.559	.211	.416
	239OtherEstateCropsNoTree	.003[g]	.341	.742	.120	.632
	245LivestockNoPresent	.013[g]	.369	.722	.129	.035
	178NaturalForestNearby	.001[g]	.076	.941	.027	.385

a. Sub District = Kerinci Kanan

b. Dependent Variable: 237TotalHHIncomeYrUSD

c. Predictors in the Model: (Constant), 213OPProductiveLandAreaHa

d. Predictors in the Model: (Constant), 213OPProductiveLandAreaHa, 97NoPickUp

e. Predictors in the Model: (Constant), 213OPProductiveLandAreaHa, 97NoPickUp, 12Educ

f. Predictors in the Model: (Constant), 213OPProductiveLandAreaHa, 97NoPickUp, 12Educ, 85BusinessIncome

g. Predictors in the Model: (Constant), 213OPProductiveLandAreaHa, 97NoPickUp, 12Educ, 85BusinessIncome, 91FuelwoodCooking

Results of Multiple Linear Regression in Each Study Area
Stepwise Method
Bunga Raya

Model Summary[a,c]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics		Durbin-Watson
					R Square Change	F Change	
1	.830[b]	.690	.677	15661.8846	.690	53.323	1.957

a. Sub District = Bunga Raya

b. Predictors: (Constant), 97NoPickUp

c. Dependent Variable: 237TotalHHIncomeYrUSD

ANOVA[a,b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	13079896254.427	1	13079896254.427	53.323	.000[c]
	Residual	5887071067.023	24	245294627.793		
	Total	18966967321.450	25			

a. Sub District = Bunga Raya

b. Dependent Variable: 237TotalHHIncomeYrUSD

c. Predictors: (Constant), 97NoPickUp

Coefficients[a,b]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	6742.517	3309.177		2.038	.053		
	97NoPickUp	38964.115	5335.888	.830	7.302	.000	1.000	1.000

a. Sub District = Bunga Raya

b. Dependent Variable: 237TotalHHIncomeYrUSD

Excluded Variables[a,b]

Model		Beta In	t	Sig.	Partial Correlation	Collinearity Statistics
						Tolerance
1	12Educ	-.118[c]	-1.032	.313	-.210	.983
	21HouseholdSize	-.094[c]	-.817	.422	-.168	.999
	22YearsVillage	.103[c]	.900	.378	.184	1.000
	35TreeAge	.109[c]	.895	.380	.184	.887
	36FreqHarvestMonth	.051[c]	.348	.731	.072	.622
	46FreqFertiliseYear	.014[c]	.124	.903	.026	.982
	83OthFarmActIncome	.050[c]	.420	.678	.087	.960
	84ShopIncome	-.001[c]	-.010	.992	-.002	.987
	85BusinessIncome	-.225[c]	-2.020	.055	-.388	.927
	91FuelwoodCooking	-.164[c]	-1.475	.154	-.294	1.000
	100TransportExpenseYearUSD	.075[c]	.579	.568	.120	.802
	213OPProductiveLandAreaHa	.002[c]	.015	.988	.003	.687
	215OPAvgPriceTonnesUSD	.062[c]	.464	.647	.096	.751
	239OtherEstateCropsNoTree	-.092[c]	-.674	.507	-.139	.705
	245LivestockNoPresent	-.117[c]	-1.018	.319	-.208	.986
	178NaturalForestNearby	-.009[c]	-.079	.938	-.016	.996

a. Sub District = Bunga Raya

b. Dependent Variable: 237TotalHHIncomeYrUSD

c. Predictors in the Model: (Constant), 97NoPickUp