Socialising the pixel, a mixed methods approach to assessing the state of forests in West Timor

A thesis submitted for the degree of Master by Research

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I hereby declare that the work herein, now submitted as a thesis for the degree of Masters by Research, is the result of my own investigations, and all references to ideas and work of other researchers have been specifically acknowledged. I hereby certify that the work embodied in this thesis has not already been accepted in substance for any degree, and is not being currently submitted in candidature for any other degree.
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## Contents

**Acknowledgments** ........................................................................................................... ii  
**Abstract** ....................................................................................................................... viii  
**Abbreviations and foreign terms** ................................................................................ x  
**Chapter 1 Introduction** .................................................................................................. 1  
**Chapter 2 Background and Context** .......................................................................... 4  
  2.1 Tropical forests: a global perspective .......................................................................... 4  
    2.1.1 Why are tropical forests important? ...................................................................... 4  
    2.1.2 State of global tropical forests ............................................................................. 9  
    2.1.2 Causes of change .............................................................................................. 10  
  2.2 Tropical forests in Indonesia and West Timor ............................................................ 12  
    2.2.1 Why Indonesia’s tropical forests are important .................................................. 12  
    2.2.2 Status of forests in Indonesia ............................................................................ 21  
    2.2.3 Causes of forest cover change in Indonesia ....................................................... 24  
    2.2.4 Driving forces of forest change in Timor ........................................................... 28  
  2.3 Satellite remote sensing of tropical forests ................................................................. 30  
    2.3.1 Socialising the Pixel .......................................................................................... 31  
  2.4 Conclusion .................................................................................................................. 33  
**Chapter 3 Study Area** .................................................................................................. 34  
  3.1 Introduction ................................................................................................................ 34  
  3.2 Biophysical description ............................................................................................... 37  
    3.2.1 Rainfall ............................................................................................................... 37  
    3.2.2 Geology and soils .............................................................................................. 38  
    3.2.3 Landscape ......................................................................................................... 39  
    3.2.4 Biogeography .................................................................................................... 42  
    3.2.6 Vegetation ......................................................................................................... 44  
  3.3 Demography ............................................................................................................... 46
Chapter 3: Content

3.4 Economy ........................................................................................................... 48
3.4.1 Agriculture ............................................................................................................ 49
3.4.2 Forestry ................................................................................................................ 51
3.5 Culture .............................................................................................................. 52
3.6 History .............................................................................................................. 55
3.7 Conclusion ....................................................................................................... 59

Chapter 4: Methods ............................................................................................ 60

4.1 Introduction ..................................................................................................... 60
4.2. Image processing ............................................................................................. 61
4.2.1 Image acquisition ................................................................................................. 62
4.2.2 Image pre-processing .......................................................................................... 65
4.2.3 Image classification .............................................................................................. 66
4.3. GIS analysis ..................................................................................................... 69
4.3.1 GIS data collection ................................................................................................ 69
4.3.2 Accuracy assessment ............................................................................................ 70
4.3.3 Current forest cover characterisation ............................................................... 72
4.3.4 Forest cover change refinement .......................................................................... 75
4.4 Case study selection ......................................................................................... 76
4.5. Interview method ............................................................................................ 77
4.5.1 Interview as an ethnographic research tool ........................................................ 77
4.5.2 Interview structure ............................................................................................... 77
4.6. Data Analysis ................................................................................................... 80
4.6.1 Thematic analysis of the interviews ..................................................................... 80
4.6.2 Data triangulation. ............................................................................................... 81

Chapter 5: Spatial Analysis Results ...................................................................... 82

5.1 Spatial analysis results .................................................................................. 82
5.1.1 Accuracy assessment .......................................................................................... 82
5.1.2 Forest Cover classification and characterisation................................................. 84
5.1.3 Forest cover change time series ........................................................................... 91
5.1.4 Case study selection ............................................................................................. 93
5.1.5 Case study site characterisation ........................................................................... 97

Chapter 6 Case study interview results and integrated analysis .........................101

6.1 Amarasi (Ratrean) #1.......................................................................................... 101
   6.1.1 Interview results............................................................................................. 101
   6.1.2 Integrated analysis ......................................................................................... 106

6.2 Bipolo #2........................................................................................................... 107
   6.2.1 Interview results............................................................................................. 108
   6.2.2 Integrated analysis ......................................................................................... 116

6.3 Fatuleu Barat (Nuataus) #3............................................................................... 121
   6.3.1 Interview results............................................................................................. 121
   6.3.2 Integrated analysis ......................................................................................... 127

6.4 Amfoang Barat Daya (Letkole) #4 ................................................................. 129
   6.4.1 Interview results............................................................................................. 129
   6.4.2 Integrated analysis ......................................................................................... 134

Chapter 7 Discussion..........................................................................................138

7.1 Introduction ................................................................................................ 138

7.2 The importance of Kabupaten Kupang’s forests ........................................... 138
7.3 The state of Kabupaten Kupang’s forests and the impacts of the mapped changes......................................................................................................................... 140
7.4 The forces behind forest cover change in West Timor............................... 143

7.5 Socialising the pixel ....................................................................................... 147
   7.5.1 Introduction.................................................................................................... 147
   7.5.2 Limitations of this study ............................................................................... 150

Chapter 8 Conclusions and Implications. ...........................................................153
<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>8.1 Major conclusions</td>
<td>153</td>
</tr>
<tr>
<td>8.2 Implications</td>
<td>154</td>
</tr>
<tr>
<td>8.3 Policy and practice recommendations</td>
<td>155</td>
</tr>
<tr>
<td>8.4 Further research</td>
<td>159</td>
</tr>
<tr>
<td>8.5 Concluding remarks</td>
<td>163</td>
</tr>
<tr>
<td>References</td>
<td>165</td>
</tr>
<tr>
<td>APPENDICES</td>
<td>172</td>
</tr>
<tr>
<td>Appendix I Image classification</td>
<td>172</td>
</tr>
<tr>
<td>Appendix II Interview Questions</td>
<td>172</td>
</tr>
<tr>
<td>Appendix III Forest type and distribution</td>
<td>175</td>
</tr>
<tr>
<td>Appendix IV Population and forest cover by Kecamatan</td>
<td>177</td>
</tr>
</tbody>
</table>
Abstract

Over recent years, deforestation in the world’s tropics has become an urgent international issue, particularly with regards to the role of tropical forests as a major carbon sink and store. One response has been the development of satellite based monitoring initiatives focused on the large peat forests of western Indonesia. The forests of some of eastern Indonesia’s semi-arid outer islands are locally important but ‘carbon poor’ and are consequently of less interest to climate change researchers. This study focuses on the Kabupaten Kupang district of West Timor which has some of the largest and least studied tracts of remaining forest in West Timor. Anecdotal evidence suggests these forests are being diminished and degraded. However no research has been conducted to assess the state of forests in this region.

Satellite imagery is an important tool for mapping and monitoring forests and there are new opportunities, with the advances in remote sensing and geographic information technology, for its wider use in Indonesia. However, whilst it is important to have quantitative data on forest cover change, these data are insufficient to inform local forest management and analysis of these data alone can distract from understanding the multiple, local scale variables influencing forest use. In order to develop effective policy and management strategies, it is necessary to link spatial data with on-ground qualitative research or to ‘socialize the pixel’.

This study uses a combination of remote sensing, GIS and social science methods to describe the state of forests in Kabupaten Kupang, and how and why they are changing. Satellite derived data of land cover and land use have become accepted baseline data for assessing the state of tropical forests, however critics of satellite based, natural resource research argue that reliance on these data shifts the focus of ecological research away from understanding causation and process to simply describing patterns. Using satellite imagery, case studies and on-ground interviews, this study explores the proposition that local social, cultural and biophysical knowledge is important for effectively using remotely sensed data as a tool to influence local management policies.

When compared to some other parts of Indonesia, the rate and extent of deforestation in West Timor was found to be relatively small and a satellite based assessment alone could conclude that it is not a critical issue. However this study
has shown that when coupled with on-ground social data a much more complex picture is developed, related to key livelihood issues. The causes of forest cover change were found to be multivariate and location specific, requiring management approaches tailored to local issues. Increasing pressure on West Timor’s forests could increase environmental degradation, food insecurity and poverty, however new opportunities to develop better collaborative forest management strategies are also evolving out of democratic reforms and increasing regional autonomy.
Abbreviations and foreign terms

BAPEDALDA - Regional Environmental Protection Agency

Desa – Village

FAO – UN Food and Agriculture Organisation

Fatu – Timorese rock outcrop mountain.

FCC - Forest Cover Change

GIS – Geographic Information System

Kabupaten – District level administrative region.

Kawasan Hutan – Forest administrative zone as defined by the central government

Kecamatan – Sub-District level administrative region.

Kepala Desa – Village head.

Kota - City


NTFP - Non-timber forest products.

NTT – Nusa Tenggara Timur

REDD - Reducing Emissions from Deforestation and Forest Degradation in developing countries
Chapter 1 Introduction

Over recent years destruction of the world’s tropical forests has become an urgent international issue, particularly in regard to their role as a major carbon sink and store. One response has been the development of satellite based monitoring initiatives focused on the large peat forests of western Indonesia. The locally important but ‘carbon poor’ forest of some of eastern Indonesia’s semi-arid outer islands are of less interest to climate change researchers. However evidence suggests that these forests are important biodiversity reserves housing some unique biota, providing vital catchment services and supporting the primarily subsistence livelihoods of people in this low income region. There are also concerns that the recent focus on forests as carbon stores will draw attention away from the other services these forests provide.

This study focuses on the district of Kabupaten Kupang in West Timor. This region was chosen because it has some of the largest and least studied tracts of remaining forest in West Timor. Anecdotal evidence suggests that these forests are being cleared and degraded yet no research has been conducted to assess their condition, the degree of change or the forces effecting forest cover. This study began at a time of rapid social change in the region with the multiple effects of political decentralisation, economic crisis and East Timorese independence having wide ranging impacts on West Timor. Other studies have examined the effects of migration, land tenure and governance policy on forests in post Soeharto Indonesia (McCarthy 2000; Thorburn 2004) but not in the distinctive biogeography and political context of West Timor. Research on tropical forest cover change has shown that the driving and proximate (local) forces involved are complex and multivariate. It was assumed that this would be the case in West Timor and that some of the forces involved would be unique to West Timor.

This study uses a combination of remote sensing, GIS and social science methods to describe the state of forests in Kabupaten Kupang and how they are changing. Satellite derived data of land cover and land use have become accepted baseline data for assessing the state of tropical forests. A perception has evolved that the broad, repeatable, quantitative measurements derived from satellite imagery are more analytically useful than ‘on-ground’ analysis. However critics of satellite
based natural resource research argue that it shifts the focus of ecological research away from understanding causation and process to simply describing patterns. Whilst satellite derived quantitative data are useful for describing the area of forest present and the rate of change, they are less useful for answering questions about why things are the way they are. However answers to these ‘why’ questions are vital for developing effective policy and management strategies. The United Nations Food and Agriculture Organization, the premier collator of global forest data, has been concerned for some time that macro-level forest analyses are overlooking important complex relationships at regional levels (FAO 1998). Using satellite imagery and on-ground interviews this study explores the proposition that local social, cultural and biophysical knowledge is important for effectively using remotely sensed data as a tool to inform local management policies. Review of the literature, remote sensing and social science research techniques were used to explore the following questions:

1. Are the forests of West Timor important from a global and local perspective?
2. What is the current distribution of forests in Kabupaten Kupang? Are they changing? What are the impacts of these changes?
3. What are the forces behind forest cover change in West Timor?
4. Can combining remote sensing/GIS data with on-ground interviews provide a method for a useful assessment of the forces influencing forest cover regional level for informing local management policies.

The literature review was used to provide global and local background and context with respect to the forests of Kabupaten Kupang, and more detailed rationale for the study. Remote sensing and GIS analysis was then used to map and characterize the forests and highlight forest cover change. Using this data four case study locations were selected to focus more detailed spatial analysis and on-ground interviews. A triangulation of the interview data, spatial data and literature review was used to develop theories about the forces involved and the implications of forest cover change in Kabupaten Kupang.

Chapter 2 (literature review) provides context for the thesis by reviewing the roles played by tropical forests in terms of supporting livelihoods, catchment services, biodiversity, carbon capture and storage. The current status of global, Indonesian and West Timorese forests is also summarised. Also discussed is the need to
combine spatial and social sciences to produce information which is useful to forest management and the techniques available to achieve this goal.

Chapter 3 provides background detail on the biogeography, economy, culture and history of Kabupaten Kupang.

Chapter 4 describes the spatial and social science methods used in this research. Detailed descriptions are given of the remote sensing and GIS analysis used to map and characterize the forests, classify forest cover change, select case study sites, interview methods, and analytical methods used to describe the causes of forest cover change.

Chapter 5 presents the results of the spatial analysis describing the forest cover and the case study selection. Characteristics of the case study sites are also presented.

Chapter 6 describes the key findings from the interviews focusing on the forest uses and benefits, causes of change, impacts of change and suggestions for management for each of the case study areas. These results are then linked to the spatial data for further integrated analysis.

Chapter 7 combines the results from the literature review, spatial analysis and interviews to explore the four research questions. Firstly the state of, and forces effecting forest cover in Kabupaten Kupang identified in this study are examined followed by a discussion of utility and limitations of the interdisciplinary approach taken.

Chapter 8 draws out the significant conclusions from this research and their implications. Recommendations for policy, practice and further research are made regarding: the use of spatial tools for improved forest management, catchment management, livelihoods, biodiversity and carbon markets.
Chapter 2 Background and Context

This chapter provides background and context to the important services that tropical forests provide and their current status from a global, Indonesian and West Timorese perspective. Also discussed is the use of satellite imagery for monitoring forest cover to provide quantitative assessments of forest cover change, social sciences methods for qualitative assessments, and the need to combine these approaches to understand causes and processes and to inform policy.

2.1 Tropical forests: a global perspective.

2.1.1 Why are tropical forests important?

Over the last decade increasing international attention is being paid to land use and land cover change (LULCC) in the tropics. Tropical forests, in particular, are recognized as playing an important role in regulating global biochemical and hydrological cycles critical for maintaining global climatic stability. These, along with a range of other more locally important ecosystem services, have been described by Chowdhury (2006), Lambin (2003) and Pattanayak and Sills (2001) as follows:

- Forest products for livelihoods;
- Supporting catchment health by regulating local water cycles and minimising soil degradation;
- Repositories of biological diversity; and
- Stores and sinks of globally significant amounts of carbon, the release of which would have a dramatic impact on global climate.

Pattanayak and Sills (2001) argue that tropical forests are a form of global natural insurance against climate change and biodiversity loss as well as local insurance mitigating agricultural risks and food insecurity. They also differentiate between the global benefits of forest conservation against the predominantly local costs. Another distinction, used by the United Nations Food and Agriculture Organisation (FAO 2009a), is between forest services that can be easily assigned a market value, such as forest products or ecotourism, and those that are often considered ‘externalities’ or outside the market, such as erosion control and biological diversity
conservation. The following is a brief summary of forest services from an international perspective.

Livelihoods

Forest based livelihoods are derived broadly through timber extraction, non-timber forest product harvest, forest based agriculture, eco-tourism and recreation.

Timber extraction is often seen as a driving force of deforestation yet the way timber is extracted and used varies widely from minimal selective harvest by local people for building materials to large scale corporate clear felling for building and pulp wood.

Non-timber forest products (NTFP) are an important livelihood component for many people living in or around forests yet are often undervalued (Falconer 1990). Food from forests is a vital part of the diet of many of the rural poor, ensuring food security particularly in lean times. Wood fuel is also an important forest product for rural communities, both for direct household consumption and sale. The FAO (2009a) estimates that over 2 billion people in the Asia Pacific region rely on wood fuels for their basic energy needs. Other important NTFP include non-timber building materials (rattan, bamboo, thatching), medicines and materials for handcrafts. Poor rural communities generally use NTFP directly or sell locally, making quantifying their market value difficult, however various authors argue that it is important to understand the value of these products to secure the rights of local people and ensure appropriate policy development and implementation (Barham, Coomes & Takasaki 1999). These issues are particularly important considering the potential for conflict over forest use that could arise out of the growing global forests for carbon markets (Pattanayak & Sills 2001).

Forest based agriculture includes shifting agriculture relying on the regenerative capacity of forests to restore soil fertility and livestock production in forests or with fodder from forests. The role of shifting agriculture in deforestation is contentious. Fox (2000) argues that rather than causing deforestation, shifting cultivation may be the most appropriate and sustainable land use in many of the forest of South East Asia. He sees shifting agriculture as a preferable use of forests to large scale forest conversion for permanent agriculture. In many developing countries, 30 to 40% of domestic animals rely on forests for some or all of their grazing and fodder (FAO
1998). Forests provide a range of fodder, particularly for small and medium sized animals such as poultry, pigs and goats, but uncontrolled grazing can quickly degrade forest ecosystems, changing forest and soil structure. The development of integrated agro-forestry systems using fodder trees supports more intensive feedlot type production in some places.

Ecotourism is becoming more popular as local and international tourists seek nature-based travel experiences that conserve the environment and support local communities. The FAO predicts ecotourism to grow by 10-20% per annum in the Asia Pacific region (FAO 1998). Many countries are promoting ecotourism for its potential to revitalize local economies and protect natural landscapes. However the international market is currently small and limited to a few areas of high scenic or conservation value.

**Catchment services**

Tropical forests can sustain catchment health by maintaining soil stability, water quality and stabilizing the hydrological cycle. Forests with a complex multilayered canopy, under-storey, ground litter and root network structure can reduce the erosive power of rain, ensure soil stability, and reduce surface runoff and mass soil movements. It is generally believed that where forest cover is reduced run-off tends to be greater, resulting in a greater frequency of flooding and a reduction in the base flow during dry periods. The actual effectiveness of forests in upper catchments for flood mitigation is currently a hotly debated topic (van Dijk et al. 2009) with no definitive proof that forests have a substantial mitigating effect on large flood events. The FAO warns that blaming land use and directing managements strategies solely to upper catchments can distract from important flood management work in lower catchments (FAO and CIFOR. 2005). The extent to which forests moderate the hydrological cycle to sustain flows during dry periods is also highly variable depending on the type and age of forest cover and the underlying geology. A less contentious claim for catchment services is that well managed natural forests in catchments provide higher quality water supplies with less sediments and pollutants. The most universal benefit from catchment forests is thus the supply of clean water for drinking and sanitation, and reduced sedimentation of dams. About a third (33 out of 105) of the world’s largest cities obtain a significant proportion of their drinking water directly from protected catchments (Dudley & Stolton 2003).
Although these catchment services provide real benefits they are often considered ‘externalities’ and undervalued as many of the benefits are often downstream and far from the source of the service (Pattanayak & Subhrendu 2004). It has been suggested that there needs to be a payment for services to people living in upper catchments to account for clean water they provide to downstream users (Dudley & Stolton 2003).

**Biodiversity.**

Biodiversity is the variety of life: the different plants, animals and micro-organisms, their genes and the ecosystems of which they are a part (Department of the Environment 2009). Biodiversity is important for maintaining ecosystem resilience to environmental disturbance, maintaining ecosystem functions and as a genetic and biochemical storehouse for future developments in agriculture and medicine.

Ecosystem resilience is largely a function of its biological diversity and a reduction in biodiversity may cause ecosystems, under disturbance, to suddenly shift from desired to less desired states in their capacity to sustain ecosystem services to society (Folke et al. 2004). In some cases, these shifts may be irreversible, or too costly to reverse.

Forest genetic and biochemical resources are the source of a wide range of products and services although less than 500 species have been systematically studied for their present-day utility and potential (FAO 2009a). The unique forest genetic resources contained in the thousands of forest species are irreplaceable and a range of international and local programs exist to conserve forest genetic resources both in situ and ex situ. These programs are primarily aimed at building an awareness of the forest genetic resources of individual country’s to promote forest protection and the gathering of seed and other reproductive materials to create genetic banks for future generations.

Myers et al. (2000) identified 25 ‘biodiversity hot-spots’ that contain exceptionally high levels of endemic biodiversity and are under particular threat to species loss. Four of these hotspots are in South East Asia. Myers argues that with limited conservation resources specific attention needs to be paid to these hotspots to avoid mass extinctions in the next few decades.
Carbon store and sink

Tropical forests hold 20-50 times more carbon per unit area than the ecosystems that replace them (Melillo et al. 1996). Tropical forests are a more important stock of carbon than other ecosystem types because of the relatively high levels of carbon they hold and the current practice of large scale conversion of tropical forests to less carbon rich land-covers. Deforestation in the tropics is the main source of increased atmospheric carbon, second to the burning of fossil fuels. Carbon released into the atmosphere through burning at the time of cutting and the subsequent decay of the remaining plant material and soil organic matter is estimated to contribute 30% to total global carbon emissions (Fearnside 2001). Not only are tropical forests a source of carbon they are also a significant sink. The rate at which carbon is sequestered into tropical forests increases as atmospheric CO$_2$ concentrations increase. Intact tropical forests have the potential to remove significant amounts of human-derived CO$_2$ from the atmosphere. Chambers et al. (2001) have calculated that the rate of carbon sequestration from the intact forest in Amazonia are about 0.2–0.3 petagrams of carbon per year which amounts to US$2–3 billion per year at $10 per Mg C.

Over the last decade the causes, and debatably the impacts, of human induced climate change have increased rapidly. A number of extreme climatic events and increasingly dire predictions from the scientific community have moved climate change action to the top of the global political agenda. Efforts to reduce emissions of greenhouse gasses have largely focused on developing market mechanisms to allocate costs to the release of carbon into the atmosphere. Another major initiative that recognizes the role of forest ecosystems, has been a suite of projects that reduce emissions from deforestation and forest degradation in developing countries. These projects are commonly referred to by the acronym REDD. It is hoped that through tying a reduction in deforestation to developing international carbon markets forests, services will be properly valued. Although good in theory, the politics of high-emitting countries, all of which are developed countries, reducing their carbon ‘foot print’ through ‘buying off’ forest in developing countries is highly contentious (Fearnside 2001; Van Oosterzee & Garnett 2008). A great deal of research is now being conducted into quantifying the global benefits verses local costs of REDD implementation.
2.1.2 State of global tropical forests

About 30% of the earth’s land area is covered by forest and almost half of this is in the tropics. A greater focus on forest cover change in the tropics has prompted more research into their extent and rate of change. Given the importance of these data to scientific research and political debates on climate change there is surprising variation in current estimates of global tropical forest cover. The most commonly used figures come from the United Nations Food and Agriculture Organisation (FAO) that conducts regular global forest assessments derived from national forest inventories. The FAO State of the Worlds Forest 2000 report estimated 1,496 million ha of closed tropical forest. Other recent global forest assessments include work conducted by the TREES project (Achard et al. 2002) using a random sample of high resolution (30m) satellite imagery and Hansen and DeFries (Hansen et al. 2008) using a global coverage of lower resolution (8km) satellite imagery and estimating 1,116 and 1,072 million ha respectively (Fig 2.1). Assessments from Achard et al. (2002) also indicate that tropical dry forests cover an additional 706 million ha.

Variation in forest cover assessments are due primarily to differences in the methods used to quantify extent and the definition of forest cover used. The FAO Forest Assessments use a definition of forest which uses a minimum threshold for the height of trees (5m), at least 10 per cent crown and a minimum forest area size (0.5 hectares). There are concerns that this definition is too broad allowing for woodlands, substantially degraded forest and plantations to be classed as forests (Lang 2008). In contrast the Australian government’s Bureau of Rural Sciences classifies trees with a canopy cover above 50% as forest and between 20-50% as woodland (DAFF 2007). The three common methodological approaches, as described in the studies above are; the compilation of national inventories, sampling with high resolution imagery and complete coverage survey with low resolution imagery.

1 The FAO also defines a variety of forest types based on the duration of the dry season, (FAO 2001): tropical rain forests or humid forests (0–3 months dry), tropical moist deciduous forests (3–5 months dry) and tropical dry forests (5–8 months dry).
As with estimation of forest cover, these different approaches also produce highly divergent figures for tropical deforestation although most studies agree that S.E Asia has one of the highest and most rapidly increasing rates in the world. The latest FAO State of the World’s Forests report, shows South East Asia to have lost forest cover at a rate of 1.3% per year from 2000-2005 a slightly higher rate (1.2%) than the previous reported period, 1990-2000. Indonesia was reported to have the highest rates within SE Asia (Fig 2.2). Latin America has by far the largest area of forest being cleared, with the greatest loss due to continued clearing in the Amazon catchment. However due to the large extent of Amazon forest the annual clearing rate when expressed as a percent of the total is relatively small. It is also interesting to note that there is a net increase in forest cover in much of the developed, temperate parts of the world. Large increases in forest cover have also been recorded particularly in China although some studies question the net gains in forest due to under reported deforestation (Hansen & DeFries 2004).

2.1.2 Causes of change
Although acknowledging the need for more accurate data to quantify forest extent and rates of change Lambin (2001) argues this alone is insufficient to improve models of land-use and land-cover change. “They must be matched by enhanced understanding of the causes of change and this requires moving beyond popular ‘myths’”. (p. 262)
He describes the common myth of tropical deforestation as being the over simplifying belief that: "Population and poverty drive deforestation, mostly through shifting cultivators’ land use and population growth." (2001, p. 262) Whilst acknowledging the role of population and poverty he goes on to describe highly variable, interacting political and local forces influencing the movement of industries and people. Within this variability Geist and Lambin (2002) have shown that there is a distinct pattern to the forces behind tropical deforestation.

Through reviewing 152 local-scale case studies they have described some major trends in terms of the proximate (local) and the underlying driving forces of change. Their work found agricultural expansion to be the primary proximate cause associated with almost all (96%) cases of deforestation although the vast majority of cases (94%) had multiple proximate causes. Over half the cases recorded wood extraction and infrastructure expansion to be proximate causes along with agricultural expansion. A simple breakdown of the specific proximate causes comparing all (global) to Asian case studies can be seen in Fig 2.3.
Figure 2.3 A breakdown of major proximate causes of deforestation by region derived from the work of Geist and Lambin (2002). Agro = agricultural expansion, Infra=infrastructure development, wood= timber and pulp harvesting.

The driving forces behind deforestation are also complex, resulting from synergistic interactions between multiple factors. Five drivers; economic, institutional, technological, demographic and cultural were defined by Geist and Lambin (2002). The most common were economic and institutional, reported in 81% and 78% of cases respectively. In more than two thirds of cases three or more drivers were reported.

Geist and Lambin conclude that “… a detailed understanding of the complex set of proximate causes and underlying driving forces affecting forest cover change in a given location is required prior to any policy intervention” (2002, p. 150). Simply knowing how much is not enough, we also need to know why.

2.2 Tropical forests in Indonesia and West Timor

2.2.1 Why Indonesia's tropical forests are important

Livelihoods
An estimated 30 million people depend on forests for their livelihood in Indonesia (Resosudarmo 2004) through forestry, non-timber forest products, agriculture, and tourism.
Forestry

The forestry sector in Indonesia is a significant contributor to employment and GDP. Country estimates from 2006 report 321,000 people directly employed in the industry contributing to 2.5% of GDP Table 2.1 (FAO 2009b). There has also been a substantial increase in the amount of plantation timber contributing to the forestry sector.

Table 2.1. A breakdown of the employment and GDP contribution of the forestry sector in Indonesia

<table>
<thead>
<tr>
<th>Employment 1000's</th>
<th>Round-wood</th>
<th>Wood Processing</th>
<th>Pulp and Paper</th>
<th>total</th>
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<td>148</td>
<td>104</td>
<td>321</td>
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<th>Gross value Added (US$ million)</th>
<th>% labour force</th>
<th>Round-wood</th>
<th>Wood Processing</th>
<th>Pulp and Paper</th>
<th>total</th>
<th>%GDP</th>
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</tbody>
</table>

An absence of very large tracts of tall closed forest in West Timor has precluded the development of a large commercial timber logging industry. Forestry in West Timor is generally in the form of small scale selective logging of high value timber such as Rose Wood (*Pterocarpus Indicus*). White sandalwood (*Santalum album L*) has long been the most valuable timber on Timor, such that McWilliam (2005) suggests that Timorese political history for the last millennium has been directly tied to struggles over control of the sandalwood trade. On an island with few other significant natural resources sandalwood has been the preeminent commodity. Yet mismanagement of the resource through poor policy decisions has seen a dramatic decline in the sandalwood industry in West Timor. McWilliam reports the contribution of value added sandalwood products to export earnings declined from a substantial 30% in 1992 to zero in 1997. As large plantation forests reach maturity increasingly the main timber species currently harvested in the region are teak (*Tectona grandis*), kayu merah (*Macaranga tanarius*), Ampupu (*Eucalyptus urophylla*), mahogany, and mixed rainforest species.
Non-timber Forest Products

Non-timber forest products have important social and economic values at subsistence, local use and commercial levels for Indonesian people living near forests. Subsistence NTFPs are consumed after minimal processing and include fruits, yams, wild meats and fuel wood. Local use products such as palm alcohol and betel nut are generally traded locally and commercial products such as spices and rattan often go through several levels of processing and pass through several transactions on their way to final use.

Honey and bees wax was one of the major export commodities from Timor, along with sandalwood, in the sixteenth and early seventeenth centuries and remains an important cash products for many villages (Monk KA 1997). Although still culturally important, hunting of pigs, deer and birds is no longer a significant source of food for many people in eastern Indonesia. This is primarily due to the scarcity of game, due to habitat loss and over hunting.

Nusa Tenggara Timur is well known for its textile weaving, with over 80,000 people in NTT involved in its production. This local craft makes a substantial contribution to the livelihoods of many rural people. In some communities in NTT cash from weaving acts as insurance providing valuable support when crops fail or are burnt by wildfires (Russell-Smith et al. 2007). There is a growing international market for high quality textiles made from natural dyes which fetch premium prices. Fair trade NGO’s, such as the Bali based Yayasan Pecinta Budaya Bebali, are forming partnerships with local cooperatives to assure fair prices for weavers (Threads of Life 2009). The traditional dying process relies on a range of natural shrubs and trees for dyes and the scarce and threatened tree jirak (Symlocos sp.), as a mordant to fix the dyes (Cunningham 2007). Research is being conducted by Threads of Life into conservation and agro-forestry methods to preserve these economically important NTFP (Threads of Life 2009).

Other NTFP from NTT include Gaharu (Aquilaria resin) and shellac or lak. Gaharu is an important component of high quality incense and is produced from the resin of hardwood trees. Lak is produced from the secretions of the shellac insect (Tachardia lacca). A number of trees species play host to lak in NTT and Sumba is the main producer in NTT. Kamiri (Candle nut) and Asam (Tamarind) are also important products in some regions.
Fuel wood is the most common NTFP used by rural people in Indonesia. In the remote and rural areas of eastern Indonesia, where access to electricity is limited wood provides the only affordable fuel for cooking. Various studies that have measured the use of fuel wood in Nusa Tenggara suggest the level of extraction is very large, beyond the amount available from garden plots. The collection of fuel wood is often the role of women and children who commonly have to walk large distances to collect the required wood. One study in East Sumba (Datta 1993) found that three villages in East Sumba (pop 2734) used about 870 tons of fuel wood from local forests each year. Furthermore Monk et al. (1997) noted the failure of the introduction of efficient wood stoves technologies in Africa and probably in Maluku due to the fact that they produce little light for cooking and are difficult to control.

Very little ethno-botanical research has been conducted into the economic significance of forests in Nusa Tenggara. One study by Russell-Smith (2007) looking at the relative economic importance of forest resources to village economies in East Sumba and central Flores found that forest resources play a very important, often undervalued, role in the livelihoods of these savanna dominated communities especially for construction timber, fire wood, medicines and food.

Shifting agriculture
Shifting agriculture and forest grazing is widespread in Indonesia. Due to its subsistence nature, the number of people involved in this activity and its relative economic value are poorly understood. Sunderlin et al. (2000) have estimated around 14% or 6 million people are dependent on shifting agriculture in the five main outer islands of Sumatra, Kalimantan, Sulawesi, Irian Jaya, and the Moluccas. A distinction is usually made between rotational shifting cultivation and pioneer cultivators. Shifting rotational cultivation is a traditional farming method through much of eastern Indonesia and relies on long fallow periods between cultivating land that been recolonised with secondary forest. Pioneer shifting cultivation moves into primary forest after land has been exhausted through excessive cultivation. Although detailed figures are unavailable, shifting rotation cultivation is common practice for most subsistence farmers in Timor (Fox, JJ 2004).

Two forms of forest based cattle husbandry are practiced in Timor. The first, and most common method, is the free range grazing of forest understory. The long term grazing of some upland forests in WWest Timor has been credited with significant
ecosystem alteration leading to monoculture stands of *Eucalyptus urophylla* (Lentz, Mallo & Bowe 1998). The second method is to grow fodder tree crops that are hand cut and fed to corralled livestock. This agro-forestry method is practiced in the Amarasi region on the south coast of West Timor using the forage tree *Leucaena leucocephala* otherwise known as lomtoro (Piggin & Nulik 2005).

**Ecotourism**

In Indonesia, ecotourism is now an official conservation strategy (FAO 2009b). Due to its rich natural heritage there is huge potential for the further development of ecotourism in Indonesia but the industry is currently small (Dalem 2002). Tourism in Indonesia is economically significant but has suffered serious setbacks over the last few years with terrorist attacks in the early-mid 2000s and the global economic crisis beginning in 2008. Eight million tourists were expected to visit Indonesia in 2008 but the figure fell to 6.4 million and revenues are expected to fall by one billion US dollars to 6.5 billion in 2009 (*Orangutan Outreach* 2009). These fluctuations in tourist numbers have seriously affected the burgeoning eco-tourism market, causing hardship for those locals who have come to rely on the industry. Tourism was similarly interrupted in West Timor in 2000. The independence referendum in East Timor led to a wave of refugees fleeing to Indonesian Timor and high tensions that resulted in the murder of UN staff in Atambua and restrictive travel warnings for West Timor (Nixon 2004). Political stability is a prerequisite for ecotourism to be a significant industry in Indonesia.

**Catchment services**

Formal catchment management in Indonesia was formulated in the 1970’s as a response to massive flooding of the city of Solo in Central Java (Anwar 2003). Attention was further focused on the state of catchments in Indonesia after large scale floods and landslides in Jakarta and in several provinces of Indonesia in 2000 and 2002 (Rachman 2002). A link was made between healthy upper catchment ecosystems and downstream productivity and safety which catalysed a conceptual shift in Indonesian forest management from a focus on timber extraction towards ecosystem management. This has resulted in catchments forming the base unit for management planning (Rachman 2002). In order to prioritise management efforts, a rigorous process of classification was conducted for all 470 major catchments in Indonesia based on condition. This classification took into account the range of main land uses: hydrology, social, economic and institutional factors (Anwar 2003). Two
catchments in West Timor, the Benain and Noelmina, were identified as critical in this study.

In order to protect watersheds, the Ministry of Forestry has designated large areas of upland catchments as Protection Forest (*Hutan Lindung*) which is under the jurisdiction of the Kabupaten (district) level forest service. A common problem in catchment management is that a single catchment will usually cover multiple administrative districts. Within Indonesia regional catchment management authorities have been established to map, monitor and develop catchment management plans across districts (*Pengalolaan daerah aliran sungai terpadu* 2008)

A range of government catchment rehabilitation programs have been implemented focusing soil conservation and reforestation activities. Indonesian government legislation states that at least 30% of a catchment should be forested. Although, as previously described, an overly simplistic understanding of the relationship between forest cover and the hydrological cycle can be problematic. Up-land reforestation programs using eucalypts in central Flores, for example, have been blamed, by local forest department staff (pers. comm. 2004), for substantially decreasing dry season stream flows. Other work in western Flores has shown that the old growth forests have a definite impact on maintaining dry season water flow (Pattanayak & Kramer 2001). Pattanayak’s research into the economic value of the drought mitigation services from forests in western Flores attributes forests with support for up to 10% annual agricultural profit.

The role of catchment forests in the supply of clean water is critical for public health particularly in rural remote Indonesia where there is no infrastructure for water treatment. Water-related health problems include water borne diseases such as diarrhoea, cholera, parasites, diseases resulting from poor personal hygiene due to water shortages (respiratory infections), and diseases caused by insect vectors that breed in stagnant water (malaria, dengue fever). Diarrheal diseases are considered the most prevalent water-related diseases. In West Timor the impact of diarrhoea on childhood health is significant particularly when combined with high rates of malnutrition and anaemia (CWS/CARE/HKI 2008). Childhood mortality rates in West Timor are higher than the national average (BPS 2009). An investigation into the role of healthy catchment forests in the prevention of diarrhoea in Flores found
a significant negative correlation between the base flow of water from protected forest and incidence of diarrhoea (Pattanayak & Wendland 2007).

**Biodiversity**

Indonesia is comprised of two mega-diverse bioregions as defined by Myers et al (2000): (1) Sundaland, including of the major islands of Java, Borneo and Sumatra as well as peninsula Malaysia and (2) Wallacea (Fig 2.4), which includes most of eastern Indonesia between Lombok and New Guinea and is named after the co-founder of the theory of evolution, Alfred Wallace, who conducted much of his field work in this region. The high levels of species diversity in Indonesia is largely due to its unique island biogeography. Sundaland was periodically connected to mainland Asia allowing biotic migration through the archipelago until subsequent sea level rise left the island isolated which led to further speciation. A similar pattern of episodic connectedness occurred through Wallacea but in this case migrations occurred through the Gondwanan land mass. Wallacea is also one of the most geologically complex regions in the world (Sodhi et al. 2004) creating a diverse range of habitats for speciation.

Little detailed research has occurred on the biodiversity of much of eastern Wallacea although bird diversity studies have shown the level of endemism to be particularly high around Timor Island. This hot spot of bird endemism has been defined by Noske and Saleh (1996) as the Timor group which includes the islands of Wetar to the north, Damar and Babar to the north east and Roti to the south as shown in figure 2.5. This group of islands contains 23 of the 29 birds species endemic to Nusa Tenggara which equates to over 16% of the 137 recorded resident species which is a significantly higher rate than for the other major island groups of Indonesia (see Fig 2.6). All except two of these species inhabit lowland forest. Noske (1997) has compared the habitat preferences of bird species between Timor and northern Australia, the closest region with a well studied avifauna, and found a much greater diversity of monsoon rainforest species in Timor. This, he suggests, is due not only to the larger expanses of closed forests in Timor but also to a more ancient expansion of woodlands and savannas in Northern Australia than in Timor allowing for a longer period of adaptation and speciation in these landscapes. Of the 137 bird species in the Timor Group, over 80 occur in rainforests with about 50 of these confined to this habitat whilst only around 18 species are found in open eucalypt or melaleuca forests. These data point to the importance of Timorese
forests from a conservation biology perspective. Surveys have found eight species to be rare and at particular risk of habitat change on Timor, six of which are Timor group endemics.

Figure 2.4 Levels of endemism from the two bioregions of Indonesia; Sundaland and Wallacea. Sundaland includes much of peninsula Malaysia and all of Borneo Island (Indonesia, Malaysia, Brunei). Wallacea includes most of eastern Indonesia excluding West Papua. The graph accompanying each bioregion shows the percentage of species endemic to that region with the total and number of endemics shown in parentheses. Derived from Sodhi et al (2004).

Due to its proximity to Australia, Timor has a unique mix of north Australian and south-east Asian flora and fauna although non-bird fauna is poorly known. Recent surveys have discovered new species of bats, frogs, geckos and skinks and the evidence suggests that there is a high level of endemism amongst all faunal groups (Trainor 2007). About 50% of the frogs and 25% of the skinks and geckos are Timor endemic.
Carbon Source and Sink

Tropical peatland forests are some of the largest reserves of near-surface terrestrial organic carbon. Large tracts of these peat forests remain in western Indonesia particularly in Sumatera and Kalimantan. Attention was focused on these forests during the massive El-Nino catalysed fire in 1997 that spread smoke haze across large parts of S.E. Asia. Whilst it was the physical and industrial disruption caused by the transboundary haze that was of immediate concern, subsequent study revealed the massive extent of carbon loss into the atmosphere. Page et al. (2002) estimated that between 0.81 and 2.57 Gt of carbon was released to the atmosphere equivalent to 13–40% of the mean annual global carbon emissions from fossil fuels. These fires resulted in the largest annual increase in atmospheric carbon ever recorded. Deforestation and the associated forest fires continue to be a huge problem. In October 2006, Indonesian officials reported 1,496 fires in Sumatra and 2,075 fires in Kalimantan (Singapore Institute of International Affairs 2006).
These facts have resulted in Indonesia becoming a major focus for Reducing Emissions from Deforestation and Forest Degradation in developing countries (REDD) schemes. The Australian government is a major investor in these projects, pledging 200 million dollars through the International Forest Carbon Initiative and specifically in Indonesia through the Indonesia Australia forest carbon partnership. The Australian government sees REDD as being “... one of the most cost-effective opportunities for reducing emissions in the short-term. While financing from developed countries will play a role, ultimately carbon markets are the only mechanism capable of mobilising investment on the scale needed to support and provide incentives for REDD” (Department of Climate Change 2009, p. 1).

One of the main goals of this partnership will be to increase international forest carbon accounting capacity by demonstrating that forests can be monitored effectively through advanced remote sensing. There is an understanding that there needs to be greater certainty in measuring emission reductions from REDD activities to inform carbon trading activities.

Whilst most of the developing REDD projects are occurring in the peat forests of Kalimantan and Sumatera there are now some eastern Indonesian (Sulawesi) schemes in development (Mamuju Habitat 2009). The success of these programs will depend largely on the development of a reliable carbon trade, on good governance and the participation of local communities through supporting livelihoods and culture. Further work is needed to prove the effectiveness of REDD and even if successful projects are developed they will not be the solution to all tropical forest loss. There is particular concern for smaller remnant forests areas that may provide important local environmental services and support significant biodiversity but the protection of which would do little to slow global warming (Laurance 2008). The danger is that the scattered ‘carbon poor’ forests such as those in the semi arid landscapes of Nusa Tenggara may be forgotten.

2.2.2 Status of forests in Indonesia

Indonesia ranks third (behind Brazil and Zaire) in its endowment of tropical forests, having 10% of the world’s remaining forests. Official estimates of forest cover in Indonesia vary widely depending on the method of accounting. The Indonesian Ministry of Forestry, using a variety of methods, has defined 120 million hectares or 64% of total land area as forest administrative zones or Kawasan Hutan. The
breakdown of Kawasan Hutan into different administrative zones can be seen in table 2.2.

It is the responsibility of the Ministry of Forestry to manage all land designated as Kawasan Hutan even where this designation does not correspond to the actual occurrence of forest cover. The common Kawasan Hutan designations are: Hutan Konservasi which is closed to all extractive use and agriculture, Hutan Lindung allows limited non-Timber forest product use, Hutan Produksi permits ongoing logging and plantation development, Hutan Produksi Terbatas limits the level of timber extraction, Hutan Produksi Konversi allow for the conversion of the land to other uses such as urban/industrial or permanent agriculture. Two studies reported by Contreras-Hermosilla (2005) compared Kawasan Hutan designations with satellite image based forest cover mapping (table 2.3). Both studies had a high level of agreement in terms of total forest cover, around 90 million hectares or 48% of the total land area. These studies also showed that around 6-8 million hectares (~8%) of forested land is outside Kawasan Hutan and around 32 million hectares within Kawasan Hutan (~36%) is not forested. This differences between administrative coverage and land coverage of forests has important consequences for forest management.

The approximate distribution of Indonesia's forest cover is as follows: Kalimantan (32.0% of the total); Irian Jaya (29.9%); Sumatra (20.8%); Sulawesi (9.7%); Maluku (5.5%); and other (2.1%) (derived from GOI/FAO 1996: 36). The other 2.1% of forests are in Nusa Tenggara (East and Western districts).

Rates of deforestation in Indonesia are, as reported above, among the highest in the world with around 1.8 million hectares being lost each year over the last 15 years (FAO 2009b). There has been little investigation of forest cover change in Nusa Tenggara but two recent studies have been conducted in Timor Leste and in Belu district of West Timor that borders Timor Leste. These studies have been largely prompted by the rapidly changing political and demographic situation of this region.

The study in East Timor by (Bouma 2004) used Landsat imagery to assess change over a ten year period between 1989 and 1999 for around 50% of the land area. This study found a total of 12.6% forest cover was lost over the ten year period equating to a loss of 132km$^2$ of dense forest and 57km$^2$ of secondary forest.
The study in Belu district (Nugroho 2008), also using Landsat imagery over the ten year period 1989-1999, focused on the cross-border Talau catchment. He found a decrease in forest cover from 4% to 3% of the catchment (720km²) and an increase in grassland from 50-60%. Although the amount of forest loss is small it was found to have occurred largely in the upper catchment and was considered significant in terms of the degraded state of the catchment.

Table 2.2: The breakdown of Kawasan Hutan for all of Indonesia based on the Forest Planning agencies forest zone delineation exercise of “Paduserasi” of 1999. Data derived from (Contreras-Hermosilla & Fay 2005). Hutan Konservasi is closed to all extractive use and agriculture, Hutan Lindung allows limited non-Timber forest product use, Hutan Produksi permits on going logging and plantation development, Hutan Produksi Terbatas limits the level of timber extraction, Hutan Produksi Konversi allow for the conversion of the land to other uses such as urban/industrial or permanent agriculture.

<table>
<thead>
<tr>
<th>Forest Function</th>
<th>Bahasa Indonesian</th>
<th>Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nature Reserve / Nature</td>
<td>Hutan Konservasi (K)</td>
<td>20,500,9</td>
</tr>
<tr>
<td>Protection Forest</td>
<td>Hutan Lindung (HL)</td>
<td>33,519,6</td>
</tr>
<tr>
<td>Limited Production Forest</td>
<td>Hutan Produksi Terbatas</td>
<td>23,057,4</td>
</tr>
<tr>
<td>Permanent Production Forest</td>
<td>Hutan Produksi (HP)</td>
<td>35,197,0</td>
</tr>
<tr>
<td>Convertible Production Forest</td>
<td>Hutan Produksi Konversi</td>
<td>8,078,05</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>120,353,0</strong></td>
</tr>
</tbody>
</table>

Table 2.3: The results of two studies that mapped the area of forest within and outside forest administration zones using satellite image data from 2002. The Indonesian Ministry of Forestry (MOF) study was conducted using Landsat data whilst the University of Wageningen and Global Forest Watch (UoW/GFW) primarily used Spot data. Difference between classification results are due to cloud cover, sensor types and classification method. Table derived from (Contreras-Hermosilla & Fay 2005)

<table>
<thead>
<tr>
<th>(Land Cover Ha x1000)</th>
<th>Forest Zone (Kawasan hutan)</th>
<th>Outside forest Zone</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>HL</td>
<td>K</td>
<td>HP/HT/HK</td>
</tr>
<tr>
<td>MOF</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Forest</td>
<td>20903</td>
<td>12858</td>
<td>49161</td>
</tr>
<tr>
<td>Not Forest</td>
<td>4798</td>
<td>2835</td>
<td>25295</td>
</tr>
<tr>
<td>UoW/GFW</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Forest</td>
<td>23180</td>
<td>12160</td>
<td>48120</td>
</tr>
<tr>
<td>Not Forest</td>
<td>4490</td>
<td>2350</td>
<td>29930</td>
</tr>
</tbody>
</table>

The study in Belu district (Nugroho 2008), also using Landsat imagery over the ten year period 1989-1999, focused on the cross-border Talau catchment. He found a decrease in forest cover from 4% to 3% of the catchment (720km²) and an increase in grassland from 50-60%. Although the amount of forest loss is small it was found to have occurred largely in the upper catchment and was considered significant in terms of the degraded state of the catchment.
2.2.3 Causes of forest cover change in Indonesia

The causes of forest cover change in Indonesia are complex and have changed markedly in recent times. A review conducted by Sunderlin (1996) identified the following proximate forces behind deforestation in Indonesia:

**Shifting Cultivation** has been contradictorily cited as one of the major causes of deforestation and one of the most appropriate and sustainable uses of tropical forests. Sunderlin’s work describes a change in the mid 90’s to the way shifting cultivation is viewed, evolving from a primary cause of deforestation to a realization that the effects of this type of small holder land use have been overstated. Part of this shift in perception has come through a better understanding of the difference between rotational and pioneer cultivation.

**Agroforestry** activities by small holders through the expansion of tree crops such as coffee, rubber, coconut often encroaches on established forest. The planting of tree crops has also been used as a means for establishment of tenure over otherwise forested land.

**Transmigration** in response to government policy to relieve over population on Java and Madura islands, has been linked to large scale deforestation. Early estimates of the amount of forest loss have been shown to be exaggerations but there is strong evidence that both formal (government programs) and informal movements of people have resulted in forest conversions.

**Population density** increase as a driving force for deforestation has been postulated and an inverse relationship between forest cover and population can be show for some parts of Indonesia. Although there is little evidence of a direct (proximate) causal relationship, population could work as a driving force for increased pressure on forest based agriculture and for migration to new areas (Lambin et al. 2001).

**The Timber industry** is an important contributor to the Indonesian economy. Estimates of the contribution of logging to deforestation in Indonesia range from 10-20%. Studies into deforestation due to timber extraction cite poor forest concession management and short term investment as drivers. The allocation of forest concessions has also been used as a form of political patronage.

**Estates and plantations** have become important drivers of land cover change, particularly with the rapid expansion of African palm oil. Whilst production of food
crops is largely controlled by small holders, cash crops are increasingly dominated by private commercial estates and state owned plantations.

Since Sunderlin conducted this study, Indonesia has been through a momentous period of political and economic upheaval which has had marked impacts on the management of Indonesia forest resources. The economic crisis that gripped South East Asia in 1997-98 placed intense pressure on a flawed economic model resulting in the end of President Soeharto’s 32-year reign in May 1998 amidst growing street protests. During the post-Soeharto period of ‘Reformasi’, sweeping administrative and economic reforms were rolled out, responding to internal political and international financial pressures. The issues most often cited as driving forest management in post New Order Indonesia are the process of political decentralisation, forest tenure structures, and the macro and micro economic responses to the economic crisis.

Decentralisation and reformasi
Indonesia’s move towards decentralisation of authority to the Kabupaten (district) level from 2000 was in response to demands for more regional autonomy in decision-making and a more just distribution of resources. Greater regional autonomy was seen as crucial to prevent disintegration of the Indonesian state. Laws guiding decentralisation allow for greater autonomy in decision making, revenue raising and budgeting to the Kabupaten level. The laws also allowed for greater control of, and increased revenues from, natural resources. Before decentralization, 30% of forest revenues went to the central government with the rest going to the provincial government and the Kabupaten received nothing. Now 64% of forest revenues go straight to the Kabupaten with the remainder divided between the provincial and central government (Resosudarmo 2004). Many Kabupaten governments believe that the successful implementation of decentralisation will depend on their ability to increase local revenue which has in some cases, led to greater exploitation of forest resources. Vague and conflicting laws related to forest administration have evolved out of the decentralisation process with central and local forestry departments vying for power over forest resources. There has been a tendency of some district governments to secure short-term economic gains with inadequate attention to long-term environmental, social and economic considerations (Resosudarmo 2004).
Another problem that has grown out of decentralisation, reformasi and economic crisis has been weakening enforcement of forest laws. There was a strong association between the military and forestry activities in Indonesia (McCarthy 2000) making transgression of forest laws by local communities dangerous. Whilst the previous authoritarian rule dealt quickly and harshly with any transgression, the new softer democratic rule meant that military enforcement of civilian laws is no longer an option. The economic crisis also dramatically reduced funds for law enforcement at a time when more people were turning to forest resources for livelihood support.

**Economic crisis**

Not only did the economic crisis reduce funds for forest law enforcement, it also changed the way the rural poor used forest resources. Sunderlin and Resosudarmo (2000) conducted household surveys of rural communities living near forests in Sumatera, Kalimantan and Sulawesi towards the end of the economic crisis (1999) to determine its effect on forest use. They found the main driver operating at the small holder level during this period was a marked increase in commodity prices due primarily, but not solely, to the devaluation of the rupiah. This resulted in a potential for greater rural incomes but, in general, income gains did not keep pace with higher costs of living. Pepper and cocoa in particular reached record market highs in mid-1998. A secondary driver was decreasing urban employment opportunities resulting in people returning to the land and increasing pressure on rural resources. A combination of these factors resulted in increased land clearing in the second year of the financial crisis (1998) with a particular focus on the establishment of tree crops such as pepper and cocoa (Fig 2.7). They also found a significant increase in the use of non-timber forest product which suggests they functioned as a safety net particularly for those households with low export incomes.

![Figure 2.7 A model of deforestation through the expansion of tree crops; derived from work by Angelsen (1995).](image-url)
The economic crisis also had an impact on forest governance with the International Monetary Fund and the World Bank providing large loans to the Indonesian government in return for their commitment to a range of reforms including measures designed to improve forest management. Most of the reforms focused on increasing the sustainability of forest concessions run by large Indonesian conglomerates. Barr (2001) has argued that the imposed measures have actually stimulated deforestation by ignoring key forces such as timber demand and illegal logging whilst encouraging improved harvesting and processing efficiencies.

Tenure

The tenure delineation of forested land has long been a contentious issue in Indonesia due to the way Kawasan Hutan is defined and the fact that central government claims control over most Kawasan Hutan land. New opportunities for reforming Kawasan Hutan delineation and forest management are seen through democracy and regional autonomy. (Contreras-Hermosilla & Fay 2005). State ownership of forest land in Indonesia began in 1808 when the Dutch Governor General declared all forests to be controlled by the state, a policy that continued through to independent Indonesian rule (McCarthy 2000). Central control of Indonesia’s enormous forest wealth was designed to secure public claims on territory, raise revenues and promote economic development through the issuing of timber concessions.

Conflict over state verse traditional forest management rights has often resulted in poor forest governance. Both the Dutch and Indonesian governments formally acknowledged traditional tenure (adat) over land unless it came into conflict with state interests. Attempts to further strengthen traditional forest tenure rights have generally resulted in more confusion than clarity. For example Contreras explains that “the 1999 Forestry Law did not change the concept of customary community tenure rights but added confusion by stating that certain areas of the Forest zone can be recognized as “Adat Forests” but these forests must be classified as “State Forest”. This is an apparent legal contradiction since “State Forests” areas are those forests where there are no rights attached to the lands and “Adat Forests” can only exist when Adat rights are demonstrated to be in effect” (2005, p. 14). When traditional rights are extinguished there is little incentive for local communities to sustainably manage resources on land over which they have no formal say. This process of disenfranchisement, leading to poor resource management outcomes, is
exemplified by the plight of the sandalwood industry in West Timor. In 1986 legislation was passed that deemed all sandalwood to be owned by the state thus removing incentive for local farmers to implement long term management strategies. This along with petty corruption and government mismanagement led to the rapidly led to the rapid decline of the industry (McWilliam 2005).

These ownership problems are exacerbated by the confusing delineation of Kawasan Hutan forest boundaries. As described previously, large areas of forest are not included in forest zones and large areas of forest zones contain no forest. This situation is described by Fay in the following way:

“An important part of the process of coming to terms with the crisis in Indonesia’s forests and reversing the trends, is to determine exactly what and where these forests are, then how, in places where it is still possible, to assure their protection. While some work has been done to improve management in some natural forest settings, little attention has been paid to defining just what is and isn’t a forest in Indonesia.” (2000, p.1)

The problem of forested land lying outside official forest zones is that they may not have the required protection to assure their long term sustainable use. The problem of lands without forest being classified within forest zone is that the traditional owners of the land are prevented from developing sustainable, livelihood improving agriculture. They may still use the land but without any tenure security it is difficult for local custodians to invest in a long term vision of sustainable land use.

The economic crisis precipitated a new political order in Indonesia that has in-turn increased demands on forest resources whilst decreasing resources available for forest protection. Decentralisation has led to wrangling over forest resource rights between local and central government at the same time as renewing hope for land tenure reform to respect traditional rights to land tenure.

### 2.2.4 Driving forces of forest change in Timor

Although on-ground social research was not conducted to determine the forces behind deforestation, the studies in East Timor and Talau Catchment (West Timor) both postulate driving forces. The Timor Leste study (Bouma 2004) argues that
extractive, unsustainable logging by Indonesian companies and the transmigration and translocation of people in and around East Timor were the main forces in play. It is also suggested that the corporate exploitation of East Timor’s forests was linked to the Indonesian military who allegedly helped finance its operations. The process of settling transmigrants into East Timor is described as a way to consolidate Indonesian rule in East Timor that also placed additional pressure on its natural resources. The translocation of East Timorese from isolated mountain villages to new settlements near roads with better access to services and military control also put pressure on new land. These processes are not unique to Timor Leste, in fact many of the outer islands experienced a similar relationship with the central government. Whereas this study describes ‘Indonesia’ as agent of change in other regions, ‘Jakarta’ was seen as the force exploiting forest resources and consolidating ‘Javanese’ rule. In the Talau catchment the movement of people is also cited (Nugroho 2008) as the major force driving land cover change but this time it was due to a massive influx of refugees from East Timor. It can be seen from these two studies that, at least around the border regions of Timor, the most important drivers are due to international political forces.

It is clear that the forces behind deforestation in Indonesia are complex, multi-layered and often regionally specific and that the driving forces have changed in recent years due to political and economic variables. These same variables have also opened opportunities for new directions in forest management in Indonesia. Improvement in the quality of the debate about Indonesian forest management requires a better understanding of where the forests are and the forces affecting them. The FAO has acknowledged that a paucity of detailed information is restricting the development of good forest policy:

“For some time, FAO had been concerned that, while the forestry situations in selected countries were well documented and global analyses regularly assesses the forestry situation at macro levels, many of the complex relationships at regional levels were being overlooked and under-appreciated. Consequently, understanding of many of the more subtle – though no less important – dynamics of the sector was being affected.” (FAO 1998, p xii)

In Indonesia’s case the global significance of the humid tropical forests of western Indonesia, due to their role as carbon stores, has resulted in a great deal of research
being conducted into the dynamics and status of these forests whilst relatively little is known about the markedly seasonally dry regions such as eastern Indonesia (Russell-Smith et al. 2007).

2.3 Satellite remote sensing of tropical forests.

Satellite derived forest cover and forest cover change mapping is considered to be the most reliable source of quantitative data although, as described above, results can be highly variable depending on method and interpretation. Indonesia is currently in the process of developing uniform approaches to forest mapping and monitoring for their national forest accounting systems. Large scale forest assessment projects generally rely on either a coarse resolution complete coverage or high resolution partial coverage sampling. Both these methods tend to be poor at mapping smaller fragmented forests and therefore the resulting datasets have limited utility for developing local land management applications. At the Kabupaten level, higher temporal and spatial resolution forest data is needed to facilitate on-ground management planning.

With evolving technologies and changing research methods, new opportunities are arising for the local application of satellite technology. Over the last ten years the cost of hardware requirements have decreased by an order of magnitude, satellite data has become more widely available (Landsat data are now free), and technological literacy and exposure to satellite data (through sites such as Google Earth) has increased rapidly. Remote sensing and GIS, once the realm of a techno–elite, are becoming more cross disciplinary and decentralized tools have been developed for assessing and monitoring natural resources (Fuller & Chowdhury 2006). Some regard satellite imagery as potentially revolutionising forestry governance by providing increased transparency and NGOs enabling to conduct independent assessments (Baker & Williamson 2006; Fuller 2006). This enthusiasm needs to be tempered by recognition of the limitations of satellite derived information about forest cover change, particularly for understanding cause. Mathew (2003) argues that these limitations are not sufficiently acknowledged and have resulted in a detrimental bias in the way human ecological processes are assessed. He believes that RS/GIS technologies have precipitated a reversal of the classic scientific focus on understanding process over description:
“In the applied environmental scientific context, studies that describe change and pattern over broad scales are often seen as being more general and scientific than local studies of social and ecological process...” and that “... the preoccupation with spatial breadth and pattern to the exclusion of ecological process has affected the natural sciences as well. Much work in landscape ecology has become increasingly concerned with pattern and scale, losing sense of process and causality” (p. 263)

There is a common perception that the broad, repeatable quantitative measurements derived from satellite image analysis are more analytically useful than descriptions by an on-the-ground observer. This has shifted research away from human or political ecological methods of understanding complex causative processes.

2.3.1 Socialising the Pixel

In an attempt to address the shift to describing pattern over process, researchers are increasingly using GIS techniques to combine economic and social data with land cover data derived from satellite imagery to find correlations between on-ground change and influencing variables (Chowdhury 2006). Chowdhury has described this as the ‘spatial driving forces’ approach to land use, land cover change and outlines three main methods. The first two are primarily concerned with spatial analysis and modelling:

1. Spatially explicit datasets: By combining satellite derived data with other spatial data layers it is possible to perform a range of analysis to explore correlations. For example data on infrastructure, population or land tenure can be intersected with FCC mapping to examine possible relationships.

2. Economic theories and econometric or statistical techniques: By combining forest cover change and ancillary spatial datasets it is possible to apply economic theories to human driven landscape process such as agricultural intensification. For example, by integrating distance to market and land rent information, an assessment can be made of economic drivers in relation to forest cover change.

Such approaches which infuse spatial data with greater social, political and economic relevance have been beautifully termed ‘socialising the pixel’ by
Gohegan et al (1998). The methods that Gohegan et al describes under these terms are pixel mining, ie inferring social information from spatial patterns; and pixel modelling, ie the predictive probability of a pixel changing (Liverman 1998). However Mathews also argues these GIS based methods reinforce a reliance on spatial correlations to infer the impact of human management, uninformed by social or historical contexts. This reliance of spatiotemporal correlations to human induced change over large areas are at odds with the human or political ecological focus of tying human land use to more local studies. The third approach that Chowdhury describes goes some way to addressing these concerns:

3. Chowdhury uses the term Methodological pluralism and scalar dynamics to refer to a multidisciplinary approach using ethnography, interviews, household surveys, field-based community and participatory sketch mapping and other methods to bring forth alternate perspectives and understandings of the changes being investigated (Chowdhury 2006). He is describing a mixed approach using social science to gain insight into the chains of causation of spatially defined phenomenon. Although challenging, such a mixed methods approach does provide unique opportunities for both the spatial scientist and the social scientist.

Whilst highlighting problems in the prevailing methods of satellite based land cover change analysis Mathews sees scope for improved research practice using such a mixed method or cross disciplinary approach:

“… one way in which RS and GIS can be used in human ecological work is to provide a broader spatial context or verification of relationships and changes observed by more localized fieldwork. Such research pairings are fruitful. The broad spatial analysis of remotely sensed data is informed by the local human ecological research which in turn benefits from the more regional analysis provided by GIS/RS.” (2003, p. 265)

Critiques of satellite based forestry monitoring are important considering the pre-eminence satellite data has taken in discussions about forest cover change. Extent and rates of change, expressed as simple numbers, are much easier to report and less politically sensitive than complex multilayered social-economic-political narratives regarding human use of natural resources. Yet in order to really
understand and effectively manage forest resources it is important to engage with complexity. Case studies, although spatially limited, provide a useful way to infer complex causation within a broader landscape context.

2.4 Conclusion

The world’s tropical forests are integral to maintaining global climatic stability and provide important services to local communities. Due to the global significance of its forests and the high rates of forest loss, Indonesia has become a focus of international efforts to curb deforestation. Although the focus is largely on western Indonesia the forests in eastern Indonesia are also important due to their unique biota and the role they play supporting the predominantly rural population. Causes of forest loss in Indonesia are complex and multi-factorial: Indonesia’s forest laws are often confusing, conflicting and can impact negatively on traditional tenure and management systems; recent economic crisis and political change has had significant impacts on forest management and, in West Timor, there has been considerable changes to land use and land cover resulting from political change in Timor Leste.

Satellite imagery is an important tool for mapping and monitoring forests in Indonesia and there are new opportunities for more local monitoring with the advances in remote sensing and geographic information technology. However, whilst it is important to have quantitative data on forest cover, these data alone can distract from understanding the multiple local scale variables influencing forest use. In order to develop effective policy and management strategies it is necessary to link spatial data with on-ground qualitative research or to ‘socialise the pixel’.
Chapter 3 Study Area

3.1 Introduction

Kabupaten Kupang is the second largest of the 21 Kabupaten in the eastern Indonesian province of Nusa Tenggara Timur, after Kabupaten East Sumba. Kabupaten Kupang encompasses over a third of Indonesian West Timor and about 17% of all of Timor Island (Fig. 3.1, 3.2).

Nusa Tenggara Timor (NTT) is the most south eastern province in Indonesia and is considered remote and ‘backward’ by the majority of Indonesians in the more developed western half of the country (Farram 2004). The latest Human Development survey, conducted in 2005, combining life expectancy, education levels and gross domestic product (GDP) per capita, places NTT as the third poorest performing province in Indonesia after Papua and Nusa Tenggara Barat (BPS 2009). The human development index (HDI) for Kabupaten Kupang is below the average for the province of NTT (Fig. 3.3), making it one of the poorest regions in Indonesia. It is interesting to note the relatively high HDI in Kota Kupang, the administrative capital of, and by far the largest urban area, in NTT. Kabupaten Kupang is a distinct district from Kota Kupang (Kupang City) although its administrative infrastructure currently resides within the boundaries of Kota Kupang. A new administrative capital is being constructed at Babau in Kecamatan (subdistrict) Kupang Tengah, about twenty kilometres outside Kota Kupang, and is due to begin operation in 2011.

Figure 3.1 The location of Nusa Tenggara Timur and Kabupaten Kupang.
Figure 3.2 The Kabupaten of Nusa Tenggara Timur province, as of 2009, showing Kabupaten Kupang (Blue) and Kota Kupang (Kupang City - Red).

Figure 3.3 The Human Development Index provides a composite measure of three dimensions of human development: living a long and healthy life (measured by life expectancy), being educated (measured by adult literacy and enrolment at the primary, secondary and tertiary level) and having a decent standard of living (measured by purchasing power parity, and income). Graphic derived from Indonesian Dept of statistics online HDI data (BPS 2009).

Kabupaten Kupang is currently comprised of three inhabited islands\(^{ii}\), Timor, Semau, and Kera which are divided into 23 administrative subdistricts (Kecamatan) (Fig. 3.4). This study focuses on just mainland Kabupaten Kupang which is home to 96%\(^{ii}\) Until 2009 included Sabu and Rijau Islands.
(275,000) of the people and is 95% of the land area (4,800 sq km) of the whole of the Kabupaten. The two Kecamatan not included in this study are both on Semau Island that lies just off the south west coast of Kabupaten Kupang. The remaining 21 Kecamatan are made up of 206 village (desa) districts.

Figure 3.4 Kecamatan (district) boundaries, village boundaries and road network of Kabupaten Kupang.
3.2 Biophysical description

3.2.1 Rainfall

Timor Island, like the rest of Indonesia, is strongly influenced by the moist monsoon winds that start in December and generally persist through to March. These northwest monsoon trade winds drop most of their precipitation before reaching NTT, resulting in much less rainfall than in western Indonesia. This is visible in figure 3.5 where Kabupaten Kupang is clearly one of the driest regions in Indonesia. An important characteristic of this rainfall is the short period over which it falls, with five months of each year receiving less than 100 mm (Fig. 3.5). This ‘seasonally dry’ climate (tropical monsoonal, Af, Köppen classification) has important implications for agriculture and the ecosystem function.

Not only is rainfall unevenly distributed over time, the spatial distribution is highly influenced by the mountainous topography of Kabupaten Kupang. Mapping this distribution is difficult due to the scarcity of rainfall stations. There are only four stations in Kabupaten Kupang: Kupang, Penfui, Oekabiti, Lelogama, (Fig. 3.6). Various studies have attempted to model rainfall distribution based on limited rainfall data and elevation data (Hijmans et al. 2005). A recent study (Santika 2004) used data from 73 observation stations over Timor Island and 1 km resolution elevation data to model rainfall as can be seen in figure 3.5.

![Figure 3.5](image.png)

Figure 3.5 The modelled annual average rainfall distribution across Indonesia derived from data produced by the WorldClim - Global Climate Data project (WorldClim 2009)
3.2.2 Geology and soils

Timor Island is part of the Outer Banda Arc islands that are thought to have originated from an Australian continental coastal fragment. Although these islands are geologically complex and controversy still exists as to their precise origin (Monk KA 1997), it is generally believed that these coastal fragments emerged above the sea about four million years ago, resulting in a mixture of sedimentary and metamorphic rocks. Fox (1996) relates how one geologist summarized the jumble of uplifted Australian continental rock mixed with a mélangé of marine and volcanic deposits overlain by raised coral reefs as “tectonic chaos” (p. 1). An important feature of the landscape is massive metamorphic rock outcrops known as Fatu. These hard marble ‘mountains’ left behind as the surrounding softer sedimentary landscape has eroded have important cultural associations and are often considered sacred. Villages were traditionally situated next to Fatu as they provided fortress like protection during times of war and often housed springs providing fresh clean water.
The main sedimentary rocks are limestone, resulting in alkaline soils. The dominant soil type in Timor is a soft shaly clay known by the Timorese name *Bobonaro* (Fox, 1996). These soils are characterized by low levels of fertility and high erodability. Soil erosion and land slips are a common and serious problem in Kabupaten Kupang. Soil infertility and soil loss is further exacerbated by the short and intense wet seasons where the majority of rain falls in heavy storms. These storm events erode fertile topsoil and contribute to the leaching of soil nutrients.

3.2.3 Landscape

The mixed nature of the soft sedimentary and metamorphic geology combined with a short and intense wet season has produced a rugged, eroded landscape. The following brief description of the major landscape features as shown in figure 3.7.

The north east of Kabupaten Kupang is dominated by Mount Timau with its pyramid like peak rising to 1774 meters. This is part of the Mount Mutis /Timau watershed region, one of the most important catchment in West Timor, which feeds the Noil Mina and Noil Bena Rivers flowing to the south coast. Noil Mina forms the south eastern boundary of Kabupaten Kupang.

Mt Timau is dominated by Ampupu forest (*Eucalyptus urophylla*). About 18% of Kabupaten Kupang is above 500 meters and receives higher rainfall than the surrounding landscape. These mesic conditions, along with the relative inaccessibility of these uplands, enables them to support some of the largest tracts of forest in the Kabupaten including some monsoon forest around Lelogama.

About 60% of Kabupaten Kupang, between 100-500m asl, is comprised of rugged hill and plateau country and supports a diverse range of habitats. To the west of Timau/Lelogama is the rugged hill country of Amfoang. Most of Amfoang is relatively dry and only accessible on foot. Over many years, shifting agriculture and grazing has maintained large areas of open savanna although significant pockets of forest occur on some of the steeper slopes. To the south of Amfoang is the mountainous region around the village of Nunsae. Dominated by Fatu outcrops, this area receives a higher rainfall than, and provides an important catchment for, the surrounding plains. Water from this area supports one of the last remaining
stands of lowland rainforest in Timor on the adjacent Babau coastal plains at Bipolo.

Figure 3.7 A three dimensional elevation model with major landscape regions labelled.

The hills of Amarasi, on the south coast, rise sharply to over 500 meters within a few kilometres of the coast. It has been observed, although no official rainfall records for this region are available, that this steep coastal incline receives in extra dry season rainfall. This is due to north westerly winds arriving at the south coast moisture laden after travelling over 700 km of ocean from Australia. This extra rain has left Amarasi more fertile the other parts of the Kabupaten. It also supports one of the largest tracts of monsoon forest within the Tamanan Yohannas national park with a unique cultural and agricultural history (Piggin & Nulik 2005).
Below 100 meters are the coastal plains which occupy around 22% of the Kabupaten. The largest expense of this landform is the Babau plains, to the north east of Kupang, which cover around 140 sq km. This region is comprised of extensive tidal mudflats and associated mangrove forests, palm savanna, much of which is overgrown with *Acacia nilotica* (prickly acacia), some important lowland rainforest and irrigated rice fields fed from the nearby Tilong Dam.

West Timor is dominated by six major catchments, three of which occur completely or partly inside Kabupaten Kupang. They are the Oesau (795 km$^2$), Termanu (593 km$^2$) and the Mina catchment (1894 km$^2$). Slightly less than half of the latter is within Kabupaten Kupang (Fig 3.8).

![Figure 3.8](image)

Figure 3.8 The major catchments of West Timor.

Work conducted by the NTT Office of Catchment Management (Balai Pengelolaan Daerah Aliran Sungai Benain Noelmina) have identified a total of fifty sub-catchments in Kabupaten Kupang. Based on a range of social-economic and biophysical characteristics, eleven have been classed as top priority for rehabilitation activities including the Noelmina and Oesau catchments in
Kabupaten Kupang (Balai Pengelolaan DAS Benain Noelmina 2007). This catchment based assessment classed 88% of Kabupaten Kupang as being at least partially degraded and almost ten percent (47000 ha) as critically degraded (Fig 3.9). Most of the degraded land is within Kawasan Hutan forest administrative zones whilst the most critically degraded is on farming land. With regards to rehabilitation activities, the government has more control over land management inside Kawasan Hutan than on farming land where the need is greatest.

3.2.4 Biogeography
In 1863 Alfred Wallace presented a paper to the Royal Geographic society in London, based on his previous 8 years of travel in Indonesia and the Malay Peninsula, defining two major geographic regions, the ‘Indo-Malayan’ region to the west of Bali and Sulawesi, and the ‘Australo-Malayan’ region to the east (Van Oosterzee 1997). The boundary between these two bio-regions was later named the Wallace Line and became the most famous and discussed biogeographic demarcation in the world. While this initial division was based on the distribution of parrot species, subsequent studies redrew the line multiple times based upon the occurrence of a range of different faunal groups. Of particular note are Webber’s line marking the transition point between the dominance of species of Asian versus Australian origin and Lydekker’s line following the edge of the Sahul (Australian) continental shelf (Fig. 3.9).

![Figure 3.9 The percentage of degraded land by severity inside Kawasan Hutan, other land and the total.](image-url)
Although not aware of it at the time, these early researchers had recognized species differentiation resulting from ancient continental evolution. Western Indonesia is derived from the ancient Eurasian super continent and sits on the Sunda shelf, whilst eastern Indonesia has a Gondwana origin with West Papua and Australia sitting on the Sahul shelf. Separating these two continental shelves (Sunda and Sahul) is Wallacea, a group of isolated island fragments (Fig. 3.10). The distinctive endemic fauna and flora of Wallacea is thus a unique result of the mixed influences of Eurasian/Sunda species from the west and Gondwanan/Sahul species from the east left to evolve in isolated island ecosystems for tens of millions of years.

3.2.5 Fauna
As described in the previous chapter, West Timor is home to a large number of rare endemic bird species. Kabupaten Kupang contains four sites classified by BirdLife International as Important Bird Areas; Bipolo, Camplong, Gunung Timau (Table 3.1) and Dataran Bena. Important bird areas are defined as sites that either hold significant numbers of one or more globally threatened species, are one of a set of sites that together hold a suite of restricted-range species or biome-restricted species, or have exceptionally large numbers of migratory or congregating species (Bird Life International2009).

Figure 3.10 Map of Sunda and Sahul continental shelves and the Wallace, Lydekker and Webber Lines. Graphic produced by Maximilian Dörrbecker. Reproduced under CC-SA license.
Table 3.1 Globally threatened bird species at each site except Dataran Bena for which there are no comprehensive survey data.

<table>
<thead>
<tr>
<th>Species</th>
<th>Timau</th>
<th>Bipolo</th>
<th>Camplong</th>
</tr>
</thead>
<tbody>
<tr>
<td>Timor green-pigeon (<em>Treron psittaceus</em>)</td>
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<td></td>
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<tr>
<td>Wetar ground-dove (<em>Gallicolumba hoedtii</em>)</td>
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<tr>
<td>Yellow-crested cockatoo (<em>Cacatua sulphurea</em>)</td>
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<td></td>
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<tr>
<td>Timor Imperial-pigeon (<em>Ducula cineracea</em>)</td>
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</table>

Other, non-bird, species of note in Timor include the Timor cuscus (*Cuscus Phalanger orientalis*), rusa deer (*Cervus timorensis*), Timor monitor (*Varanus timorensis*), estuarine crocodile (*Crocodylus porosus*), Shrews sp. (*Crocidura*), palm civet (*Paradoxurus hermaphrodites lehmannii*) and a large number of bat species, some of which are endemic to the region. All these species are potentially under threat due to habitat fragmentation and hunting.

### 3.2.6 Vegetation

Kabupaten Kupang has the largest area of forest cover in West Timor (Dinas Kehutanan NTT 2006). The most complete vegetation survey for Kabupaten Kupang was conducted in 2007 by the provincial department of conservation and Nusa Cendana University (BAPEDALDA 2007). A large number of detailed site surveys were conducted across West Timor. This set of surveys was used to attribute a vegetation distribution map (Fig 3.11). The report groups the vegetation cover into seven classes as follows:

**Ampupu Forest (47 sq/km)**

Ampupu is the local name for *Eucalyptus urophylla* which is endemic to the region. This forest type generally occurs above 900m (asl) and has been classified as a seasonal montane forest (Monk KA 1997). Ampupu forests reach heights of 30 meters and form a thick canopy cover (>60%). It has been suggested that the dominance of Ampupu in these forests is a result of increased grazing and fire pressure over the last one hundred years. Ampupu is more fire resistant and less palatable than a range of seasonal montane species. The Ampupu forests that dominate the Timau region are part of a catchment complex that extends through to
Mount Mutis in adjacent Kabupaten Timor Tengah Selatan and are important for maintaining the health of the major Benain and Mina river catchments.

**Monsoon Forest 298 sq/km**

The monsoon forests of Kabupaten Kupang occur from 20 to 600m asl where annual rainfall is above 1500mm and/or ground water is accessible. Monsoon forests are characterised by a three layered structure with top emergent tree species, the main closed canopy and a lower shade tolerant layer. A common feature of these forests is the species diversity in both the tree and shrub layers. These forests in Kabupaten Kupang are dominated by *Jambolifera trifoliate* and *Ficus pubinervis* and are home to some rare endemic bird species.

**Mangrove Forest 20 sq/km**

Although under threat, significant areas of mangrove forest remain in the Kupang Bay area with the largest tract south east of Kabupaten Kupang on Manipo Island and the adjacent coast. Manipo Island is classified as a wildlife reserve and is an important refuge for a wide range of animal species. These closed canopy forests

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Figure 3.11
Vegetation
distribution derived
from the
BAPEDALDA survey
(BAPEDALDA
2007).
reach a height of 25 meters and are dominated by *Rhizophora apiculata*. Mangrove forests are important nurseries and feeding grounds for a wide range of marine life and are important for supporting commercial fisheries.

**Woodland Forest 907 sq/km**
These ‘dry evergreen’ forests are common on the mid-slopes between 100-500 meters and are dominated by *Mallotus ricinoides* and *Hibiscus timoriensis*.

**Open Forest 691 sq/km**
Mostly located in the northern mountains of Kabupaten Kupang, the savanna forests are dominated by *Casuarina junghuhniana* and *Eucalyptus alba* (kayu putih).

**Palm Savanna 724 sq/km**
The palm savannas are most commonly associated with lowland alluvial plains. The dominant species of palm savannas in Kabupaten Kupang are the drought tolerant *Corypha utan* and *Fluocortia sp*. The *Corypha utan* (Gebang) and the associated *Corypha elata* palm provide an important source of housing materials and sago stock feed. Another palm commonly found on these plains is *Borassus sundaicus* or lontar palm. The lontar palm is also an important source of building materials and produces a sweet flower and sugar syrup which has traditionally been a staple of the diet of the Rotinese people.

**Savanna 2218 sq/km**
The distribution of vegetation in the open savannas, whilst generally sparse is highly variable. The dominant imperata grasses can become quickly invaded by woody weeds, depending on grazing or burning pressures. For example the dominant tree species of the open savannas is the hardy *Acacia nilotica*, known in Australia as the invasive weed, prickly acacia. Depending on management geology and slope, other common tree species include *Eucalyptus alba* and *Casuarina junghnia*. In some areas of moister gullies or poorly drained depressions, bamboo and lantana thickets are common.

### 3.3 Demography
Data on demography are derived from the latest Kabupaten Kupang Department of Statistics report, “Kabupaten Kupang dalam angka 2007” (BPS Kabupaten Kupang,
The demographic data are compiled from national census data which are collected at ten year intervals, (last conducted in 2000), and local population surveys (last conducted in 1995). Projections from previous data are often used when reporting current statistics. It should be noted that the accuracy of the figures presented in these reports is often questioned by local, informed people.

Mainland Kabupaten Kupang had a total population of 275,000 in 2006 and a growth rate of 5.4% per annum (BPS Kabupaten Kupang, 2007). A significant contributor to this population growth was the transmigration of 2,500 people into Kabupaten Kupang. The average population density of 53 people per square kilometre is about half that of the NTT (91/km$^2$) and the nation as a whole (116/km$^2$). The population distribution is skewed around the south east near Kupang City, with population densities below 25/ km$^2$ for much of the northern
part of Kabupaten Kupang (Fig 3.12). The population is predominantly young, with almost half (45%) being under the age of 20 years (Fig. 3.13). The skewed age distribution and the current high population growth rates suggest the population will continue to grow rapidly and place increasing pressure on the Kabupaten’s limited natural resource base.

Health and education statistics are collected annually through the national Socio–Economic Survey (SUSENAS). The latest report (2006) found that 10% of people over ten years of age had received no schooling and around 50% did not continue schooling after the age of 16. Although generally education levels are not high, literacy rates for the whole population were recorded at 85%.

3.4 Economy

The 2006 SUSENAS data reports an average annual income around 243 USD with over two thirds of the monthly household expenditure used for purchasing food. The latest National labour force survey, conducted in 2006, reported a total active labour force of 160,962 people and an unemployment rate of 5.5% in Kabupaten Kupang. Of those employed, 82% were working in the agricultural sector and provided almost half of the gross domestic product (GDP), contributing around USD 43 million to the economy. The next largest contributing sector is government services. Together agriculture and government provide two thirds of the GDP (Fig 3.14).

Whilst the primary industries sector is the largest employer and income producer, the incomes for individual workers are usually small. It is interesting to note the dominance of food crops and livestock in the primary industries sector contributing almost 80% of the GDP compared to only 1% from forestry. The government sector is also important to the local economy. Government, waged jobs are substantially supported with funds from the central government and are highly sought after for the employment security they provide and as a vital source of external revenue for the Kabupaten.
3.4.1 Agriculture

Providing a small income, farming in Kabupaten Kupang is largely a subsistence livelihood activity dominated by the traditional practice of shifting agriculture. Shifting agriculture relies on a rotation system allowing soil fertility to naturally rebuild after a number of years (5-15) of being left fallow. Fox (1977) describes this system of agriculture as precarious and unreliable, increasingly under pressure, and particularly vulnerable in Timor due to the short and unreliable nature of the wet season and the poor fertility and water holding capacity of the soils. This, Fox believes, has been exacerbated by the introduction of cattle by the Dutch in the early part of the 20th century, resulting in increased erosion of fragile Timorese soils. Most of the subsistence farmers of West Timor experience a “hungry period” towards the end of the dry season as stored crops from the previous harvest are exhausted. When this occurs it is common for some communities to supplement their diet with forest products such as native yams, particularly where government relief is not available.

The major staple crops are maize, cassava, and sweet potato. Maize is planted shortly after the rains begin usually in December and harvested in March. The
majority of the maize is dried and stored to last through to the next harvest. Cassava is drought tolerant and, although not particularly nutritious, an important staple, with both the leaves and roots eaten.

Over the last few decades there has been a movement away from traditional/local food crops towards rice as a staple food, in urban populations particularly. This cultural shift was promoted by Indonesian government programs supporting a western Indonesian cultural belief that cultivating and eating rice was a sign of advancement. As part of this effort a major irrigated rice region was developed in Kecamatan Kupang Tengah supported by the Japanese government through the building of the large Tilong Dam in the nearby hills. This single development is responsible for around half the rice produced in Kabupaten Kupang. In addition to this about 6500 tonnes of dry-land rice are also produced each year.

Dry-land rice production is prone to failure when the rains are delayed or the wet season is relatively ‘dry’, and despite most of Kabupaten Kupang being unable to produce rice yet it has become favoured by many rural poor particularly as food for children. This has resulted in some local food crops being sold at markets to provide cash to purchase rice and has been reported as a factor in decreasing levels of food security in NTT (Muslimatun 2009). Recent research (Wiendiyati et al. 2010) suggests that maize is still preferred over rice by adult Timorese as it is more sustaining whilst doing physically demanding agricultural work. For many, eating maize with every meal is also seen as a symbol of their ethnic identity. Recognising these issues the NTT government has recently begun actively promoting the value of more traditional food staples. The main food crops grown in Kabupaten Kupang are cassava, rice and maize (fig 3.15).

A wide range of tree crops are grown in both house gardens and as medium sized plantations. The main cash crop species are shown in figure 3.16. Along with these a wide range of fruits trees, such as papaya, oranges, bananas and jackfruit are grown, mostly for domestic or local consumption.
Most cattle grazing is free ranging with some intensive feedlot style cattle farming, most notably in Amarasi district. Although a primary source of income for some, intensive cattle farming is restricted to just a few regions. More commonly farmers rely on raising small livestock such as goats, pigs and chickens for both domestic consumption or for sale.

Agriculture in Kabupaten Kupang directly supports most of the population and is the major contributor to the economy yet an increasing population, changing cultural practices and greater frequency of dry years (delayed, shorter and/or dryer wet seasons) has seen continuing food security issues and increasing incidence of malnutrition.

3.4.2 Forestry.

Around 45% of mainland Kabupaten Kupang is within Kawasan Hutan administrative zones. The percent of Kawasan Hutan within each administrative type for Kabupaten Kupang compared to the whole of Indonesia as is shown in figure 3.17 with the distribution and amount in Kabupaten Kupang shown in figure 3.18. There is a relatively small area committed to nature conservation in contrast to the relatively large area designated protection forest. The main nature conservation parks are at Champlong, protecting an important catchment and spring, Dataran Bena/Palau Menipo wildlife park, Tamanan Yohannas (Amarasi) and Baumata. Protection forests are primarily designated for upland catchment management purposes and the largest extent can be found around Mt Timau. It is also interesting
to note the very small area of forest designated for conversion (HK) to other land use, the only area being near Kota Kupang and presumably zoned for urban or industrial expansion.

![Figure 3.17 Percentage distribution of Kawasan Hutan Types in Indonesia and Kabupaten Kupang TW/SM = tourist or recreation park, HL=Protection Forest, HPT = Limited production forest, HP=Production forest, HK=Forest to be converted to other land use.](image)

The main forestry (timber extraction) activity occurs within Production and Limited Production forests zones, with teak being the primary plantation timber. In 2006, timber harvest included 959,000 cubic meters of teak from plantations and 118,000 cubic meters of mixed timber from natural forests. Small amounts of bamboo and palm (Lontar) timber harvest were also recorded. The recorded values for non-timber forest products are very small and probably underestimated due to the local nature of their harvest and consumption.

### 3.5 Culture

The culture of Kabupaten Kupang is constantly evolving and adapting to new influences and economic opportunities. Significant changes have occurred over the last century with increasing external cultural and political influences. Firstly through Dutch expansion into the mountains in the early 19th century, introducing Christianity and greater levels of state rule then, after independence, increased governance and control by the Javanese-dominated Indonesian national government.
The Atoni (also known as the Atoin Meto or the Dawan) are the main ethnic group in Kabupaten Kupang with smaller populations of people with Rotinese, Bugis and Chinese ethnicity. The Atoni language is known as Uab Meto and is part of the Timor-Flores group of Austronesian languages. The Atoni are also known as mountain people (orang gunung) due to their traditional shifting cultivation which was previously confined to the mountainous interior of Timor. Coastal areas were visited for hunting purposes but largely left for others such as the Bugis fishing people from Sulawesi or the coastal plain palm farmers from the nearby island of Roti. The expansion of the sandalwood industry and the introduction of maize by the Dutch saw a large increase in the Atoni population resulting in a more widespread dispersion of people from isolated mountain enclaves (Farram 2004).

More recently, government programs have actively sought to relocate communities from their traditional mountain villages to areas closer to roads with better access to...
government services. Translocated people will often walk great distances to continue agriculture at their old villages. So, although the Atoni commonly are not living in their traditional mountain villages, there often remains a strong connection to their traditional lands.

Atoni people are well known for their ‘bee hive’ houses, a circular thatched structure used for cooking, sleeping and the storage of maize (see Fig. 3.19). Maize is kept in the roof and constantly smoked by cooking fires thus reducing insect infestations. These houses can often be seen behind newer modern houses built with encouragement from the government in an attempt to ‘modernise’ the Atoni and reduce the amount of respiratory ailments coming from the poorly ventilated traditional houses.

Figure 3.19 A traditional Atoni ‘bee hive’ house constructed from local timber and grass thatching. Commonly used for storing maize and cooking.

The Timorese social system revolves around clans related to place and kinship relations. Political alliances are tied to clans and extended through bride-giving and bride-taking. The importance of ‘place’ in traditional Timorese culture is also expressed in its spiritual connection to the land. McWilliam (2001) has described the central role of the natural environment to traditional Timorese cosmology as such:

“If one were inclined to select a core symbol of Timorese indigenous religion, it would be the ritually potent image of rock and tree. This pairing is a leitmotif of Timorese ceremonial sacrifice and invocation to ancestors and the unseen powers of the deity and spirit. Across the island, the rock and tree form remains a highly charged symbolic cultural structure.” (p. 91)
The term le’u is used to express a set of values about ‘sacred’ forests areas. Although still in use the influence of le’u beliefs have decreased with the increase in state and Christian religious authority. Traditionally le’u forests are governed by a set of laws curtailing hunting, wood extraction and agriculture yet most le’u forests have been subsumed into one of the Indonesian forest administration categories defining a new set of laws governing the use of the forest. Although Indonesian land law has provision to respect traditional tenure and management, in reality the replacement of traditional law by state law in forest governance has resulted in a disenfranchisement of local people from their traditional rights.

The central role of forests in Timorese culture is not difficult to understand. In a generally harsh landscape, forests represented shelter, food and security, and the careful management of forest resources was important for survival. The centrality of this concept is also expressed in the traditional creation story related by Fox as follows:

“…the only woman on earth gave birth to a daughter whose umbilical cord was intertwined in the roots of a banyan tree. As she grew so did the banyan to become dry land. As “trunk”, she produced both sons (”fruit”:kluat) and daughters (“flowers”:funan) shaded by an ever growing banyan.” (2004, p. 13)

Although almost all Atoni would call themselves Protestant Christians, most still hold many traditional animist beliefs. Officially 85% of people identify as Protestant, 10% as catholic, around 2.5% as Muslim or Hindu and around 2.5% as not converted to one of the state sanctioned religions and maintain solely animist beliefs (BPS Kabupaten Kupang 2007).

3.6 History

Early history

The earliest evidence of human occupation of Timor dates back at least 40,000 years (O’Connor & Aplin 2007) but evidence of occupation on nearby Flores (Morwood, J et al. 2004; Morwood, M 1999) 800,000 BP suggests the date may be much earlier. The earliest evidence of agriculture is from about 5,000 years BP (Fox, JJ 2004), which is believed to mark the arrival of seafaring Austronesian peoples. It is assumed, as the Atoni language is part of the Austronesian languages common to
the majority of SE Asia, that the current Timorese inhabitants are part of this later wave of migration.

The earliest written descriptions of Timor Island are concerned with the sandalwood trade. The Chinese were aware of the quality of sandalwood coming from Timor in the 13th century. These early reports describe a power structure with kings and chiefs probably enhanced through wealth derived from sandalwood.

**Dutch period**

The Dutch arrival in West Timor occurred during a period of conflict with the Portuguese over control of the important Maluku ‘spice island’ trade routes. A fortress was established in Kupang in the mid-seventeenth century to both cement Dutch power in the region and to act as a post to facilitate the lucrative sandalwood trade. The wealth brought by sandalwood fuelled a complex history of warring factions and empire building to assert control over its trade. McWilliam (2005) argues that at this time “sandalwood politics” was the driving force behind constant power struggles between indigenous Timorese clans. It was also the source of ongoing conflict between the Dutch and local power holders such as the Portuguese allied Topasses, based in Flores, and the local rulers. The Dutch largely tried to stay out of these complex local power struggles and found the people from the neighbouring island of Roti better allies in establishing regional authority than the difficult Timorese (Farram 2004). This resulted in extensive Rotinese migration to Kabupaten Kupang especially along the coastal plains where they could practice their traditional lontar palm-based agriculture.

The Dutch did not attempt to exert significant direct influence on the interior of West Timor until the late nineteenth century under their ‘pacification program’. Dutch propaganda at the time promoted the altruistic notion that they were modernizing a backward people. However the real motivating force was more likely to have been increasing tax revenue and the consolidation of power in order to establish their colonial credentials at a time of European global expansion. The long-term effects were profound, with the introduction of Christianity and education (often linked), indentured labour and infrastructure. This process of pacification resulted in a series of insurgencies against the imposition of colonial rule.
Through this time the Dutch had only a small presence in West Timor. During World War Two, Timor was to become a strategically important link between Asia and Australia and, without adequate resources to defend the island, both the Dutch and the Portuguese sought Australian assistance. When the Japanese invasion of Indonesia finally reached West Timor in February 1942, much of the resistance was conducted by Australian troops in Kabupaten Kupang around Babau and Oesau on the road from Kupang to Camplong. The conspicuous absence of the Dutch in this fighting and their quick surrender of Kupang surprised the Timorese and dispelled any illusion of Dutch invincibility (Farram 2004).

**Independence**

The Dutch return to Indonesia after WWII was brief. A new, educated elite had developed under Dutch patronage and a new post war confidence led to the ousting of the Dutch. In 1950, West Timor became a part of the new independent Republic of Indonesia. Many of the political institutions and administrative structures developed during Dutch rule remained but were transformed for the task of developing a cohesive Indonesian national identify. This resulted in increased investment in infrastructure in West Timor developing schools, health centres and roads (Farram 2004). However the levels of investment in eastern Indonesia often lagged behind that of the wealthier western parts of Indonesia.

A period of stability and development followed until the overthrow of the Soeharto regime in 1998 which led to a range of important changes in West Timor. Perhaps the most significant political outcome of this time was the creation of a new nation on the island of Timor, ie Timor Leste.

**East Timor**

Under mounting international pressure the new president of Indonesia, B.J. Habbie, allowed for a referendum in East Timor on its continued integration with Indonesia. Under Soeharto, the Indonesian government had invested heavily in East Timor and saw potential for lucrative returns from the large offshore oil and gas reserves jointly owned by Australia and Indonesia. East Timorese independence was strongly opposed by most of the Indonesian elite, especially the military, as it represented a loss of face, a loss of investment and potential revenue, and importantly set precedence for the disintegration of the Indonesian state (Nixon 2004). With conflicts continuing in Aceh, West Papua and the Maluku islands there
was a fear in Indonesia of a domino effect with secessionist movements gaining strength through an example set by East Timor. The resulting vote for East Timorese independence unleashed a wave of violence organized by the Indonesian military resulting in the influx of over a quarter of a million refugees into West Timor. Some of these refugees were able to return to East Timor after the initial violence subsided but many stayed. West Timorese communities provided land for cultivation and permanent camps were set-up throughout NTT. The refugees also included some pro-integration militia groups who continued to incite unrest in West Timor including the murder of three United Nations aid workers killed in Atambua in September 2000. These murders resulted in the UN and all other foreign aid organizations leaving West Timor and international flights from Kupang to Australia (Darwin) being cut. A period of international isolation for West Timor followed with a significant slowdown in economic development.

Whilst East Timor was receiving billions of dollars in international aid and was expected to receive large royalties from the oil and gas field developments West Timorese felt neglected. This has sparked calls by some in West Timor for a claim to some of the oil and gas revenue and even for the creation of a new pan island Timorese nation. Inspired by the pre-colonial Timorese state of Wehali that encompassed much of both east and West Timor the short lived ‘Negara Timor Raya’ movement sought the re-unification of Timor (Nixon 2004). Secessionist movements in Aceh and West Papua also gained inspiration from East Timorese independence which needed to be curtailed by the central government in order prevent the fragmentation of the Indonesian nation. The most direct way to quell regional disquiet was to increase regional autonomy through a process of decentralisation.

**Decentralisation**

The devolution of the majority of local administrative and decision making power to the Kabupaten level during the presidency of Abdulrahman Wahid, was the aim of Law 22/1999 regarding regional administration and law 25/1999 regarding financial balance between central government and regional administrations both launched in 2001. The major problems with regard to the successful implementation of the decentralisation program have been identified as confusion over conflicting policy and laws, inexperienced and corrupt local officials resulting in poor governance, and over optimistic expectations about increased opportunities for local
people (Nixon 2004). Some of the issues specifically related to forest governance have been raised in the previous chapter. The decentralisation process is still evolving and the high levels of expectation are now matched by high levels of cynicism about district level election processes and the newly elected leaders. District elections are highly contested with traditional family and kin connections being an important factor in securing votes. More recently, West Timor has seen the election of some more progressive and well educated leaders bringing hope for more transparent and proactive governance.

3.7 Conclusion

The rugged diverse landscape of Kabupaten Kupang has some important stands of natural forest. It’s relatively infertile soils and short wet season leave the largely subsistence rural population relying on services from functional ecosystems to support their livelihoods. However much of the land has been degraded through extensive human use and an increasing population is likely to put further pressure on the region’s natural resources. Recent political changes provide challenges and opportunities for improving land management into the future.
Chapter 4 Methods

4.1 Introduction

This study used quantitative satellite image and spatial analysis methods to characterise current forest cover and identify potential case study sites where forest cover had changed. Case studies were used to focus more detailed investigation into the social forces around forest use. Theories where developed about forces involved in forest cover change through the triangulation of data from three sources: (1) spatial data, which provided local geographic context, (2) literature, providing a broader national context, and (3) semi-structured interviews to provide local perspectives and context. Qualitative analysis of the interviews, using thematic coding, was undertaken and linked to the literature and spatial analysis. This approach, as shown in figure 4.1, could be viewed as remote sensing research applying social science research tools.

Mixing quantitative spatial and qualitative social methods in this way is not common in either the spatial or social sciences. Most texts on mixed methods in social science research describe the use of multiple social science approaches, including the mixing of quantitative and qualitative techniques (Tashakkori & Teddlie 2002). The need for greater social science input into remote sensing studies has been argued in recent books (Fox, J et al. 2003; Liverman 1998). However the studies presented have largely focused on quantitative spatial analysis and mathematical modelling of socio-economic variables to understand causes and to predict future trends. Chapter 2 outlined criticisms of research focusing on spatial correlations to infer the impact of human management uninformed by social and historical context. Social scientists would argue that the only way to develop useful theory is to engage directly with people in the landscapes being studied.

Two recent research projects that have effectively combined social and remote sensing/spatial sciences for in-depth case study analysis include the work of Dennis etal (2005) who used interviews and a range of rural appraisal exercises linked with satellite data to develop theories about the relationship between land users and fire in Western Indonesia. Fox and Vogler (2005) also used interviews and satellite imagery to establish the socio-economic links between land-use and land-cover change in montane South East Asia. These studies are important
examples of the type of mixed methods research that is possible. Unlike this project, however, these studies involved large multi-disciplinary teams conducting field work over a period of years.

This study used simple but robust satellite image processing methods to broadly classify forest cover and highlight areas of significant forest cover change. Spatial data analysis techniques were used to characterise the forest cover and forest cover change within a range of biogeographic and administrative areas. The following sections describe these spatial analysis methods in more detail.

**4.2. Image processing**

All the image processing was conducted using ER-Mapper 6.2 software. The image
The Landsat satellite series was the primary source of data for this study. Landsat imagery was chosen due primarily to its long temporal extent with imagery dating...
from 1972 to the present. Landsat also has a high temporal resolution (acquisition), a comprehensive and readily available archive and a low price per unit area. These attributes make Landsat the platform of choice for many land-cover change studies (Trigg, Curran & McDonald 2006).

Table 4.1 The satellite imagery acquired for the study.

<table>
<thead>
<tr>
<th>Image Date</th>
<th>Satellite</th>
<th>Bands</th>
<th>% coverage of Kabupaten. Kupang</th>
<th>Acquired from</th>
</tr>
</thead>
<tbody>
<tr>
<td>06/10/72</td>
<td>Landsat 1</td>
<td>MSS 1,2,3,4</td>
<td>88.5</td>
<td>USGS</td>
</tr>
<tr>
<td>31/8/82</td>
<td>Landsat 4</td>
<td>MSS 1,2,3,4</td>
<td>88.5</td>
<td>ACRES</td>
</tr>
<tr>
<td>11/09/89</td>
<td>Landsat 5</td>
<td>TM 1-5,7</td>
<td>95.2</td>
<td>TRFIC</td>
</tr>
<tr>
<td>24/08/94</td>
<td>Landsat 5</td>
<td>TM 1-5,7</td>
<td>97.9</td>
<td>ACRES</td>
</tr>
<tr>
<td>17/09/00</td>
<td>Landsat 5</td>
<td>TM 1-5,7</td>
<td>97.8</td>
<td>TRFIC</td>
</tr>
<tr>
<td>10/10/06</td>
<td>Landsat 5</td>
<td>TM 1-5,7</td>
<td>98.8%</td>
<td>ACRES</td>
</tr>
<tr>
<td>05/07/08</td>
<td>ALOS</td>
<td>ANVIR</td>
<td>65.6%</td>
<td>ACRES</td>
</tr>
<tr>
<td></td>
<td></td>
<td>PRISM</td>
<td>46.4%</td>
<td></td>
</tr>
</tbody>
</table>

An acquisition date for all the imagery around September was chosen so as to minimise transient seasonal effects on the landscape such as; obscuring cloud cover in wet season imagery, residual wet season greening in early dry season imagery and excessive fire affected areas in late dry season imagery. The majority of this imagery was purchased through the Australian Centre for Remote Sensing (ACRES). The 1994, 1982 and 1972 imagery was already held by Charles Darwin University as partial subsets of the original imagery. The 1994 image was repurchased for this study to cover more of mainland Kabupaten Kupang with all spectral bands. The imagery from 1989 and 2000 was obtained through the Tropical Rain Forest Information Center (TRFIC 2009). Image coverage is shown in figure 4.3.

TRFIC is a NASA Earth Science Information Partner, a consortium of organizations that collect, process and distribute Earth Resource Satellite data. The TRFIC data was obtained as
ortho-rectified imagery. Ortho-rectification uses elevation data to produce the most accurate geographic correction of satellite imagery.

![Satellite Image Coverage](image)

Figure 4.3 Coverage of the satellite imagery used in this study.

High resolution imagery was also acquired to provide a better understanding of the land-cover and as a ground truth layer for assessing the accuracy of classified Landsat imagery. Imagery from the Japanese Advanced Land Observing Satellite (ALOS) was used because it was one of the cheapest sources of high resolution data, and cloud free imagery for Kabupaten Kupang had already been captured and was held in the ALOS archive. The ALOS satellite carries three main sensors, data captured in July 2008 from the following two sensors was purchased for this study:

PRISM (Panchromatic Remote-sensing Instrument for Stereo Mapping) has a 35 x 35 kilometer scene extent, a 2.5 meter pixel resolution, and captures data for one wavelength of light (visible green).

AVNIR-2 (Advanced Visible and Near Infrared Radiometer type 2) has a 70 x 70 kilometer scene extent, a 10 metre pixel resolution, and captures data for 4 bands wavelength of light.
4.2.2 Image pre-processing

Rectification and Registration

Rectification is the process whereby satellite imagery is geographically corrected to fit a defined co-ordinate projection. Registration is the process of rectifying an image by fitting it to a pre-rectified data set. In this case the satellite data were rectified to a Universal Transverse Mercator (UTM) coordinate system by registering it to a mosaic combination of the following pre-rectified data sets:

- Ortho-rectified 2000 Landsat imagery from TRFIC
- High resolution ALOS PRISM data.

The rectification accuracy of these data sets was assessed against a mosaic of seven scanned 1:25000 map sheets covering one-third of the southern portion of Kabupaten Kupang.

Radiometric Correction

Radiometric correction is a technique to reduce the differences between two image dates resulting from variation in the acquisition conditions (e.g. sensor performance, solar radiance, atmospheric effects) rather than changes in surface reflectance. Radiometric correction of multi-temporal satellite data sets increases the accuracy of land-cover change analysis.

A common method of radiometric correction is ‘relative radiometric normalization’. This approach uses one image as a reference to which the radiometric properties of all other imagery are adjusted to match. Many different relative radiometric normalization techniques have been developed (Yuan & Elvidge 1996). This study uses a bright/dark invariant target technique as described by Hall et al (1991). Invariant targets are features that should not change over time such as deep water or bare rock. By comparing the average spectral response between image dates from multiple invariant bright and dark sample features it is possible to produce a regression algorithm for relative radiometric normalisation.

For this study the September 2006 Landsat was used as the reference with all other imagery being adjusted to its radiometric properties. Multiple dark (deep ocean) and bright (bare rock, sand and cloud) sample targets were selected for each image date. The mean averages for each band and sample target were imported into Excel. A linear regression analysis was conducted in Excel to determine the intercept (i)
and slope (s) values for each band of each subject image. A new, corrected dataset was created in ER-Mapper for each image date by applying the slope and intercept values to each pixel for each band as follows:

New digital value = (Digital value *s)+i

The radiometrically normalized image was then clipped to the mainland area of Kubupaten Kupang removing the ocean and the administrative region of Kabupaten Kota Kupang, areas not included in this study.

*ALOS imagery pre-processing*

The 2.5 meter panchromatic resolution ALOS PRISM data imagery was combined with the multiband 10 meter resolution ALOS AVNIR imagery to produce a composite three band 2.5 meter resolution image. This high resolution colour composite image provided a base for guiding classification and as reference data for accuracy assessment.

**4.2.3 Image classification**

*Current Forest Cover*

The first step in classifying forest cover using the September 2009 image was to develop an understanding of the landscape as represented in the Landsat image. Each land-cover type has a spectral signature representing its reflectance properties over multiple wavelengths of light. Personal observation in the field, high resolution ALOS and Google earth imagery was used to interpret the spectral response of different land-cover types. It was clear from this visual assessment that the near infrared band (4) was the least effective for differentiating between vigorously growing scrub and forest land-covers. Band combinations 2,3,5 (Green, Red, MIR) and 1,2,3 (Blue, Green, Red) appeared be the most effective for distinguishing the canopy cover of established forests from other land-cover types.

Forest cover mapping was conducted using a supervised classification method whereby regions of known land-cover types are selected as ‘training sites’ to inform the subsequent classification (a more detailed description of the supervised classification is provided in Appendix I). Training sites were selected based on field experience, high resolution ALOS and Google Earth imagery and previous mapping conducted by the provincial department of conservation (BAPEDALDA 2007).
Multiple training sites for each of the following land-cover types were selected: closed forest, open forest, scrub, savanna and bare ground. The criteria for selecting these land-cover types, as shown in table 4.2, were adapted from the Australian Government and the FAO definitions of forest cover (DAFF 2007), as detailed in chapter two. The Australian forest canopy cover thresholds were used as the FAO definition was considered too broad and would pose difficulties in spectrally classifying forests at the lower end of its 10% canopy cover thresholds. The FAO definition of canopy height was used as the two meter lower threshold in the Australian definition was considered too short for the forests of Timor.

Table 4.2. Land-cover type attribution used for the selection of classification training sites.

<table>
<thead>
<tr>
<th>Land-cover type</th>
<th>Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Closed Forest</td>
<td>Evergreen forest with greater than 50% canopy cover &gt; 5m</td>
</tr>
<tr>
<td>Open forest</td>
<td>Evergreen forest with greater than 20% canopy cover &gt; 5m</td>
</tr>
<tr>
<td>Scrub</td>
<td>Greater than 20% canopy cover &lt; 5m</td>
</tr>
<tr>
<td>Savanna</td>
<td>Less than 20% canopy cover</td>
</tr>
<tr>
<td>Bare ground</td>
<td>No vegetation</td>
</tr>
</tbody>
</table>

Supervised classifications were conducted on both the 2,3,5 and 1,2,3 band combinations. A visual accuracy assessment of the resulting classification was made using the ALOS imagery as the reference data. Based on this assessment the training site selections were adjusted to improve the classification accuracy. Several iterations of classification with training site adjustment were conducted until results were considered acceptable for a systematic accuracy assessment.

Forest Cover Change
The goal of the forest cover change classification was to map areas of large and verifiable change to guide case study site selection. A complete analysis of all change in Kabupaten Kupang was not conducted as it was considered that it would be prone to unavoidable and unquantifiable errors due to the complex nature of the rugged seasonally dry tropical environment and problems associated with
conducting retrospective accuracy assessment. Radiometric correction removes some reflectance anomalies however in such a complex and modified landscape significant differences between image dates due to sun angle, effects of seasonal greening and fires remain. Furthermore whilst all image dates were rectified to the same ortho-rectified map base it is impossible to remove all registration errors. The resulting mis-alignment from even small registration errors can lead to the false classification of forest edges as increasing or decreasing. This can cause significant errors in change classification in highly fragmented landscapes such as those of Kabupaten Kupang. Quantifying these potential errors through a retrospective accuracy assessment requires good quality reference data at points in time corresponding to the satellite image dates. Aerial photography is the most common source for historic reference data when assessing change (Congalton & Green 1999) but obtaining these data is commonly problematic (Baban & Luke 2000). It was decided, due to the difficulty in obtaining historic aerial photography for West Timor, an accuracy assessment would not be conducted on this component of the mapping. It would, therefore, not be possible to make any supported statements about overall change. By focusing on specific case study sites of large scale change it was possible to avoid environmental or technical mapping errors and conduct an analysis of the social-historic context of the change through on-ground interviews.

A wide variety of land-cover change assessment methods have been developed (Xiuwan & Xiuwan 2002). For this study, image differencing and on screen manual digitizing was used. Using simple, relative change delineation between dates and post classification manual editing allowed the application of manual pattern detection and contextual analysis along with on-ground knowledge to guide the final classification. These techniques are robust and provide the greatest operator control over the classification output.

In order to highlight areas of change between dates, difference imagery was produced by subtracting consecutive pre-processed Landsat image dates and adding a correction value as such:

\[
\text{Difference image} = (\text{Image date 1}) - (\text{Image Date 2}) + 127 
\]

or

\[
2006 \text{ to } 2000 \text{ difference image} = (2006)-(2000)+127
\]
Five difference images were produced to show change between dates, in the image time series, i.e. 1972-1984, 1984-1999, 1989-1994, 1994-2000, 2000-2006. For each difference image classification, training sites of significant land-cover change were selected using the base satellite image pairs as a guide. Areas of change due to seasonal or other short term variation, as assessed with reference to the satellite image pairs, were selected as ‘no change’ training sites. A supervised classification was run classifying each image into three classes: increased cover, decreased cover and no change.

4.3. GIS analysis

4.3.1 GIS data collection

Ancillary Data
A variety of biogeographic and administrative data were obtained to assist in the analysis of the forest cover and forest cover change. The following data were provided by the provincial department of conservation (BAPEDALDA) and Kabupaten Kupang department of forestry (Dinas Kehutanan):

- Contour data for Kabupaten Kupang
- Hydrology, creeks, streams, rivers and lakes
- Transport infrastructure: roads and tracks
- Vegetation mapping 1:1000000 scale (BAPEDALDA 2007)
- Administrative boundaries for sub-district (Kecamatan) and village (Desa)
- Kawasan Hutan, national forest administrative zones. These data were the most recent available at the time of the study but some of the zoning has changed with subsequent reassessments. These data were of low resolution and did not include some of the smaller Kawasan Hutan zones.

The contour, sub-district and village administration, transport and hydrology data were derived from 1:25000 mapping conducted in the mid-nineties.

Field Data
Field data were collected as points attributed with land-cover information to provide an understanding of the landscape and as point specific information to
assess the classification accuracy. The ground survey was conducted over a three
day period in the late dry season (November) to ensure maximum accessibility
around the Kabupaten. Data were collected using a PDA mobile device with a
Bluetooth connection to a GPS data logger. A simple data entry form was set up on
the PDA using ‘Cybertracker’ field data collection software. A rapid visual
assessment of land-cover characteristics was made from a car and recorded directly
into the PDA along with a coordinate location approximately every three minutes.
The following land-cover characteristics were recorded:

- Percent canopy cover
- Land-cover type
- Dominant tree species
- Direction of observation from vehicle

Using this technique land-cover information was systematically collected over a
large (Fig 4.4) area in a relatively short period of time.

4.3.2 Accuracy assessment

In order to quantify the degree of confidence in the forest cover classifications an
accuracy assessment was conducted. The accuracy assessment method used here
follows techniques described by Congalton and Green (1999). To conduct an
accuracy assessment, ‘ground truth’ or reference data are collected for subsequent
comparison with the classified data set.

It was initially planned that the field data would act as the sole source of reference
data. However it became apparent, during collection, that these data may not be
providing a broad representative indication of vegetation cover comparable with a
classified Landsat pixel due to the high occurrence of substantially altered land
cover, from homes and gardens, on roadside verges. Therefore accuracy assessment
comparing roadside attributed field data with classified Landsat pixels, that
represent the aggregate cover over a 900 sq meter area (90x90 m), was considered
problematic. Furthermore the poor quality of road infrastructure in this relatively
remote part of Indonesia made motorised access to large parts of the study area
impossible, thus reducing the field data coverage. In other regions where road
access is limited, such as northern Australia, aerial surveys are often employed to
obtain transects of ground truth data. This was not possible in West Timor.
Figure 4.4 The distribution, with the forest type attribution, of the 413 ground data points across Kabupaten Kupang.

Due to these issues it was considered necessary to augment the field data with an alternative source of reference data. High resolution imagery from the Japanese ALOS satellite was chosen for this purpose and a two stage accuracy assessment was undertaken. Firstly the two final land-cover classifications (123, 245) were subjected to accuracy assessment using ALOS imagery followed by a further verification assessment of the most accurate classification using the field data.

The accuracy assessment process, as shown in figure 4.5, involved first importing the classified satellite data into ARC-View from ER-Mapper for reclassification into three primary land-cover classes; forest, scrub and open. A 20km x 25km polygon was then created which bounded a representative sample of land-cover classes and topography on the classified dataset and lay within the coverage of the ALOS colour
composite imagery. Within this polygon 115 random sample for points were generated. A 90 x 90 meter polygon (3x3 pixels on the classified image) centred on each random point was then created. Each sample point was then attributed with the dominant classified land-cover within this polygon. This data aggregation technique was used in order to avoid errors due to the following: scale difference between the classified and reference imagery, mis-registration (even sub-pixel misalignment between imagery can place the sample point in locations tens of metres apart), where the sample point is a ‘mixel’ (an aggregation of multiple land-cover types) in the classified image and unrepresentative of the general land-cover. The land-cover type for each sample polygon was attributed using the reference (ALOS) imagery and then the classified imagery. These data were entered into an Excel spread sheet and the level of concurrence tabulated. An error matrix was produced showing the errors of omission and commission for each land-cover class.

The classification with the highest accuracy was then re-assessed using the field data. The field data points were attributed from the classified data using the 90x90 meter polygon data aggregation technique. The field data land-cover attributions were simplified to the same three primary classes used in the classified data. Once again these data were analysed in Excel to produce an error matrix showing three measures of accuracy:

- **Producers accuracy** indicates the error of omission. This measure is the probability of a point on the ALOS reference imagery being attributed the same cover type as on the classification.

- **Users accuracy** indicates the error of commission. This is the probability that a classified pixel corresponds to reference data and so actually represents that category on the ground,

- **Overall accuracy** is calculated by dividing the total correct (i.e. the sum of the major diagonal) by the total number of samples.

4.3.3 Current forest cover characterisation

In order to further characterise the forest mapping, spatial analyses were conducted using biogeographic and administrative spatial data as shown in figure 4.6.
Figure 4.5 Forest cover classification accuracy assessment process flowchart.

**Forest cover by type**

A detailed vegetation survey of West Timor, conducted by the NTT government and the local state university (Universitas Nusa Cendana) was used to divide the forest cover classification into forest types (BAPEDALDA 2007). This survey included detailed site data linked to small scale mapping showing vegetation distribution. This mapping was converted to a raster grid format and the forest classes assigned a unique value. The forest cover classification was then added to the vegetation type raster to produce a new raster grid of forest type distribution. There are considerable scale differences between the vegetation type mapping (~1:200000) and the satellite data (~1:50000); however this distribution analysis is only intended as a general indication of forest composition.
Initially the contour data were processed to create a raster Digital Elevation Model (DEM) using ARC-GIS spatial tools. The large scale of the contour data (1:25000) allowed for the DEM to be produced at a high resolution (20 meter pixel). A raster slope model was then created from this DEM. These topo-models were then categorized into elevation and slope classes as shown in Table 4.3. Elevation classes are often defined relative to the landscape which they are being used to describe. In this case elevation was divided into five classes based on field knowledge of the landscape using common descriptive labels. Slope classes where derived from the Australian Soils and Land Survey, Field Handbook (McDonald et al. 1990). These classified raster topo-models were then intersected with the vegetation type classification to produce grids of forest cover by elevation and forest cover by slope. The count values from these grids were exported into Excel for further analysis.

Table 4.3 Topographic classes derived from the digital elevation model.

<table>
<thead>
<tr>
<th>Height</th>
<th>Label</th>
<th>Grid Value</th>
<th>Slope</th>
<th>Label</th>
<th>Grid Value</th>
</tr>
</thead>
</table>
### Administrative Analysis

Vector data for the subdistrict (Kecamatan) and forest administrative areas were converted to raster grids with unique value identifiers for each Kecamatan or forest administration type. They were then combined with the forest type grid to produce forest cover distribution by administrative boundary.

#### 4.3.4 Forest cover change refinement

The process of refining the assessment of forest cover change (FCC), as shown in figure 4.7, involved first cleaning the image by removing small polygons then manually editing the remaining polygons with reference to the base data.

The land-cover change classifications were first imported into ARC-GIS and converted into vector polygon files. The size of each vector polygon was then calculated and all polygons below 4000 sq meters were deleted. This removed the majority of misclassification due to edge effects and mis-registration. The remaining change polygons were manually edited with reference to the base satellite image pairs from which they were derived. All areas where increased or decreased forest cover could not be clearly ascertained by visual reference to the satellite imagery were deleted.

<table>
<thead>
<tr>
<th>0-100m</th>
<th>Coastal Plains</th>
<th>100</th>
<th>0-1.5%</th>
<th>Flat/v-gentle incline</th>
<th>100</th>
</tr>
</thead>
<tbody>
<tr>
<td>100-250m</td>
<td>Foot Slopes</td>
<td>200</td>
<td>1.5-5.5%</td>
<td>Gentle incline</td>
<td>200</td>
</tr>
<tr>
<td>250-550</td>
<td>Upper Slopes</td>
<td>300</td>
<td>5.5-18</td>
<td>Moderate Incline</td>
<td>300</td>
</tr>
<tr>
<td>550-750</td>
<td>Up lands</td>
<td>400</td>
<td>18-30</td>
<td>Steep</td>
<td>400</td>
</tr>
<tr>
<td>750+</td>
<td>Sub-Montane</td>
<td>500</td>
<td>30+</td>
<td>Very steep</td>
<td>500</td>
</tr>
</tbody>
</table>
4.4 Case study selection

A case study approach was used for this research as it allowed for an in-depth study using multiple methods of data collection and interrogation (Stark & Torrance 2005). Furthermore case studies allow for the exploration of complexity, explore processes as well as outcomes, and describe the context and setting of a situation (O'Leearly 2004).

A critical issue for conducting case studies is case selection. In case study theory, depth is generally favoured over coverage as the focus on a single case allows deeper analysis than is possible for multiple cases. However multiple cases allow for comparison between different situations. For this project multiple case studies were used to capture variation between communities in their relationship to forests and perceptions of the forces driving forest cover change. Although case study analysis has been criticised for the limitations for generalisation beyond the case study data, it has also been argued (Flyvbjerg 2006) that the strategic selection of multiple case studies can increase the capacity to generalize. For example Flyvbjerg believed that “Atypical or extreme cases often reveal more information because they activate more actors and more basic mechanisms in the situation studied” (p. 229).

There are two main strategies for case selection; random and information oriented. The present study used an information oriented approach. Spatial data, developed through the research process, was used to choose extreme cases of FCC from a variety of biogeographic and socio-economic conditions. These selection criteria could be considered (Flyvbjerg 2006) to be following the ‘extreme case’ and ‘maximum variation’ models of information oriented selection.

The combined forest cover change mapping from all image dates was used to identify forest cover change hot-spots. With the aid of biogeographic spatial data (elevation, slope, forest type, rainfall) to assure biogeographic variation, five regions that showed high levels of forest cover change were then chosen for further investigation. Field experience, literature and local expert advice were used to determine socio-economic variation and likely causes of FCC between sites. These data were used to guide the final selection of case study sites. Further spatial
analysis was then conducted in a 2500 ha circle encompassing the case study areas to quantify the biogeographic and FCC histories for each site.

4.5. Interview method

Interviews were used as an effective means of gathering social data in the field. The following is a description of the interview process.

4.5.1 Interview as an ethnographic research tool

Conducting interviews to obtain information about the experiences of a person or a community is an ethnographic research tool. Ethnography is research engaged directly with the people that are being studied. This makes the researcher an active ‘instrument’ (Golbart & Hustler 2005) that carries its own cultural background into any observation. It is therefore important for the ethnographic researcher to be aware of the complexity of their relationship with the people they are studying in order to design a method that both produces useful results and is ethical. In conducting interviews it is necessary to be conscious of class, gender, ethnic, generational, national, local and other identities of both the interviewer and the interviewee. It is also important to be aware of the complex social dynamics involved when forming the interview questions. Furthermore ethnography is not about finding the absolute ‘truth’ but to understand ways in which people make sense of the events around them to reveal how their lives are involved in larger social, cultural, economic and political processes (Cook & Crang 1995). The interview structure and approach for this study was developed with attention to these issues and addressed the following questions: who will be interviewed, who will conduct the interviews, what questions will be asked and how will they be asked.

4.5.2 Interview structure

In order to gather both regional and local perspectives from the interview process it was decided to interview both people not living at the case study sites (local) and people concerned with but not living at the case study sites (non-local).

The subjects for the non-local interviews were experts in Timorese forest ecology and history from academia and government residing in Kupang. It was decided that
it would be more appropriate for the author to interview these people than local participants as there would be less status imbalance due to professional and racial background (more familiarity with foreign researchers), less need for cultural socialisation of the project as these participants would already be aware of this research and there would be few language difficulties as they would be fluent in Bahasa Indonesia. Three interviews were conducted in Kupang with two academics from the local university and one local forest department officer. The interviewees were chosen through associations with the Kabupaten Kupang Forestry department and at the local state university, Universitas Nusa Cendana (UNDANA) developed during the first year of research.

The subjects for the local interviews were village leaders at each of the case study sites. This included, but was not exclusive to, the local government leader (Kepala Desa) and the local cultural head (Kepala Adat). It was more appropriate for a local team to conduct these interviews as it was necessary to possess a good understanding of subtleties of local cultural etiquette. It was also not expected that all participants would be fluent in Bahasa Indonesia or even if they were that it was the most culturally appropriate language to use. It was thus considered important that a Dawan (Atoni) speaker be part of the interview team. A consultant team was drawn from UNDANA, led by an experienced research ecologist. This team included an officer from the provincial department of conservation (BAPEDALDA) and a local Atoni post graduate student. The team was initially trained in the purpose and practice of the interviews. I was present at several of the first field interviews to observe the process and to ensure that ethical procedures were followed.

Two to three individuals were interviewed at each case study site. A protocol was followed of first visiting the Kepala Desa for each case study site to introduce the research followed by a request for interviews. Usually the Kepala Desa directed the team to other potential participants after being interviewed. This approach assured that the least friction was caused by the team’s presence and the interview process. This was important as there was the potential for difficulties and tension when discussing controversial forest resource issues related to tenure and resource rights. Although this approach assured a smooth process it seriously reduced the diversity of perspectives obtained as no women and no very poor people were interviewed. To get a more representative sample of local perspectives would have required a
larger project and a much longer socialization period. These interviews were conducted over a six month period as separate field trips of 1-2 days for each case study site. In this respect breadth was chosen over depth in the case study method.

Conventional interview theory suggests that fully structured, tightly controlled interviews are most appropriate for testing theories whilst lightly structured more open interviews are most appropriate for building theories (Wengraf 2001). The purpose of this component of the research was to both test the theory that complex and multiple forces are effecting forest cover but also to develop theories about common themes in these forces. To fulfil these two objectives, a semi-structured interview approach was taken, addressing the main research questions but allowing for open ended responses.

Interview questions (IQ) were derived to serve the central research questions (RQ) as follows:

1. -(RQ) Are the forests of West Timor important from a global and local perspective?
   1.1. (IQ) What are rural people’s relationships to forests in Kabupaten Kupang?

2. -(RQ) What is the current status of forests in Kabupaten Kupang? Are they changing? What are the forces behind forest cover change in West Timor?
   2.1 (IQ) What are people’s perceptions of how and why the forests had changed and the effects of perceived change?
   2.2 (IQ) What management strategies could improve forest governance in Kabupaten Kupang?

These guiding interview questions were further developed in consultation with the UNDANA research team. A full list of interview question can be found in appendix II. All the interviews were digitally recorded for later transcription by the UNDANA team. Where necessary, responses in Bahasa Atoni were translated into Bahasa Indonesia. The researcher translated half the interviews, two from each case study site and two of the three non-local interviews, from Indonesian into English with the remainder translated by a professional consultant translator.
The ethical procedures followed during the course of the interview process involved adhering to protocols that ensured that informed consent was obtained and the confidentiality of the participants was maintained. During the interview and transcription process the participants were not directly identified. The interview data were grouped and reported in general terms only. A clear and thorough description of the nature of the research and the probable outputs was provided verbally to the participants and verbal consent was obtained. It was considered culturally inappropriate to provide written material about the project and expect signed consent in locations where literacy rates are low. These protocols and procedures were approved by Charles Darwin University’s Human Research Ethics committee.

4.6. Data Analysis

4.6.1 Thematic analysis of the interviews

Systematic qualitative analysis of the interviews was achieved through the thematic codification of the interviews based on concepts relevant to the research questions. This was achieved as a two stage process: familiarisation through the initial translation of the interview into English followed by more detailed examination of the text to find concepts relevant to specific research questions. During translation digital comments were made, noting key concepts, links between concepts and any translation confusion related to local dialect and language use that needed clarification.

A broad range of techniques and tools are available to facilitate qualitative data analysis ranging from pen and paper annotation to complex text analysis software developed to sort masses of data searching for relationships and interconnection (O’Leeary 2004). As the volume of interview data produced by this study was not large, codification was conducted manually on screen. This was achieved by using a different colour digital highlighting pen for each of the main research questions. Throughout this process, key explanatory phrases or quotes were noted for future reference.

For each case study location, the resulting highlighted concepts were pasted into a new document grouped by research question. Concepts were then further sorted into similar themes based on the relationship of the interviewee to forests and their
perception of forest cover change. Through this process key themes from each case study location were identified.

4.6.2 Data triangulation.
The principle of triangulation in social research theory is that researchers should use at least three sources of data in developing any complex theoretical concept (Wengraf 2001). By comparing and contrasting a range of data sources, more complex and robust models can be developed and interpretations from any one data source can be cross checked. As noted by Greene, et al (2005)

“The early roots of mixed method social enquiry are found partly in the construct of triangulation which involves the use of multiple methods - each representing a different perspective or lens – to assess given phenomenon in order to enhance the confidence in the validity of the finding.” (p. 274)

This approach is particularly important in small scale studies, such as this one, using thematically analysed data sets where tests of statistical significance are not possible (O’Leeary 2004). Consequently this study does not seek authoritative ‘truths’ about forest cover change rather common and divergent themes around forest cover change and their implications on management are explored as derived from the three data sources: satellite derived and ancillary spatial data, literature, and field interviews.
Chapter 5 Spatial Analysis Results

This chapter presents the results from the spatial analysis of Kabupaten Kupang forest cover and the case study sites, the case study interviews and an analysis combining the spatial and interview results.

5.1 Spatial analysis results

5.1.1 Accuracy assessment

An accuracy assessment of the forest cover classifications was undertaken to determine the best results to use for subsequent forest cover characterisation analysis. The initial accuracy assessment was conducted, with reference to the ALOS imagery, on the two final forest cover classifications, bands 1,2,3 and bands 2,3,5, using the three final land-cover classes; forest, scrub and open. The results are presented as error matrices (Table 5.1, 5.2) showing the three measures of accuracy:

1) The producers accuracy for the 1,2,3 classification was very good (94%) for forest cover but very poor for the scrub and open cover types suggesting some classification confusion between these classes. Conversely the producers accuracy for the 2,3,5 classification showed reasonable accuracy for the open class.

2) The users accuracy for the 1,2,3 classification was below 50% for the scrub class meaning that more often than not scrub had been erroneously mapped as forest or open. The users accuracy for the 2,3,5 classification was generally much better for the scrub class.

3) The overall accuracy of the 2,3,5 classification was 70% compared to 65% for the 1,2,3 classification although neither result was considered to be sufficiently accurate for reliable analysis.
Table 5.1. Error matrix for the classification with bands 123 using ALOS imagery as the reference data. The overall accuracy is highlighted in blue.

<table>
<thead>
<tr>
<th>Classified Data</th>
<th>Reference Data</th>
<th>Net Users</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forest</td>
<td>15</td>
<td>4</td>
</tr>
<tr>
<td>Scrub</td>
<td>0</td>
<td>14</td>
</tr>
<tr>
<td>Open</td>
<td>1</td>
<td>8</td>
</tr>
<tr>
<td>total</td>
<td>16</td>
<td>26</td>
</tr>
<tr>
<td>Producers</td>
<td>0.93</td>
<td>0.53</td>
</tr>
</tbody>
</table>

Table 5.2. Error matrix for the Classification with bands 2,3,5 using ALOS imagery as the reference data. The overall accuracy is highlighted in blue.

<table>
<thead>
<tr>
<th>Classified Data</th>
<th>Reference Data</th>
<th>Net Users</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forest</td>
<td>15</td>
<td>5</td>
</tr>
<tr>
<td>Scrub</td>
<td>2</td>
<td>27</td>
</tr>
<tr>
<td>Open</td>
<td>2</td>
<td>14</td>
</tr>
<tr>
<td>total</td>
<td>19</td>
<td>46</td>
</tr>
<tr>
<td>Producers</td>
<td>0.78</td>
<td>0.58</td>
</tr>
</tbody>
</table>

These results suggested that a major confounding factor was the differentiation between scrub land cover and the other classes. Further accuracy assessment was conducted after the data had been aggregated into two classes ‘not-forest’ (a combination of the open and scrub classes) and ‘forest’.

Tables 5.3 and 5.4 show much improved levels of overall accuracy and much lower errors of omission or commission for both classifications. Both of these data sets were of sufficient accuracy to justify further analysis; however, it was decided, based on the greater overall accuracy, to continue working with the 1,2,3 band classification.
Table 5.3. Error matrix for the aggregated classification with bands 1,2,3 using ALOS imagery as the reference data. The overall accuracy is highlighted in blue.

<table>
<thead>
<tr>
<th>Reference Data</th>
<th>Forest</th>
<th>Not Forest</th>
<th>Users</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forest</td>
<td>15</td>
<td>6</td>
<td>21</td>
</tr>
<tr>
<td>Not Forest</td>
<td>1</td>
<td>76</td>
<td>77</td>
</tr>
<tr>
<td>Producers</td>
<td>0.93</td>
<td>0.92</td>
<td>0.92</td>
</tr>
</tbody>
</table>

Table 5.4. Error matrix for the aggregated classification with bands 2,3,5 using ALOS imagery as the reference data. The overall accuracy is highlighted in blue.

<table>
<thead>
<tr>
<th>Reference Data</th>
<th>Forest</th>
<th>Not Forest</th>
<th>Users</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forest</td>
<td>15</td>
<td>5</td>
<td>20</td>
</tr>
<tr>
<td>Not Forest</td>
<td>4</td>
<td>70</td>
<td>74</td>
</tr>
<tr>
<td>Producers</td>
<td>0.78</td>
<td>0.93</td>
<td>0.90</td>
</tr>
</tbody>
</table>

In order to further validate this data set the 1,2,3 band classification was assessed against the collected field data. The results, as shown in table 5.5, show a better accuracy than using ALOS reference data. This supported a degree of confidence in the classified data sufficient for further analysis.

Table 5.5. Error matrix for the Classification with bands 1,2,3 using field data as the reference. The overall accuracy is highlighted in blue.

<table>
<thead>
<tr>
<th>Reference Data</th>
<th>Forest</th>
<th>Not Forest</th>
<th>Users</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forest</td>
<td>80</td>
<td>11</td>
<td>91</td>
</tr>
<tr>
<td>Not Forest</td>
<td>12</td>
<td>156</td>
<td>168</td>
</tr>
<tr>
<td>Producers</td>
<td>0.86</td>
<td>0.93</td>
<td>0.91</td>
</tr>
</tbody>
</table>

5.1.2 Forest Cover classification and characterisation

The 1,2,3 band forest cover classification, as shown in Fig 5.1 a, classed a total of 854 km$^2$ as forest, which is 17% of mainland Kabupaten Kupang. Two regions with
extensive forest cover include the Amarasi region along the hills of the south coast and the Timau mountain forest complex in the north east of the Kabupaten.

Forest cover by type
The forest classification cover was added to the land-cover type map (Fig 3.10) to provide a broad picture of forest type distribution (Fig 5.1 b). The area and dominant tree species are shown in Table 5.4. (More information about the land-cover type is provided in chapter 3 and a detailed breakdown of species composition can be found in appendix III.1).

Most extensive forest occurred within the woodland land-cover type, about 28% of the total, with the next greatest area (23%) occurring within the monsoon forest cover type (Fig 5.1a). If deciduous forest were also mapped it is probable that the area classified as forest in the woodland, open forest and savanna classes would be greater. As expected the *Eucalyptus urophylla* and evergreen monsoon forest land-cover types are the most forested. However it is interesting to note that almost 35% of the monsoon forest land-cover type has no forest.

Forest cover by topography
Elevation and slope provide an indication of forests accessibility and the potential erosion risk from forest loss. It can be seen in Table 5.5 and Figure 5.3 that the majority of forest exists on upper slopes (250-550m) on moderate inclines. There is a clear correlation between slope, elevation and the amount of forest remaining. Only about 6% of flat country below 100 meters is forested, indicating that the most accessible and best agricultural land has been largely cleared. It can also be seen that about 45% of very steep (>30%) land is not forested. Analysis of forest cover in the three main catchments, as shown previously in figure 3.7, is presented in table 5.6. It can be seen that the Kabupaten Kupang component of the Noelmina catchment and the Oesau catchments contain only about 10% forest cover, much less than the Kabupaten average.
Figure 5.1. Distribution of forest cover in Kabupaten Kupang (a) from the final classification, and (b) overlain on the BAPEDALDA forest type mapping.
Table 5.4 The area (ha) of forest classified within each land-cover type as defined by BAPEDALDA (2007) with the two dominant tree species shown.

<table>
<thead>
<tr>
<th>Label</th>
<th>Indonesian Label</th>
<th>Dominant Tree Species 1</th>
<th>Dominant Tree Species 2</th>
<th>Area (ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Woodland</td>
<td>Hutan Terpencar</td>
<td>Mallotus ricinoides</td>
<td>Grewia koordersiana</td>
<td>24167</td>
</tr>
<tr>
<td>Monsoon Forest</td>
<td>Monsoon</td>
<td>Jambolifera trifoliata</td>
<td>Homallium tomentosum</td>
<td>19669</td>
</tr>
<tr>
<td>Open forest</td>
<td>Savanna Hutan</td>
<td>Casuarina junghuhnniana</td>
<td>Acacia leucophloea</td>
<td>17661</td>
</tr>
<tr>
<td>Savanna</td>
<td>Savanna Terbuka</td>
<td>Acacia nilotica</td>
<td>Nauclea orientalis</td>
<td>16807</td>
</tr>
<tr>
<td>Euc. urophylla</td>
<td>Hutan Ampupu</td>
<td>Eucalyptus urophylla</td>
<td>Ehretia acuminata</td>
<td>4101</td>
</tr>
<tr>
<td>Palm Savanna</td>
<td>Plam Savanna</td>
<td>Corypha utan</td>
<td>Acacia nilotica</td>
<td>2819</td>
</tr>
<tr>
<td>Mangrove</td>
<td>Mangrove</td>
<td>-</td>
<td>-</td>
<td>173</td>
</tr>
</tbody>
</table>

Figure 5.2. The percent of total the total areas classified as forest cover occurring within each land-cover type (a) and the amount of each land-cover type forested (b).
Table 5.5 Area of forest (ha) in each slope class.

<table>
<thead>
<tr>
<th>Height</th>
<th>Label</th>
<th>Area (ha)</th>
<th>% Slope</th>
<th>Label</th>
<th>Area (ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-100m</td>
<td>Coastal Plains</td>
<td>6913</td>
<td>0-1.5</td>
<td>Flat/v-gentle incline</td>
<td>3099</td>
</tr>
<tr>
<td>100-250m</td>
<td>Foot Slopes</td>
<td>16878</td>
<td>1.5-5.5</td>
<td>Gentle incline</td>
<td>9200</td>
</tr>
<tr>
<td>250-550</td>
<td>Upper Slopes</td>
<td>34067</td>
<td>5.5-18</td>
<td>Moderate Incline</td>
<td>42630</td>
</tr>
<tr>
<td>550-750</td>
<td>Uplands</td>
<td>16050</td>
<td>18-30</td>
<td>Steep</td>
<td>23456</td>
</tr>
<tr>
<td>750+</td>
<td>Sub-Montane</td>
<td>11555</td>
<td>30+</td>
<td>Very steep</td>
<td>7079</td>
</tr>
</tbody>
</table>

Figure 5.3 The distribution of forest in Kabupaten Kupang as a function of (a) slope and (b) elevation. The first data series (blue) shows the percent of total forest cover occurring at each slope and elevation class, the second (red) shows the percentage of each slope and elevation class forested.

Table 5.6 Percent forest cover by three major catchment in Kabupaten Kupang. The Noelmina value is only for the part of the catchment within Kabupaten Kupang.

<table>
<thead>
<tr>
<th>Catchment</th>
<th>% forest cover</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tarmanu</td>
<td>18.9</td>
</tr>
<tr>
<td>Noelmina</td>
<td>10.4</td>
</tr>
<tr>
<td>Oesau</td>
<td>11.4</td>
</tr>
</tbody>
</table>
Forest cover by administration

Kawasan Hutan

Although Kawasan Hutan forest administration zones are not indicative of forest cover per se they influence forest management. The break-down of forest distribution by zone can be seen in table 5.6. Nearly half the classified forest occurred outside Kawasan Hutan leaving it free from national government influence. The next largest area of forest is within the protection zone, largely managed to maintain up-land catchment condition, although only a quarter of this zone is actually forested. From a conservation perspective it is interesting to note that less than 4% of forested land exists within national parks and nature reserves and less than a third of land within this classification is actually forested.

Table 5.6: Forest administration zones within Kawasan Hutan.

<table>
<thead>
<tr>
<th>Kawasan Hutan</th>
<th>Area (ha)</th>
<th>% of total forest area within each zone</th>
<th>% of each zone forested</th>
</tr>
</thead>
<tbody>
<tr>
<td>Outside forest zone</td>
<td>37460</td>
<td>43.9</td>
<td>13.8</td>
</tr>
<tr>
<td>Protection Forest</td>
<td>24678</td>
<td>28.9</td>
<td>24.8</td>
</tr>
<tr>
<td>Limited Production Forest</td>
<td>10869</td>
<td>12.7</td>
<td>27.1</td>
</tr>
<tr>
<td>Production forest</td>
<td>9257</td>
<td>10.8</td>
<td>15.2</td>
</tr>
<tr>
<td>National Park/Nature reserve</td>
<td>3099</td>
<td>3.6</td>
<td>30.7</td>
</tr>
</tbody>
</table>

Kecamatan boundaries

The distribution of forests amongst Kecamatan is most informative when viewed spatially or coupled with other data. Forest cover distribution, as mapped in figure 5.4 shows, a general trend of increased forest cover with distance from Kota Kupang in the south west. There also appears to be a corridor of diminished forest cover following the main road from Kupang through West Timor.
Another way to look at forest distribution is through its relationship to Kecamatan population data. Population distribution by Kecamatan can be seen in figure 3.11 (chapter 3). Figure 5.5 shows Kecamatan population density and forest cover. There is a general trend towards increasing forest cover with decreasing population density which is consistent with a preference to settle outside forests and, if population increases, forest tends to be replaced by housing and agriculture. However notable exceptions can be seen with Amarasi and Amarasi Selatan, where there are some of the highest levels of forest cover and a reasonably high population density. At the other end of the scale is Amfoang Timor, the furthest north eastern Kecamatan bordering the East Timorese enclave of Oecussi, where there are low population density and fairly low levels of forest cover. (A detailed breakdown of forest distribution by Kecamatan can be found in appendix III.2 and an alternative
Figure 5.5. Percent forest cover shown in green and population density in year 2007 (people per square kilometre) shown in blue for each mainland Kecamatan.

5.1.3 Forest cover change time series

The forest cover change time series shows generally increasing levels of forest cover change over time (Fig 5.6). It also shows substantial differences over time in the type and intensity of cover change between different regions. Some areas of note are the south coast which shows large areas of cover increase followed by forest loss between 1994-2006 (box 1 Fig 5.6), a region just to the north west of Kupang showing continuous dynamic change with increasing levels of cover loss (boxes 2,3,4) and the increasing cover loss in the fairly remote regions of the central north of the Kabupaten (box 5).
Figure 5.6 Forest cover change time-series from 1972 to 2006 and combined for all years. Red boxes on the combined image show areas of large scale change targeted for further investigation. Cover decrease is shown as dark red and cover increase as green.
5.1.4 Case study selection

Five forest cover change ‘hot-spots’, as marked by red boxes in figure 5.6, were further investigated to guide the case study selection.

Amarasi

The Amarasi region on the south coast of Kabupaten Kupang showed an extensive amount of vegetation growth and clearing (Fig 5.7). It did not appear that this was a result of a temporary ‘green flush’ due to a rain event as this greening was not apparent elsewhere in the image. It was considered possible, due to this region’s unique agricultural history (described in chapter 3), that this change was associated with agroforestry.

![Figure 5.7 Land-cover changes along the coast of the Amarasi district from 1994-2000 and 200-2006. Cover increase is shown in green and decrease in red.](image_url)

Kecamatan Kupang Tengah

The change in forest cover, in Kecamatan Kupang Tengah, was seen to be associated with the construction of the large Tilong dam (Fig 5.8). A field visit to the region found that clearing of a palm forest downstream of the dam was to facilitate the development of an irrigated market garden. The change seen here was part of a one-off agricultural development in a palm savanna landscape.
Babau coastal plain

A large area of land-cover change on the Babau coastal plains in Kacamatan Kupang Timur showed a history of regrowth and clearing (Fig 5.9). Field investigation of this area found the region to be heavily infested with *Acacia nilotica*, known as the prickly acacia in Australia. Considered a weed in Australia, here it is used as a fuel wood and a nitrogen fixer on fallow land. The majority of clearing and regrowth was associated with the management of the acacia. The change seen here was part of a continuous agricultural cycle in an acacia scrub landscape.
Kecamatan Sulamu

The change in Kecamatan Sulamu is associated with a remnant tract of lowland monsoon forest in Bipolo village. Assessment of the change over a 25 year period shows almost continuous forest cover loss (Fig 5.10). This forest is a rare example of coastal lowland monsoon forest.

Figure 5.9 Forest-cover change mapping on the Babau coastal plains of Kecamatan Kupang Timur for 1989-1994, 1994-2000 and 2000-2006 shown in the bottom left box.

Figure 5.10 Forest-cover change between 1972 and 2006 around Bipolo village, Kecamatan Sulamu. Forest cover loss is shown as a gradation of yellow (1972-1982) to dark red 2000-2006. Forest cover increase is shown as green.
Fataleu/Amfoang

The investigation of this region focused on two areas of recent change in forest cover on the coast in (1) Kecamatan Fataleu Barat and in the hills bordering the Timau forest complex (2) in Kecamatan Amfoang Barat Daya (Fig 5.11). Assessment of the coastal site on the Landsat imagery suggested the development of some housing infrastructure. Subsequent investigation using Google Earth imagery (Fig 5.12) confirmed this interpretation. It was considered most likely by forestry department informants, based on the formal layout of the housing, that this development was associated with a transmigration program possibly for refugees from Timor Leste. The Amfoag Barat Daya forest cover change in a mountainous and remote region showed on-going and increasing change, which seemed likely to be associated with traditional shifting agriculture.

Figure 5.11 Land-cover change along the coast in Kecamatan Fataleu Barat and in the hills of Kecamatan Amfoang Barat Daya from 1972 to 2006. Forest cover loss is shown as a gradation of yellow (1972-1982) to dark red (2000-2006). Forest cover increase is shown as green. Black boxes mark two sub-regions for investigation, on the coast (1) and in the hills (2).
5.1.5 Case study site characterisation

It was decided, based on location, forest type, topography and probable causes of change in forest cover to select the Amarasi, Bipolo, Fatuleu Barat and Amfoang Barat Daya regions as the case study sites. Spatial analysis was conducted within a 2500 hectare circle around the regions of interest, as shown in Fig 5.13, to characterise biogeographic and FCC variation between the case study sites.

Figure 5.12 Google Earth imagery showing a large housing development in Kecamatan Fatuleu Barat.

Figure 5.13 The location of the four case study sites indicated by a 25km$^2$ circle:

1- Amarasi,
2- Bipolo,
3- Fatuleu Barat,
4- Amfoang Barat Daya.

The four case study sites are on a north-south axis representing a range of biophysical and social factors. The variation between the sites in forest cover and topography and in forest cover change history is shown in Figs 5.14 and 5.15.
Figure 5.14 Biogeographic characteristics of a 25km$^2$ region around the four case study sites: (a) the total percentage forested area from the forest cover classification and the percentage contribution of the main vegetation types, from BAPEDALA mapping, (b) the percent within each main elevation class (metres above sea level) and (c) the mean and standard deviations (SD) of slope.
Figure 5.15 The forest cover loss trajectories of a 25km$^2$ region around the four case study sites showing (a) the amount of clearing between image dates and (b) the cumulative amount of clearing in hectares between 1972 and 2006.

The following is a description of the sites as characterised by their forest cover, topography, population density and forest cover change history.

1. **Amarasi**, is on mixed savanna, monsoon forest country with a relatively large extent of forest remaining (20%). The study area is rugged coastal land falling evenly into the three elevation categories below 550 m. It is significant that the Amarasi region has, as noted above, an exceptionally high population density despite having high forest cover (Fig 5.5). The forest cover change pattern is unique amongst these case studies, showing both substantial cover increase and recent decrease. The forest cover change, based on an assessment of the imagery and literature, was thought to be associated with agro-forestry activities.

2. **Bipolo** is in an area of largely palm savanna with remnant monsoon forest on a flat lowland plain. Forest cover has been decreasing steadily over the last 25 years
with a slight decrease in the rate of forest loss between 2000 and 2006. This site has the least forest remaining of the case studies and represents a rare area of coastal plain forest. As described in chapter 2, this site has high conservation significance; it is also the closest site to Kota Kupang and under continuing pressure. The area is adjacent to the most heavily populated part of Kabupaten Kupang (Fig 5.5) with an average of 217 people per km² in the neighbouring Kecamatan Kupang Timur compared to the average of 53/km².

3. **Fatuleu Barat** has mixed coastal savanna, palm savanna, woodland, with 7% forest cover. The region is dominated by low lands but has some steep hills. The area of forest loss has been small but increasing. Much of this change is due to a housing development most probably associated with a transmigration camp. This region has a medium population density (90/ km²).

4. **Amfoang Barat Daya** case study area is dominated by woodland vegetation and has the largest amount of remaining forest cover (41%). The study area is in steep, rugged hill country with 38% over 250 meters. Although Amfoang Barat Daya is amongst the most sparsely populated (26 people/km²) kecamatan on mainland Kabupaten Kupang it also has high and rapidly increasing levels of clearing. It is probable that forest cover change in this area is primarily due to shifting agriculture.

Each of the sites has a unique biophysical, demographic and forest cover change history. The following chapter describes the case study forests and the ways they have changed through the perceptions of a range of interviewees.
Chapter 6 Case study interview results and integrated analysis

This chapter presents, for each case study site, the interview results and, by incorporating the spatial data and literature, an integrated analysis of people’s relationship to forests, the causes and impacts of forest cover change and the implications for forest management.

A total of seventeen interviews were conducted: two with researchers from a local university, one with a Kabupaten Kupang forestry department officer and fourteen with local village leaders. The interview results are presented here as key findings from each of the case study areas. For each site, interviews were conducted in one village in the case study area. The interviews were linked to the satellite imagery to find correlations between mapped change and described events.

6.1 Amarasi (Ratrean) #1
Amarasi lies in a relatively high rainfall area of Kabupaten Kupang and has a unique history of innovative land use. The fertile land and distinctive farming practices here support a relatively high population density whilst maintaining a large extent of forest. The satellite data showed a dramatic increase in forest cover between 1994-2000 and a similar decrease in the same area from 2000-2006 along the coast.

6.1.1 Interview results
Desa Ratrean (Fig 6.1) was chosen for the interviews as it encompassed most of the spatial analysis study area. Four interviews were conducted with senior members of the Ratrean community.

Background
Amarasi is well known for agroforestry practices, initiated by the local ruler in the 1930’s, using lomtoro (*Leucaena leucocephala*). The non-local interviewees described the system of harvesting lomtoro leaves to fatten penned cattle as being effective and a model for integrated agroforestry systems elsewhere. The region gained extra support for this approach when, during the 1960’s, the national government actively promoted cattle fattening programs.
Figure 6.1 The location of the interview village. The spatial analysis study area is shown in blue, the village borders are shown in black and the current forest distribution is shown in green.

Uses/Benefits

All the local interviewees mentioned the importance of shifting cultivation with nearly half their community still practicing it in the nearby forests. Shifting agriculture was described as the most important activity in the forest whilst benefits from non-timber forest products were rarely mentioned. One person believed that the illegal logging of timber in the forests also provided the community with income. Regulating the climate and water cycle was also mentioned by most respondents as an important function of the forest.

Causes of forest cover change

Proximate forces

One of the academics interviewed believed that a cause of the large scale reduction in forest cover seen on the satellite imagery was an outbreak of a leucaena aphid (psyllid) in the mid-80’s causing widespread destruction of the lomtoro forests. Subsequent reforestation was conducted using different varieties of leucaena that are resistant to attack from this pest.

Most of the local interviewees thought there was a small reduction in forest cover primarily due to shifting cultivation. This decrease was perceived to be a result of increasing village population and people coming from other villages to cultivate land in this area.
there are also people from Amanuban and Amanatun (TTS Regency) opening cultivation here, especially near the beach. The number of people there has been as many as one dusun (sub-village).

One interviewee mentioned the out-break of *laceana psyllid* in the mid-80s as having had major impacts on lomtoro forest cover however all the interviewees cited illegal commercial timber logging by local people as having an impact on the forest (Fig 6.2). A recent case of kemiri (*Aleurites moluccana*) logging near the beach and older cases now in court were mentioned:

*Before when I was still the head of the village I would prevent and warn people against taking wood from the forest. It is not like that now. I am very angry that it is like it is now but what can I do?*

*I am sure that now the forest is much more damaged than before and every day the situation becomes more serious. The destruction is done by illegal logging and clearing for ladang. In Ratrean village there is illegal occupancy by the community. Although I already provide a report to the Kabupaten and province I have received no response. My observation is that people enter for illegal logging every night. We have met people in the forest area at 1 in the morning. Why are there people in the forest in the middle of the night? Not for genuine activities.*

Lomtoro reforestation was mentioned as an important activity in the past but is no longer a group activity on common lands. The only reforestations still occurring are small scale activities around some springs and on private land. A local village elder described how:

Figure 6.2. Recent timber cutting in the forests surrounding Ratrean. (Photo I W. Mudita)
In 1981 Ratraen was the champion in a greening contest through planting lomtoro, but not anymore. Now they do not plant trees on the common land like before.

Driving forces
There was widely differing views on the driving forces behind the forest change between the local interviewees. All of them acknowledge the replacement of traditional forest law by state law but they differed in their perceptions of how these laws work. Half the interviewees believed that on the whole the government law was respected despite admitting that illegal logging still occurred.

No one dares to enter the village-managed secondary forest, but sometimes they take wood from there to build a village office, school or church. To do that we usually ask for permission from district and are also facilitated by KRPH to avoid violating the regulations.

The others believed there had been a complete breakdown of forest governance.

Because the government now pays no attention to the forests all the people now enter the forest to get wood. Before we still listen to the kepala desa, now people just cut and sell what they want.

…it is backwards, before it was difficult to take wood from the forest, now it easy. Before we used to plant trees now we just cut them.

A lack of forest department staff monitoring the forests is seen as a key factor in the lack of governance. The one government officer assigned to monitoring the forests in this district was said to be inexperienced and living in Kupang city. One government response to logging mentioned was to increase timber taxes which were seen as counterproductive and that it demonstrated that the government was more interested in raising revenue than protecting the forest.

Impacts of forest cover change
All the interviewees at Retraen said that living conditions are much better now than in the past primarily due to better transport infrastructure making access to markets easier (Fig 6.3). However views on the role of local forests in this economic improvement where divergent:

3 KRPH (Kesatuan Resort Pemangku Hutan). A unit of forest guard under the provincial Forestry Department
Unrelated:

*We have an asphalt road now.... this better economy has nothing to do with the condition of the forest, it is because a better infrastructure and the people’s hard work.*

Easier Exploitation:

*I think the economy is better now because the community can just go into the forest to cut wood and the roads are better, allowing trucks to enter and take the wood.*

Doubts about sustainability:

*The economy of our community may be better due to illegal logging but for how long?*

Figure 6.3 Bitumen road through the forests of Amarasi. (Photo I W. Mudita)

Better infrastructure, more wealth and government assistance programs have meant that some resources that the forests provided, such as food and medicine, are no longer considered important.

**Future forest management**

Most village interviewees thought that much tighter control over forest use was needed. One interviewee saw forests as dynamic places that are always changing therefore there was no problem and no change to forest management was needed. Half of the respondents thought that a lead needed to be taken by the government:
My suggestion is that it would be good for the Forest Department to take control of monitoring the forest and not surrender control to the village government or the forest will be destroyed by petty local officials.

A large increase in government staffing and infrastructure was seen as a requirement for better forest monitoring:

There needs to be tighter monitoring with more staff and clear rules. We need a lot of staff here because there are many tracks through the forest... I think we need order back in the system with trained managers with a high level of education and NGO experience.

6.1.2 Integrated analysis

Relationships to the forest.
The livelihoods of the community here are still connected to the forest around them through its use for shifting cultivation and timber extraction. The forest is described as secondary forest maintained through shifting cultivation and growing lomtoro. The forest in this case study area is outside Kawasan Hutan zones. Traditional governance of the forest is no longer functioning and has not been replaced by coordinated government-facilitated management. The local people see the forest area slowly diminishing with varying degrees of concern.

Causes of forest cover change.
The causes of the forest cover change seen in the satellite imagery are not clear from the interviews. Visiting the actual area of forest cover change was not possible at the time the interviews were conducted due to their remote location. A possible explanation proffered by one non-local observer was that the re-growth seen from 1994-2000 was a result of recovery from the earlier decimation of lomtoro by the leucaena psyllid. However this was said to have happened during the mid-80’s so it is surprising that this recovery was not apparent in the earlier image pair (1989-1994). It was also suggested that the subsequent cover loss (2000-2006) was due to excessive clearing of kemiri trees along the coast. Increased pressure on the forests due to immigration, particularly to the coastal areas, was also described as a potential influence on forest cover. However none of these potential causes definitively describe the change mapped from the satellite imagery. It is possible
that the change could have been the result of a local rainfall event. The local characteristics of Amarasis show that a late dry season rainfall event is possible and could explain the greening along the south coast seen in the mid-September 2000 satellite image. The absence of rainfall stations in Amarasi makes this proposition difficult to test.

The proximate causes of forest cover change were described as shifting cultivation, exacerbated by increasing population, timber extraction by the local community and, at one point, a severe plant pest infestation. A lack of forest governance, traditional or government, was seen as the primary driver of forest cover change. Improved transport infrastructure was seen to have both increased the quality of life, yet hastened the loss of forest. Change in forest cover and the way forest was used was seen to have improved the standard of living of the community although there was concern that if the level of forest use continued at the current rate there would be problems in the future.

Conclusion

The community had a utilitarian view of their forests. Although considered important, they were seen as garden forests, a result of decades of cultivation. There was a general feeling that government needs to retake control of forest management to prevent unsustainable logging and encourage rehabilitation. Previous ‘traditional’ community practices and laws are no longer strong and over recent years the government has disengaged from forest governance. The community appears to be too large or fragmented to allow for successful local governance.

The interviews, although insightful, did not clearly identify the cause of the mapped forest cover change. A range of possible causes have been postulated including the likely possibility that no long term change has occurred. This is significant as the area of change was very large and its inclusion in any assessment of forest cover change in West Timor would be significant. Further on-ground assessments are required to clarify what is actually happening in this area.

6.2 Bipolo #2

Little forest remains in this region that was previously home to a large tract of lowland monsoon rainforest and palm forest. Its proximity to the population centre
of Kupang continues to place pressure on this area.

6.2.1 Interview results

Desa Bipolo (Fig 6.4) was chosen for the interviews as it contained the remaining forest within the spatial analysis study area. Three interviews were conducted with three senior members of the Bipolo community.

Figure 6.4 The location of the interview village. The spatial analysis study area is shown in blue, the village borders shown in black and the current forest distribution shown in green.

Background

Bipolo is known regionally as an area of great fertility and as a centre of conflict over its natural wealth. This conflict goes back to the period of Dutch rule when Rotinese, allied to the Dutch, were brought to settle the area which led to disputes between the local Timorese, who largely inhabited the nearby mountains and the Rotinese. This resulted in a major conflict in 1912 known as the Bipolo war and eventually led to the forest being divided between the Rotinese (Oeteta) and Timorese (Bipolo) groups (Fig 6.5).

All the local respondents described the forest as a place of significant cultural importance to the community. A traditional story describes how this forest existed from the birth of the world and has remained unchanged as sacred forest. The forest is known locally as Netaopi after a story of a group, with a baby called Netaopi that entered the forest and became lost. Baby Netaopi died as they could not find their way out. The community describes a strong
link between their village, Bipolo, and the forest Netaopi. The cultural significance of this forest meant that there were strict traditional laws governing the use of the forest to the extent that each family was allocated specific trees marked with their name for which they were responsible. The village interviewees also describe strong links to the nearby mountains, relating how they have moved between the lowland forest and the mountains (Fig 6.5). Although no clear reason was given, it was described how the community moved to the mountains in 1952, to settle in the village of their grandparents. Then, in 1975 during the Soeharto New Order era, they moved back down to Bipolo forest at the request of the local government.

The forest remained as community controlled forest until about 1960 when it became state controlled (Kawasan Hutan). The fertility of this area was well known and even before the Bipolo war there was 13-18ha of rice fields here. A new administrative capital centre is now being built nearby on the Babau plains (Fig 6.5).

Uses/Benefits
All the local interviewees described multiple uses and benefits from the forest that have changed significantly over time. The most commonly cited current use was for firewood. Honey collection was also said to be an economic forest product although the harvest is now small (Fig 6.6). A continuing but minor use of the forest for food, medicine and hunting on rare occasions was also mentioned. Agriculture is no longer practiced in the forest.
The most important cited benefit from the forest was as a regulator of the climate and the flow of water. They saw the forest as providing the water to maintain their rice fields.

*To me, the forest is characteristic of Bipolo Village. If I protect the forest, I protect my paddy field at the same time. The rice fields in Bipolo depend on the rain.*

Figure 6.5 The location of Bipolo and Oeteta villages, (a) the mountains where the Bipolo community lived prior to 1975, (b) Netaopi forest, (c) the area of aquaculture ponds and (d) the location where the new Kabupaten Kupang administrative capital is being built.

Figure 6.6. Non-timber forest products harvested from Bipolo forest; bee hives, providing honey and wax, and fire wood and fencing timber.
Causes of forest cover change

Proximate forces

One of the academics interviewed believed that some of the deforestation at Bipolo occurred as a result of conflict between the villages of Oeteta and Bipolo:

The forest is actually in Bipolo but to prevent the Oeteta people from entering they built a settlement to the west on the border between the two villages so they can claim the forest ……Looking at the change of Bipolo forest over time you can see the set up of the sub village by 1989.

The clearing of the forest is blamed directly on logging companies facilitated by the government. Descriptions of the activities of the government and logging companies were mostly specific and consistent between the village interviewees:

.... 1965 then CV Cahaya Bapa came to cut the trees. They used kombong saw. CV Meranti came in 1972, and many companies came afterward to cut the trees. The forestry department erected the sign board saying “This is Government Property” in 1980. The Agency built an office in 1995. However, the tree cutting continued, finally stopping in 2000.

In 1980 or 1981 the Kabupaten and Provincial government came here with entrepreneur from Sulawesi. With this the forest was destroyed by the government.

First when the companies came they requested the instruction about which forest they can cut but the forestry department gave contradictory instructions. More and more companies came to cut the forest, with officials from the forestry department, and cut the forest until there was no more. It’s like the government was also destroying the forest.

There is mention of the local people’s involvement in timber extraction only after the government and logging companies are said to have taken most of the wood. Thinking they were missing out, some local people are said to have ‘stolen’ timber from the forest.
Shifting cultivation is described as being a traditionally important way of farming that was practiced until the year 2000 but now has been replaced by home gardens and rice fields. The last time the forest area was used for agriculture resulted in forest fire and conflict with the forestry department. The expansion of the rice cultivation began after the community returned to the forest in 1975, first clearing Gewang (Palm) forest in the wetlands and slowly expanding into the Kawasan Hutan. This expansion was substantially aided by previous logging, with much of the cleared land being converted to rice fields. The creation of a large aquaculture industry was also described as contributing to the clearing of mangroves in the southern part of the village.

Attempts to develop plantation forestry were described usually in negative terms as most of the trees, usually teak (Fig 6.7), died due to the land being too wet, they were not paid for their work planting trees and they had no rights to use the trees they planted.

*Teak trees were first planted by the community without a wage. Since then these trees have been cut down. On the eastern side they take less so there is still a lot there whereas on the western side it is all gone.*

In 1997 some local people went to jail for their involvement in illegally harvesting the teak. Some areas where teak has died have since been turned into rice fields.

**Driving forces**

The movement of the Bipolo community back and forth from the lowland forests to the mountains was a response to broader political changes. The move back down from the mountains to Bipolo forest was part of the New Order regime’s process of ‘uniting Indonesia’, to bring people under government control and provide government services.
Figure 6.7 The western border of Bipolo forest. On the right is a teak plantation and to the left the remnant rainforest.

Increased clearing in the late 1990’s and 2000 was attributed to regime change by a Kupang based academic in the following way:

*The Soeharto government was really very tight with forest policy and was backed up by the military so the people were afraid of being caught. Now the military have no control over this issue. People have more access to the forest, meaning they can clear larger areas. This (Bipolo) is a kind of protected area but because of the change in regime there is no protection and sometimes the forestry guy does the bad thing as well, such as illegal logging and hunting so the people around the forest get jealous and wonder why they can take timber but we cannot.*

Policies aimed at increasing rice production in NTT and developing commercial industries such as the aquaculture developments were also cited as driving forces behind the clearing at Bipolo.
Changes in forest law was described as being a problem by all the interviewees. Traditional law was described as:

\[
\text{if you harvest wood without the knowledge of the traditional leader you would be fined and must pay with silver. This changed during the transition from Dutch to Indonesian rule.}
\]

The change from customary forest to state forest meant that the local people no longer had any say over the use of the forest. The zoning of Bipolo as production forest resulted in intensive logging and the subsequent zoning as protected forest closed the forest to any use. The Kawasan Hutan laws has left the community very confused:

\[
I \text{ do not know where the community forest zone, state forest, protected forest is and where is the conservation forest. It's all in the power of the government.}
\]

\[
\text{Now if we want to build a house we take trees from the mountains. The mountains are also within Kawasan Hutan but if we take trees from there the forest department cannot see it.}
\]

The forest zone covers a large area around the village. They describe their village as being in an enclave within the forest unable to plant or cut any trees. They are also concerned that the government will take land they have already cultivated away from them.

Corruption and collusion with illegal logging is a common theme. One interviewee related how he had once reported theft of teak from the forest to the forestry department only to be threatened by the forestry department with imprisonment if it was a false accusation. Once the stolen wood was found and was taken to the forest department office from where it disappeared.

**Impacts of forest cover change**

The most severe impact from the loss of forest was believed to be the loss of reliable fresh, clean water sources.

\[
\text{Now there is only a little bit of forest left and we worry in the end there will be none. Now there is only one spring, Oenenuk, that flows all year, but this}
\]
spring is far from our rice fields. Before we had three springs and now the river in Bipolo is dead. When all the springs are dead where will we get water in the dry season?

Rainfall is also said to be more unreliable and damaging flooding more common. In order to provide more reliable water for the rice fields, a dam was built on the river running through the forest. The construction of this dam was initially supported by the local government then opposed by the forestry department who said it was illegal to build it within the Kawasan Hutan. The dam was built anyway but subsequent flooding washed it away.

Difficulties getting timber for local buildings and confusion over the forest laws and Kawasan Hutan boundaries were also said to have substantial impacts. One village interviewee described how he had to travel a long way to get the wood to build his office but was still accused by the forestry department of illegal logging. The depletion of the forest has also had a substantial impact on honey and bee wax collecting that was once an important economic contributor to the community.

Future forest management

Opinions about the way ahead to protect the forest vary. Ongoing conflict with the government over forest management has resulted in an antagonistic attitude towards government control.

In my opinion, the present forest has been infiltrated by “city territory”. Just give the forest back to its people, in this case to village elders who hold the customary law.

Another interviewee believed that too much community control could result in conflict within the community. Joint management was favoured although the community was wary of the government interference.

Two of the interviewees thought that the forest should be re-zoned as recreation forest to be managed by the community with activities to support the local economy. They see the creation of a tourist industry as a realistic option as the development of the new provincial capital nearby (Fig 6.8) would provide visitors.
They would also like to see a redrawing of the Kawasan Hutan boundary so they have more rights over the land they have cultivated and so they do not feel trapped in a ‘forest enclave’.

6.2.2 Integrated analysis

Relationships to the forest

The rich resources of Bipolo have long been the focus of exploitation and development, and the rights to access its natural wealth have been a source of conflict. The biodiversity wealth of the forest is also recognised internationally with Birdlife International listing it as an Important Bird Area (Birdlife International, 2009). The forest is well known among professional and amateur ornithologists who visit regularly. It is interesting to note that none of the interviewees mentioned birdlife diversity specifically as an important asset of the forest.

The people of Bipolo felt the forest was an important part of their cultural identity. Creation stories linked them to the forest, known as Netopi, from the beginning of time. They believe they have some customary rights to the forest but have seen traditional claims and laws extinguished by the government and the forest plundered by ‘outsiders’. At the same time the local economy has been largely
decoupled from the forest but they still see a direct relationship between the success of their non-forest based activities and the health of the forest.

Causes of forest cover change

A time line of forest cover change as described in the interviews is shown with the corresponding satellite imagery in Figs 6.9 to 6.14.

Figure 6.9 In 1972 the people of Bipolo were still residing in their mountain village. They describe some commercial logging to have begun in 1965 and 11 ha had been cultivated for rice. The area was wet and fertile, densely forested with monsoon rainforest and Gewang Palm.

Figure 6.10 By 1982 the community had moved down to the forest and settled around location b. More commercial logging is said to have begun in 1972 which is evident as cover thinned around the edges for the forest. Clearing at location a is probably associated with rice field development.
Figure 6.11 By 1989 substantial clearing had occurred along the border between the two villages. This was described by one non-local informant as a result of the Bipolo community clearing the land to claim ownership. The Bipolo interviewees, in contrast, made no mention of conflict between the two communities as an influence on land management. They did describe government facilitated logging by entrepreneurs from Sulawesi. Clearing at locations b and c appear to be associated with rice field development which may have been facilitated by commercial logging.

Figure 6.12 By 1994 the forest was divided between the two villages with large forest loss also apparent at locations a and b.

Figure 6.13 The forest is said to have been reclassified as protected forest by 1996 but what appears to be continued agricultural expansion can be seen at locations a and b. Some forest cover gain is apparent in the hill around location c associated with attempts at teak and mahogany plantations. Large cleared patches in the remaining Bipolo forest can also be seen. This is probably related to shifting cultivation and associated wild fire, described by a local interviewee as last occurring in the year 2000.
The proximate causes of deforestation are commercial logging and agricultural expansion. It was common during the Soeharto era for large logging companies, often with military affiliation, to be given concessions to some of the best forest. Large scale clearing by the local community is unlikely as it would have been illegal and dangerous. The detailed descriptions of a succession of logging companies harvesting the forest suggests that it was considered an important source of revenue and any illegal timber extraction would have been closely monitored. It is also clear that, although the community was angered by the scale of deforestation and their disenfranchisement from forests management they also benefited from the opening of new land for agriculture.

The driving forces behind the clearing are related to government social and economic policy. It was the new order policy of unification that brought the Bipolo people from their mountain village to the more accessible coastal forest location. Government policies supporting the development of rice as a staple crop for all Indonesians encouraged the community to change from traditional shifting cultivation to becoming rice farmers and permanent gardeners. The fertility and swampy attributes of this area also supported this conversion. The other driving force was the policy of building Indonesia’s economic wealth through commercial timber production (Sunderlin, William D. & Resosudarmo 1996). Clearing of remnant forest stands in the post-Soeharto era would have been possible because of the lack of monitoring. Competition for resources between the two villages was not mentioned by the local Interviewees as a force that was driving forest use.
The deforestation of one of the last lowland monsoon forest sites on Timor island is a particular concern in terms of biodiversity loss, particularly of some rare endemic species. A recent visit by Dr Richard Noske found most of the species recorded previously (Noske, R & Saleh 1996) were still present (pers com 2009). There were indicators that bird numbers were reduced leaving populations more vulnerable to future habitat disturbance.

Lifestyle changes at Bipolo have resulted in livelihoods previously dependant on forests being replaced by settled farming and aquaculture. However destruction of the forest is attributed to the drying of once reliable water sources and more variable rainfall which has direct impact on the welfare and agricultural productivity of the communities. When timber is required it is taken from forest other than Netopi but unclear forestry law and haphazard law enforcement has made even this problematic. Poor socialisation of forestry activities have resulted in a poor relationship between the local community and the forest department and a feeling of insecurity about their land-rights.

**Future forest management**

The interviewees showed evidence of understanding the significance of the forest and an awareness of opportunities for better management. Primarily they wanted to have more control over the way the forest is managed. The need for government involvement is acknowledged but the general feeling is that customary management would be better than government management. They hoped that this area will be reclassified as recreation forest with government support to create visitor facilities and be a potential income source for the community.

**Conclusion**

The forest at Bipolo grew because of the unique environment created by year round mountain water seeping out into a large fertile plain. These attributes also made the land valuable for agriculture and a ready source of timber. Government policy of the Soeharto era actively supported this deforestation. A subsequent lack of clear forest governance over the last decade has left the community confused and insecure. The development of the new administrative capital of Kabupaten Kupang is both a threat to the survival of the remnant forest and an opportunity for its preservation as more people move into the region. This will depend on the level of local and national government commitment to protecting this area and reversing
decades of indifference to the local community’s views, to form a new collaborative approach to managing this forest.

6.3 Fatuleu Barat (Nuataus) #3

6.3.1 Interview results

The village of Nuataus (Fig 6.15) was chosen for the interviews because it was the closest long-term settlement to the spatial analysis study areas. Three interviews were conducted with senior members of the Nuataus community.

![Figure 6.15 The location of the interview village. The spatial analysis study area shown in blue, the village borders shown in black, the location of the main road is shown in red and the current forest distribution is shown in green.](image)

Background

In 1998 Nuataus village was divided into three smaller villages Desa Nautaus, Desa Naitae and Desa Tuakau. Actual boundaries dividing these villages do not seem to have been precisely surveyed but the approximate location of the villages are shown in figure 6.15.

The majority of people of Desa Tuakau are recent arrivals resettled through a government translocation program and do not have a historic understanding of the area. The policy of translocation is not intended to deal with problems of overpopulation, rather to bring disadvantaged people within Kabupaten Kupang to less isolated or more fertile land. In Kabupaten Kupang there are a number of
translocation camps many of them also housing people from East Timor. One of the academic interviewees described the process in the following way:

_Usually there is no conflict because they move people from the same Timorese ethnic background. All of them are Christian protestant and with similar tradition. East Timorese can bring a lot of conflict. A lot of the settlement built along the coast is for people from the inland area because the government wants people living in these inland areas to have more access to services. That is the policy of the government of Kabupaten Kupang but sometimes people in these settlements leave because it is difficult to get water._

The people currently living in the Nuataus coastal area moved there in 1989 as part of the government program to bring communities closer to government services and markets. The area prior to this time was only sparsely populated with a few scattered Rotinese families. The original village for the people of Nuataus is approximately fourteen kilometres from their current settlement. The old village is isolated with no road access. The first people came down of their own volition and purchased land from the local Rotinese families in the mid-eighties. The subsequent translocation of the whole village was assisted by the government. The people here still maintain a close connection with their old village, travelling there regularly by horse to conduct shifting cultivation and manage livestock. A few people still live in the old village to tend livestock and gardens.

**Uses and benefits**

The forests are a place for shifting cultivation but since moving to their current settlement the area available for cultivation, outside the Kawasan Hutan restricted zones, is small (Fig 6.16). Shifting cultivation is still practiced in the old village area. The forests remain an important source of firewood and building timber, mostly for local use but some is sold. For harvesting timber, permission needs to be sought from the local traditional leader or landowner.

Hunting and gathering food in the forest is still practiced and, at times, is a useful addition to the local diet but it has become less important since the introduction of a subsidised rice program (RASKIN). Honey collecting, for local consumption and as a source of income, is also still practiced. The use of medicinal plants has largely been replaced by medicines available through the local clinic.
Causes of forest cover change

Proximate forces
This coastal area has been the site of large population increase over the last twenty years due to the translocation of people. Multiple settlements have been developed in once forested land. First, in 1989, the people of Nuatuas move from their mountain village:

It was all forest here when I first came. There were many white woods (eucalyptus) and each tree needed four men to hug it. We cut them for farming and to build our houses.

Following the division of Nuataus into three villages in 1998 Desa Tuakau became the location of a large translocation settlement (Fig 6.17).

In 2000, a local transmigration program began and it started in two steps. There was a request from the regency to start the program and they first approached the villagers here. A settlement existed in Sub Village 5 (Siumolo) before new village establishment. The landowners gave their land for local translocation program. Then there was a request from the district to build houses.
The clearing of native forests also occurred in the area of the old village area to develop a commercial timber plantation in 1991 shortly after the community resettled near the coast. Other causes of forest cover change cited include increased logging due to a higher population requiring more building timber, better road access to some areas and a wider use of chainsaws.

*Forests that can be reached by car are gone. Now there is no forest around here that still has big trees. For us in Nuataus, the forest still exists because it cannot be reached by a car so it is too difficult for those who want to take wood from it.*

![Image](image_url)

Figure 6.17 New cultivation at Tuakau with intact monsoon rainforest on the hills behind.

**Driving forces**

One academic described the translocations as follows:

*There are no feasibility studies for the translocation because it is a local project by the local department of translocation. So they move them to the new place and they cut down the forest and because government policy changed after the Soeharto regime the Kabupaten government can do what they want.*

The community was initially reluctant to move from their old village to the coastal settlement but felt they had no choice:
We moved to this place because ABRI Masuk Desa (AMD; village military program) asked us. If AMD didn’t ask us, we would never move. We would still be in the old village.

It was a difficult move for many, leaving behind their gardens and livestock, yet it has resulted in better access to health care, education, markets and subsidised food programs. Housing at the new settlement however has long been inadequate and the new house program at Tuakau was supported because:

We thought the translocation settlement was only for the local people, so we agreed. However, more outsiders lived in the new settlement than the local people. We protested all day and an officer from the district said that we must stop protesting and told us that the government would give us houses to live. They lied to us. First they built 100 houses and after that many outsiders came in and lived in those houses, but there were only few local people got the houses to live in the location of local transmigration....If we had known it was going to be like this, we would not have given the land for settlement.

The settlement at Tuakau, organised by the Kabupaten Kupang department of Translocation, provided housing (Fig 6.18) to poor people from a range of places in Kabupaten Kupang. Some clearing on the forested hills in Tuakau were attributed to the new translocation people.

With regards to the clearing and development of the plantation in the old Nuataus area one interviewee described how they had no say in the development:

We could not do anything because it was the government’s program and we were very afraid of the government under Soeharto. If we spoke out we would be summoned. Our plantation was all taken by HTI (plantation forestry). People from Timor Tenggah Selatan Kabupaten came and cut the trees for HTI program. We could not do anything because it was all about money. Finally the Regent gathered us in Camplong and he said “The HTI that belongs to the government has suffered a financial lost so you are not allowed to take wood from HTI area.”
Impacts of Forest Cover Change

Changes in forest cover are seen together with impacts resulting from a range of cultural and livelihood changes associated with translocation and forest zoning laws. Many of the local interviewees believed that pressures on local forests would continue to increase as more people move to the area. The interviewees linked forest cover loss in the hill country with increased flooding and landslide events impacting their lowland rice cultivation.

Figure 6.18 New housing at Taukau translocation camp

Future forest management

Government leadership was seen as a prerequisite for improved forest management:

We are now the migrants here so it is very difficult to do any reforestation.
In my opinion, it is difficult to involve the landowners in reforestation activities except if the government tells them to do so.

This is not surprising since the majority of the people living in this area are doing so at the request of the government. In Nuataus they describe a recent resurgence of traditional law governing forest use but its application is limited to the local community and some activities. There is also concern about increasing manganese prospecting, with people new to the area going into the hills and destabilising the
land by clearing vegetation and digging holes. This activity seems to be unregulated.

6.3.2 Integrated analysis

Relationships to the forest

The people in this area have had their relationship to their traditional lands and forest disrupted by the process of translocation. Some services formerly provided to them by the forest, such as medicine and food security, are now provided by the government. As livelihoods have changed so have their association with the forests.

Figure 6.19 Forest cover decrease from 1982 to 2006. The spatial analysis area is shown in blue and the main road in black. Cover increase is shown in green.

Causes and effects of forest cover change.

The largely roadside clearing, seen between 1982-1989 (Fig 6.19), is most likely a result of the Nuataus community translocating to this area in 1989 and clearing for housing, gardens and rice fields. Clearing from 1989 through to 2000 is primarily around upland hill forest and is probably due to an increasing population seeking new farming land and building timber. It is possible that some of the clearing occurred in order to obtain timber for the new settlement at Tuakau although this was not specifically mentioned in the interviews. Clearing between 2000 and 2006 is
centred on the development of the translocation camp and associated farming areas at Tuakau.

The proximate forces for the majority of the mapped clearing are the creation of new settlements and farming areas. Increasing population also resulted in increased clearing of forests on adjacent hills for farming and timber extraction. The primary driving force has been government translocation programs. The process of bringing the Timorese ‘mountain’ people to more accessible coastal areas has been ongoing for many decades. It was seen as an important part of unifying the nation and civilising ‘backward’ people. It was also a means of moving subsistence farmers from their traditional lands to free it for commercial production, as occurred in Nuataus, with the development of plantation forestry in their old village land. The need for new settlements has increased in recent years with a rising population and an influx of East Timorese refugees. Better infrastructure (i.e. roads), and better technology, (e.g. chainsaws) has also driven an increase in forest clearing. Decreased forest cover has meant that less forest timber is available, requiring people to grow their own. Increased flooding and siltation are also associated with upland clearing.

**Improving forest governance**

With decreasing local forests resources there has been a greater reliance on traditional community law to govern forest use. Although traditional law is practiced it has little influence over the major land holders and the newest settlers. Government programs have been implemented without regard for community concerns, resulting in some feelings within the community of anger and powerless in the face of government demands. More responsive community engagement by government planners is a prerequisite for better land management here.

**Conclusion**

Coastal translocation programs are likely to continue as the population of Kabupaten Kupang increases. These settlements pose unique problems to land management with few people having a traditional connection to the areas they settle or skills in lowland farming. The community is largely appreciative of the increased opportunities provided by resettlement but are wary of challenges ahead as increased pressures impact on limited coastal resources.
6.4 Amfoang Barat Daya (Letkole) #4

6.4.1 Interview results

Desa Letkole (Fig 6.20) was chosen for the interviews as it contained a large area of remaining forest and was a location of some recent change. Four interviews were conducted with senior members of the Letkole community.

![Figure 6.20 The location of the interview village. The spatial analysis study area is shown in blue, the village borders are shown in black and the current forest distribution is shown in green.](image)

**Background**

Communities in this area are strongly interconnected through the movement of people between villages. Traditional customary practices are still strong with the matrilineal tradition of husbands living in their wife’s village still being followed. The dominant language in this area is Atoni with many community members only having limited knowledge of Bahasa Indonesia.

Letkole is remote, and access to villages in this region is very difficult. Much of this area is described as existing within Kawasan Hutan, a combination of protected and production forest (Fig 6.21). This zoning was said to have occurred in 1977. Some of the villages in this area are within enclaves surrounded by Kawasan Hutan. A fence has been built around Letkole village to separate the area for cultivation from the Kawasan Hutan (Fig 6.22). This fence was ordered by the village leaders to prevent...
conflict with the government. The small size and isolation of this community means that the local leaders have strong control and traditional laws operate here to ensure that the Kawasan Hutan zone is not over exploited.

Figure 6.21 Forests surrounding Letkole Village. (Photo I W. Mudita)

Teak and lomtoro planted within this area provide the community the majority of their timber and firewood needs. The remoteness of the village and the poor quality of the roads means the village is largely isolated from external influences, and opportunities for commercial trade are limited.

Figure 6.22 The village fence demarking the village land. (Photo I W. Mudita)
**Uses/Benefits**

For most people the forest is a place for shifting cultivation. This is in conflict with the zoning of the majority of the forest as Kawasan Hutan within which this activity is prohibited. Shifting cultivation is now either conducted illegally or confined to village settlement enclaves within the Kawasan Hutan. However gathering of non timber forest products is permitted within the Kawasan Hutan and remains an important part of the culture and livelihoods for Letkole people.

*We make gardens every year which is enough for our food needs. If sometimes the harvest is low, we supplement our diet with forest tubers and by hunting.*

*We hunt deer, wild pigs, civet cats, chickens, moneys, birds, kus-kus for the meat. Usually we hunt during the clear months like now (July). Some trap chickens, pigs, monkeys, likewise we hunt with dogs for deer, kus-kus, monkey, pig. Birds we shoot with air-guns. Here dogs are very important, every house has many dogs. The meat we just eat. If we want to sell, to who? We are far from everywhere.*

The forest is also described as a source of medicine, fodder and honey. Occasionally small quantities of timber are taken from the Kawasan Hutan for building houses or public buildings (Fig 6.23).

*We usually take wood less than 1 cubic meter so we don’t have to ask permission. If we take a lot of wood, we have to ask permission from the district forestry office. The people here usually use cajuput, red wood (matani), kayu kmeku for building materials. I don’t agree if the woods are taken out of the village because the people here also need the wood.*

Small amounts of teak grown by the community are sold but most of the timber harvested by the community is used by the community. Poor access makes transporting timber out of this area difficult.
Causes of forest cover change

A primary cause of change, as described by a forestry department officer, was due to a program encouraging the development of commercial tree crops such as cashew within the forest area of Kecamatan Amfoang. This program was known as *lahan compak* (land compact). Remote, community controlled land was targeted for this program. Large areas of forest land were cleared for plantations but, due to poor access to markets this program largely failed. Poor, uncontrolled farming practices resulting in fires lit to clear land escaping, and becoming destructive wild fires, which were also cited as a cause of forest loss. This project was an initiative of the Kabupaten Kupang government designed to raise revenue from some ‘underdeveloped’ parts of the Kabupaten after it received greater powers for planning and development through the regional autonomy process. ‘Lahan compak’ was not mentioned as operating at Letkole.

The village of Letkole moved to its current location from its previous flood prone river location in 2006. Some forest vegetation was cleared to build the new settlement. The Letkole interviewees attribute clearing in the surrounding hills (Fig 6.24) to unregulated shifting cultivation activities of a neighbouring coastal village. Increased population, cultivation and associated wild fires are seen as a major problem:

*The forest here is decreasing because the number of people here is increasing and opening new fields. Therefore there is sometimes fire in the forest which...*
causes worse damage. More forest is damaged because of the fire than of the process of opening a farming field. The production forest has never been on fire while the protected forest is on fire frequently.

Figure 6.24 Shifting cultivation clearing on steep hill sides near Letkole. (Photo I W. Mudita)

Impacts of forest cover change
The ‘lahan compak’ program encouraged people to refocus their livelihoods from traditional shifting cultivation and livestock rearing to commercial tree crop plantations. The failure of this program is said to have seriously impacted the forests and people’s traditional livelihoods.

Changes in the forest administrative classification has dramatically limited the area of land available to local communities for cultivation. There are mixed feelings within the community about government control of forests:

The forest here became Kawasan Hutan protected in 1977... When the officials came here to set the forest boundary it included some land that had houses on it for example the village secretary’s house. The community was not brave enough to protest, at that time the officials were abusing their power and the people here were scared of the army, ...the local people did not want to give the land but they cannot fight back. I say that it is good to protect the forest because people can keep having children but the forest
cannot keep expanding so it is important for the government to protect the forest.

The community lives a subsistence lifestyle mostly within the boundary of their settlement area. Their traditional hunting and gathering activities in the Kawasan Hutan have not been substantially affected by changes in forest cover and zoning. Activities designed to improve the local economy are ineffective or unavailable due to the poor quality of the roads.

Future forest management
The interviewees believe that there needs to be more encouragement for growing useful tree species such as lomtoro within village areas to reduce the use of the forest for firewood and farming. There also needs to be more support for growing local useful tree species such as casurina, tamarind, meranti and kusambi. Reforestation of areas which are prone to erosion is also recognised as a priority.

6.4.2 Integrated analysis
Relationships to the forest.
Due to their isolation, the people of Letkole have the strongest traditional relationship to their forests compared with the people at other case study sites. Their livelihoods are strongly linked to the forests, and forest use is guided by strong customary law. Although the extent to which the forest is farmed has changed with the imposition of government restrictions, generally the way it is used has not.

Causes and effects of forest cover change.
This size and number of cleared forest patches has increased dramatically over the mapping period (figure 6.25). This is particularly apparent from 2000-2006 where several very large clearings are apparent. The only land clearing event specifically described as occurring in Letkole, i.e. moving of the village away from the river in 2006, is not clearly visible in the mapping.
The primary proximate cause of forest cover change in this area is due to shifting cultivation. Increased clearing was described as being related to an increasing population and poor farming practices resulting in damaging wildfires. The driving forces here are increased population density and less regulation of forest use. The marked increase in forest cover change through 1994 to 2006 is attributed to less government control in the post Soeharto era. Land clearing for commercial plantation development through the lahan compa’ program was also described as an important cause of deforestation but it was not mentioned by the local community in this area. This program may have evolved out of the shift to regional autonomy and a desire to raise more local revenue through economic development programs.

Impacts
No direct impacts from forest cover change in Letkole are described although the introduction of Kawasan Hutan laws has required a large amount of livelihood adaptation. Although local impacts are yet to be felt, the increasing clearing of upland forests has a potential impact on downstream water quality. An example of this was visible 12 kilometers to the north-east of Letkole, just outside the important Timau protected forest area, where a large landslip was visible on the 2006 imagery (Fig 6.26). A total of 18 ha of forest were cleared between 1994 and 2000 on land at
450 meters (asl) with slopes up to 32%. It appears that this clearing could have contributed to the 20ha land slip. The potential effect on downstream catchment health of this scale of erosive soil loss is considerable. The scale of clearing in this relatively remote upland area is also significant. It is often easier to clear one large plot rather than many small ones, especially if the site is far from a village, but the larger the plot the slower the rate of forest regeneration and the greater the potential for soil erosion (Monk KA 1997).

Figure 6.26 Landsat image time series showing upland forest clearing from 1994 to 2000, an area of 18ha highlighted in yellow, and a subsequent landslip of around 20ha clearly visible in the 2006 image.

**Improving forest governance**

In Letkole strong traditional governance and customary law is seen to be effective in protecting local forests resources. The re-establishment of effective government control is required to improve forest management elsewhere in this area.
Conclusion

Well governed, traditional shifting agricultural practice can be a sustaining and sustainable forest land use. Attempts to restrict or change livelihood focus from shifting to permanent or plantation agriculture may be more damaging than careful management of traditional practices. Increasing population pressure and government economic development programs can have a damaging impact on pland forests which in turn may have negative impacts lower in the catchment.
Chapter 7 Discussion

7.1 Introduction
This chapter explores the four research questions; (1) Are the forests of West Timor important? (2) What is the current status of the forests in Kabupaten Kupang and what impacts have there been from the mapped change? (3) What forces are driving the change in forest cover?, and lastly (4) was ‘socialising the pixel’ effective for assessing forest cover change at a regional level?

7.2 The importance of Kabupaten Kupang’s forests.
The forests in Kabupaten Kupang are globally significant in that they support some rare endemic biota. Also important are the services that the forests provide to local rural communities. There was wide variation between the case study communities in the way they related to and valued the forests around them. In all cases their relationship had changed significantly in recent decades due to people’s movement from their traditional land (translocation), the imposition of government forest use restrictions, the provision of government services supplanting those that were once provided by the forest, and deforestation (Table 7.1). The way forests are now used, governed and valued also differed between sites but in most cases they were considered important for livelihoods, wellbeing and culture (Table 7.2).

Table 7.1 The primary forces driving change in the way communities relate to forests.

<table>
<thead>
<tr>
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<th>Translocation</th>
<th>Government forest laws</th>
<th>Provision of services</th>
<th>Deforestation</th>
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<tbody>
<tr>
<td>1-Amarasi</td>
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<td>x</td>
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<td>x</td>
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<tr>
<td>2-Bipolo</td>
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<tr>
<td>3-Nuataus</td>
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<td>4-Letkole</td>
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Table 7.2 The primary ways forests were used (blue), valued for services (green) and governed (pink) and in the case study communities.

<table>
<thead>
<tr>
<th></th>
<th>(1) Amarasi</th>
<th>(2) Bipolo</th>
<th>(3) Nuataus</th>
<th>(4) Letkole</th>
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<tr>
<td>Shifting Cultivation</td>
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<tr>
<td>Timber</td>
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<td>Food</td>
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<tr>
<td>Medicines and honey</td>
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<td>Water services</td>
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<td>Sacred forests</td>
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<td>Governed by Customary law</td>
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<td>Governed by government law</td>
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The Bipolo community describe their Netaopi forest in terms similar to the way McWilliam (2001) outlined the traditional Timorese concept of sacred, or *le’u* forests, as ancestral gifts. However their rights to govern this forest have been long extinguished by government law and commercial exploitation. Nevertheless the forest is still considered sacred and vital for the future of their community. The Bipolo was the only community studied that did not use forests for shifting agriculture.

Traditional law is strongest in the remote mountain village of Letkole where it has adapted to fit with Kawasan Hutan laws governing forest use. The people here still rely on many forest resources to supplement their livelihoods. In contrast the coastal settlements of Nuataus and Tuakau are far from the residents’ traditional lands. The people of Nuataus maintain a connection to their old village and their remaining *le’u* forests by arduous travel on foot and horseback. Land use around the coastal settlements is influenced by the fact that the residents have no traditional connection to the land on which they live. Damaging manganese exploration, for example, was described as a thoughtless activity conducted by “new arrivals” over whom traditional governance had no sway.

Known for its innovative forestry practices, Amarasi seems to have suffered the greatest breakdown of traditional law compared to the other study sites. At this site forests were seen primarily as a resource, for fertile land and timber. The traditional
elders expressed frustration at the lack of adherence to traditional ways and the failure of government to regulate forest use.

7.3 The state of Kabupaten Kupang’s forests and the impacts of the mapped changes.

Forest cover in 2006 was 17% (854 km$^2$) of mainland Kabupaten Kupang which is substantially lower than the estimated national coverage of 48% (Table 2.2). The following is a description of the forest cover in terms of catchment services, livelihoods, biodiversity and carbon storage and capture.

**Catchment**

According to national regulations, 30% of a catchment should be forested (Rachman 2002). The results from this study show that three major catchments (Oesau, Noelmina, Tarmanu) in Kabupaten Kupang all have substantially less than this amount. Two of the catchments, Oesau and Noelmina, with only about 10% cover, have been identified as high priorities for rehabilitation. Many upland areas are zoned as protected forest (Hutan Lindung) in order to protect catchment services. However, in Kabupaten Kupang, less than a third of the protected forest zone and slightly less than a third of upland country (>550m) is forested. These data suggest considerable scope for upland re-forestation activities or the redrawing of protected forest boundaries.

Upland clearing in Kabupaten Kupang, often on steep slopes, has the potential to cause a downstream reduction in water quality as evidenced by large landslips (Fig 6.42). More intensive use of upland forests as shown in the Letkole case study (#4) area could impact on catchment services. Forest loss or degradation is seen as the primary cause of water supply problems by interviewees. Although the role of forests in regulating water flow is contentious, dry springs and rivers, erratic rainfall and more destructive floods were all seen by the interviewees to be related to reduced forest cover. This perception may be related to the fact that more people are now living on and cultivating, naturally flood prone coastal land.

**Livelihoods**

Almost half (44%) of the mapped forest occurred outside Kawasan Hutan zoning, allowing local communities to continue traditional shifting cultivation unimpeded
by government regulation. The fact that little forest remains on flat land at lower altitudes indicates that the most accessible land has been converted to non-forest uses. Proximity to Kupang, access to markets and transport infrastructure may also be factors influencing a shift from forest dependent subsistence agriculture to more commercial agricultural ventures (Fig 5.3).

Livelihoods have changed more as a result of government policy and infrastructure development than through changes in forest cover. Government laws restricting access to forests, resettlement and road building have resulted in less dependency on forest resources. However in areas of increasing cultivation (Amfoang, Nuataus, Amarasi) there is a risk that, as more marginal (steep, infertile) land is utilized by the rural poor, the resulting environmental degradation (Fig 6.26) will lower productivity and increase poverty, creating a positive feedback loop of impoverishment. This two way link between poverty and the environment (Fig 7.1) is not necessarily a downward spiral. Investment, appropriate technology, good governance and agricultural innovation can reverse this trend (Shiferaw 2006).

**Biodiversity**

The most important forests in conservation terms, due to their limited distribution and unique biota, are the monsoon, mangrove and Ampupu forests. Substantial amounts of monsoon forest still exists although very little in lowland or flat areas. The Ampupu forest occur largely in remote mountainous areas, and work by the World Wildlife Fund suggests that they have been extensively degraded by over-grazing (Lentz, Mallo & Bowe 1998). Only 3.6% of forests in Kabupaten Kupang,
compared with 14% nationally (Fig 3.17), are within some form of conservation zoning. Over two thirds of the land within conservation zoning has no forest. The conservation parks that do exist are designed to protect some plateau monsoon forest (Yohannas Grand Park) and mangrove forest, although enforcement of forest protection laws is weak. This study strongly suggests that the present protected area network is inadequate and there is scope for an expansion of the nature reserve system to be more representative of forest ecosystems in Kabupaten Kupang.

The little research that has been conducted for developing base-line biodiversity data in West Timor has focused on the avifauna. Bipolo is one site with international recognition as an important site for endemic bird species. The dramatic decline in forest cover at Bipolo would suggest a similar fate for the size and diversity of the bird population. A survey of this site showed a similar range of species to earlier surveys but a substantial decline in numbers (R. Noske, pers. comm. November 2009). The interviewees’ responses to questions about hunting suggest that many larger mammals (deer, cus cus, civet cats, pigs) are still common in remote forests however their numbers quickly decline once roads are built into a previously inaccessible area. Hunting is part of the culture of many forest communities and so preventing people from harvesting such non-timber forest products is difficult. An understanding within government of Timor of the unique avifauna was evident in public awareness promotions such as a Kupang airport poster calling for Timor’s unique birds to be left free in nature (Fig 7.2). Although this is a positive first step, effective biodiversity conservation needs on ground activities.

Figure 7.2 National forestry department information and awareness raising poster showing the bird species unique to Timor Island.
Carbon storage and capture
The 854 km$^2$ of forest in Kabupaten Kupang could represent a significant carbon store however research is needed to determine the storage capacity of the various forest cover types. The forest distribution data provided by this study could act as useful base data for estimating total carbon storage in this landscape.

The development of REDD type schemes in Kabupaten Kupang appear limited as there is no large scale forest conversion and so no opportunities to significantly reduce carbon emissions by preventing forest conversion. Emissions from shifting cultivation should be in a state of equilibrium as burnt vegetation is also left to regrow. However there could be a net carbon loss due to increasing shifting cultivation in primary forests and wild fires resulting from careless clearing. With more careful management, shifting cultivation could remain a carbon neutral activity. Further research could quantify the scale of carbon loss due to shifting and evaluate its potential in terms of REDD type investments.

7.4 The forces behind forest cover change in West Timor.

The forces involved in forest cover change at the four case study sites are presented in Table 7.3. Results from this study concur with work conducted by Fox and Vogler (2005) and Geist and Lambin (2002) in showing that two or three proximate variables and three to five driving variables have influenced forest cover change.

Sunderlin and Resosudermo’s review (1996), detailed in chapter 2, identified six proximate forces in Indonesian deforestation; shifting cultivation, agroforestry, transmigration, population density, timber industry, estates and plantations. The results of the present study are broadly consistent with some of his findings and inconsistent with others.

Table 7.3 The forces perceived to be involved in forest cover change over the study period (1972-2006), adapted from Geist, and Lambin (2002).

<table>
<thead>
<tr>
<th>Proximate</th>
<th>1-Amarasi</th>
<th>2-Bipolo</th>
<th>3-Nuataus</th>
<th>4-Letkole</th>
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Agricultural expansion, most commonly in the form of shifting cultivation, was cited as a cause of forest loss at all the case study sites. This is despite the government of Indonesian, like other countries in the region, attempting to limit its practice and develop a more economically productive agricultural sector by declaring areas as protected forest, resettling people in the lowlands, and promoting permanent agriculture. Sunderlin’s work suggested that the impact of shifting cultivation had previously been over stated yet this study shows that, when driven by population increase, poor institutional governance and changes in cultural attitudes, its effect on forest cover could be significant. Although shifting cultivation has been practiced in this region for many generations and is a sustainable and appropriate land use in many situations (Fox, J 2000). It appears in some landscapes in Kabupaten Kupang, particularly in the uplands of Amfoang, to be reducing forest cover. In contrast to other parts of Indonesia, small holder agroforestry was not found to be the cause of forest loss in Kabupaten Kupang except when actively facilitated by government programs.

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<tr>
<td>Agricultural expansion</td>
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<tr>
<td>Permanent</td>
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<tr>
<td>Shifting</td>
<td>x</td>
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<td>Wood Extraction</td>
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<td>Commercial</td>
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<tr>
<td>Infrastructure Expansion</td>
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<td>Settlement</td>
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<td>Other</td>
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Number of forces: 3 3 3 2

Driving

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<td>Economic</td>
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<td>Population</td>
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Number of forces: 5 4 4 3
Translocation, not transmigration, was found to be having a substantial impact on land use and land cover in Kabupaten Kupang. Infrastructure expansion through the development of new settlements was a factor in most of the study sites. Multiple waves of settlement have occurred at both Nuataus and Bipolo largely driven by translocation policy. Some additional pressure was placed on the translocation program with the need to resettle and integrate East Timorese refugees. The projected large population increase (Fig 3.12) will have an increasing impact on Kabupaten Kupang’s natural resources, particularly if the policy of resettling people on new land is to continue.

Although the timber industry was not found to be a cause of large scale change, in most of Kabupaten Kupang, wood extraction was a contributing factor in most of the case study sites. The extraction of wood differed in degree and driving forces at each site. Commercial timber logging was a primary force in forest loss only at Site 2 (Bipolo). Much of the logging here occurred as part of the Soeharto regime’s policy of awarding large timber concessions to form political alliances and promote economic development. At Site 3 (Nuataus) logging was mostly small scale and conducted by external operators. Policies aimed at developing a commercial plantation industry drove one economically unsuccessful venture at Nuataus. At Site 1 (Amarasi) logging was said to be conducted illegally, primarily by local operators driven by reduced traditional and government forest governance. In both Nuataus and Amarasi, the development of better transport infrastructure and mechanical harvesting technology was also a driving factor. Harvesting timber for domestic use was not mentioned as a cause of forest cover change by any of the interviewees.

These results show how multiple driving forces work together to create situations conducive to forest cover change (Fig 7.3). Immigration, translocation and resident population increases with less effective government regulation of forest use, in the post Soeharto Era, are placing more agricultural pressure on some forests. Resettlement of communities on land closer to government services has broken traditional ties and diminished customary law governing the way forests are used. Modern tools such as chain-saws and trucks also allow for more rapid forest conversion. These driving forces are in turn driven by broader political forces which, in Indonesia, have changed radically during the course of this study. The fall of Soeharto, the economic crisis, reformasi and decentralisation have all had
profound impacts on forest governance, land rights, and economic development. Some political forces are a continuation of policies designed to develop the economy and unify the nation whilst others are a direct result of democracy and regional autonomy.

Democracy, regional autonomy and the economic crisis
Under the current system of regional autonomy there is greater incentive for local government to commercially exploit their forest resources. Whereas previously the Kabupaten received very little direct revenue from forests use, they now get the majority (64%). This, along with a need for more revenue to be raised at the Kabupaten level to support local development, has increased pressure on local forest (Holtzappel & Ramstedt 2010). In Kabupaten Kupang policies promoting the development of commercial tree crops in Amfoang (lahan compak) and increasing timber taxes may have been examples of changes in forest policy to increase district government revenue.

In contrast to some other regions of Indonesia (Sunderlin, W. D. et al. 2000) the economic crisis of the mid-nineties did not appear to be an influencing factor on forest use in Kabupaten Kupang. The largely subsistence lifestyle of many people would have insulated them from the worst effects of the economic crisis. Furthermore the lack of a large commercial tree crop industry also protected the forests from being cleared to exploit high commodity prices, at this time, as occurred elsewhere. Fox (2009a) has described a shift, in some parts of South East Asia, from land use change being predominantly driven by national policies to one driven by expanding and internationalizing commercial opportunities this does not appear to be the case in West Timor.

Forest Governance
The expansion of state forest management, during the Soeharto regime, in many cases, resulted in extinguishing of customary rights to traditional lands and has had a profound effect on many communities’ traditional livelihoods. Some described themselves as living in enclaves within Kawsan Hutan, resulting in less land being available for agriculture and thus requiring an intensification of land use. A history of minimal community consultation when defining Kawsan Hutan zones has resulted in confusion about their location and land tenure insecurity. Without tenure security there is less inclination for land management with a long term,
sustainable perspective. Clearer communication and more consultation is necessary to promote better cooperative land management between local communities and government. The process of Kawasan Hutan boundary delineation and classification has been highlighted by one as an impediment to good forest management and in need of reform (McCarthy 2000). Anomalies in the classification of Kawasan Hutan zones relative to the actual occurrence of forest is also a source of confusion and land use conflict throughout Indonesia. New Kawasan Hutan zones were being formulated during the course of this study with the purpose of defining boundaries more responsive to the on-ground biophysical and social-cultural realities although none of the interviewees in this study mentioned that they had been consulted about this process.

The post-Soeharto era of regional autonomy has also seen a break down of forest law enforcement as fewer funds are available for policing and there is less political will by locally elected leaders to enforce laws on their electorate. Former concessions for forest exploitation were given to a few select companies and, with military backing, forestry laws were strictly enforced.

7.5 Socialising the pixel

7.5.1 Introduction
Remote sensing studies are often represented as being detached and objective yet critics suggest that their simplistic quantitative results tend to mask the social, political and economic contexts necessary for answering important land-use and land management questions (Elwood 2006; Matthew, T & Peter 2003). To address this, new synergies are being found between the social and spatial sciences. Through spatial science social scientists are gaining a better sense of spatial context through understanding the roles of scale, place and connectivity. Conversely spatial scientists are gaining skills from the social sciences for documenting and analysing processes to develop a better sense of social and historic context (Fielding & Cisneros-Puebla 2009).

This study has shown the utility of remotely sensed data for directing social analysis to uncover multiple, interacting forces involved in forest cover change. Through exploring the social and historic context of a pixel, represented as static in space and time, a wealth of information, in some cases going back centuries and spanning continents, was uncovered. Rich and complex social narratives around every point
of change were found that would be impossible to infer through the analysis of spatial patterning alone. At times the interviews challenged the satellite interpretation, and vice versa, and through comparing the data sources a better understanding and new paths of investigation were developed. For example:

- The change at Nuataus (#3), initially thought (based on the literature, spatial patterning and some local advice) to be due to the development of a transmigration camp possibly for East Timorese refugees, was found to be a result of a more local movement of people related to national and regional policies.  
- The increasing clearing around Amfoang was thought to be solely from shifting cultivation. However government efforts to develop a tree crop economy was also a possible cause and the people of Letkole (#4) described a tightly controlled traditional approach to their forest use. Further on-ground research needs to be conducted to clarify the roles played by increasing population, the expansion of unregulated shifting cultivation and government development projects in the clearing mapped by this study.  
- In Amarasi (#1) the forest cover change was thought, based on the literature describing this region’s unique agriculture, to be related to agroforestry practices, yet none of the activities or events mentioned in the interviews conclusively described the mapped change. Further on-ground investigation is required to determine if the mapped change was a real change in land cover or a result of a short term seasonal flux. Without the interview data casting doubt over the image interpretation the large extent of forest cover change along the south coast (Amarasi) could be erroneously included in change mapping and reporting.
Figure 7.3 The causative relationship between the identified driving and proximate forces influencing forest cover in Kabupaten Kupang.
In remote sensing studies ‘ground truthing’ is the process of obtaining the biophysical ‘truth’ of a particular pixel location whilst the social-historic ‘ground truth’ is often ignored. However this research has shown that even a limited social science investigation can provide useful contextual detail about how things were, how they are now and why they have changed.

7.5.2 Limitations of this study

Forest cover mapping
Satellite derived land cover data are often presented as being authoritative and unambiguous however clear and detailed descriptions of the methods employed to validate these data are not always available. Moreover, controversy surrounding highly divergent estimates of tropical forest cover extent and change has been the cause of some concern (Achard et al. 2002).

Assessing the accuracy of satellite derived data is difficult and is often an afterthought in remote sensing studies. Obtaining representative and accurate biophysical ground truth data is particularly problematic in rugged, heterogeneous landscapes such as those of West Timor with poor road infrastructure limiting access, and modified roadside vegetation. In this study high resolution satellite imagery provided additional verification to the field data. By combining these two ground-truth data sources a better understanding of the landscape and the limitations of the Landsat imagery was obtained. Through simplifying the land-cover classification a useful forest map was produced, although it did not differentiate between a variety of vegetation types (ie scrub, modified secondary forest, primary forest), map deciduous forest or distinguish between planted and native forests. For this study it was considered most useful to produce a simple map (with limited discrimination between land cover classes) with a reasonably high level of accuracy. It would be a useful task to further classify particular forest patches or landscapes to determine if it was possible to accurately map a wider variety of land cover types.

The accuracy of cover change data derived from satellites is often not rigorously assessed. It is assumed that if the accuracy of the land cover classification technique is good then the accuracy of the mapped change between image dates will also be reasonable. This approach is problematic in West Timor as consistent land cover
attribution between dates is difficult because of rugged terrain and highly variable climate. In this study the interview process proved valuable as a form of historic ‘ground truth’ for validation of the cover change mapping. This approach however limited change detection to a few small case studies.

Remote sensing and GIS are not neutral tools; even apparently ‘objective’ maps are socially constructed. GIS has the potential to reduce or exacerbate social inequities, to further concentrate power in a techno-elite or to democratise information, depending on who controls the information and its analysis (Dunn, Atkins & Townsend 1997). The method used in this study maintained a separation between the researcher as analyst and map maker, and the subject of research, the place and the people. In this context traditional criticisms of the elitist, non-inclusive and disempowering nature of GIS are, to some extent, validly applied to this study. However, by choosing not to quantify and describe forest cover outside of the case study sites, a decision was made to analyse only spatial data that was linked to ‘social ground truth’ data which provided social and historic context. In this way voice was given to some local perspectives.

Social survey

The small scale of this project limited the time and scope for the interview component to the extent that its validity may be questioned. To counter potential criticisms of his work in the montane forests of mainland South East Asia, Fox (2005) contended that:

“Many analysts argue that these samples are too small to make any meaningful conclusions. We submit that an oral history or narrative perspective allows us to develop an understanding of change through historical detail and interpretation. Historical analyses of landscape grasp the complexity of events, in particular stochastic or non-random but unpredictable events that significantly affect land-cover and land-use change. They include changing political economies, environmental feedback on land use, and external shocks.” (p. 402)

I would similarly assert that the present study, although having an even smaller sample size than Fox’s, makes a useful contribution to understanding the nature of forest cover change in West Timor. However I also acknowledge that the results would have been substantially more informative if they included more interviews
from a broader range of community members, particularly women and younger people. More interviews with more rigorous analysis would have provided more robust results. Direct reference to the satellite mapping at the time of the local interviews may have also provided more opportunity for more input into the interpretation process. Although these limitations suggest the results are more indicative than authoritative, I believe they are useful for directing further work and sufficient to inform some policy directions.
Chapter 8 Conclusions and Implications.

This chapter describes the main conclusions from this study and the implications of this work on policy and practice and further research.

8.1 Major conclusions

The following major conclusions have been drawn from this study:

- Forest cover in Kabupaten Kupang has decreased over the period of this study (1972-2006) with some regions showing an increase in the rate of forest loss. The causes of this change, consistent with similar studies, were found to be multivariate and location specific. Although the combination of factors influencing forest cover change varied between study sites, three common interacting factors/mechanisms were identified: (1) immigration and translocation, (2) tenure insecurity, and (3) reduced forest governance. These factors were, in turn, driven by broader political forces formerly related to national building (unification), and more recently related to democracy and regional autonomy. More specifically it is concluded that the:

  1. Official translocation and the unofficial local migration of communities has broken traditional ties with land and diminished customary law governing the way forests are used (case studies 1,2,3).
  2. A history of minimal community consultation when defining Kawasan Hutan zones has resulted in confusion about the location of these zones, and in land tenure insecurity (case studies 2,3,4). Without tenure security there is less inclination for land management with a long term, sustainable perspective (case studies 2,3).
  3. There has been a reduction in resources and government authority with regards to forest policing and management during the era of regional autonomy (case studies 1,2,3).

- Improving forest management is important for sustaining the livelihoods for many rural people in Kabupaten Kupang. Furthermore poor government
engagement and collaboration with local communities has often resulted in unsustainable forest use (Chapter 6).

- Even a limited social science investigation, linked to satellite data, provides contextual detail about how forests have changed, why they are as they are, and how management could be improved. Furthermore social research can be an important source of validation data, particularly where alternate sources of historic ground truth are absent.

- Satellite and other spatial data can be a useful tool for directing social science research, particularly to aid the strategic selection of multiple case studies to increase the capacity for generalization.

8.2 Implications

In this study, forest products and services were found to be a significant part of all rural communities’ livelihoods (Chapter 7.2), although a breakdown in government and traditional governance threatened the sustainable use of the forests. The movement of people around Kabupaten Kupang has changed the relationship most communities have with the land that supports them. Sacred or le’u associations in most cases are no longer a force governing land use. Traditional law and tenure has also, in most cases, been over-ridden by government law and tenure however a post ‘New-Order’ breakdown in government law enforcement has left a power vacuum in forest management (Resosudarmo 2004). This, linked with continuing forest cover loss, shown by the satellite data, implies that without renewed respect for traditional law, and collaboration between government and local communities/villages, pressures on the remaining forests will most likely continue to have negative impacts on the livelihoods of rural people in Kabupaten Kupang.

The conclusion that linking social science research to satellite data provides substantially more information, than that provided by either discipline in isolation, implies that this type of integrative research is useful for maximising the utility of remote sensing studies. This is particularly true for tropical forest monitoring where huge resources are being put into the developing forest cover change metrics, which provide little insight into underlying causes and are therefore of limited use for improving forest management. This study also found the social science field research to be a valuable source of validation data, which, at times, contradicted the
assumed nature of mapped changed as assessed from the satellite data alone. This implies a greater role for qualitative field research as a form of historic ‘ground truthing’ for improving the accuracy of satellite based land cover change research particularly where other historic data are unavailable.

The conclusion that satellite data can also be useful for informing social science research also implies a potential synergy between the disciplines that is harnessed when research is developed in an interdisciplinary, as opposed to a multidisciplinary, mode. Through an interdisciplinary approach, spatial and social sciences can inform the direction of research though a two-way dialogue to produces new methods of inquiry. A traditional multidisciplinary research approach to forest cover change assessment, whereby the disciplines maintain discrete research methods, reduces the potential for practical application of the research results.

8.3 Policy and practice recommendations

Forest mapping and monitoring
Regional autonomy, decreased technology costs, an increasing availability of spatial data and an increasing range of GIS tools for facilitating community engagement is providing opportunities for more proactive land management initiatives. The decentralisation of mapping skills could be an important component of better governance and natural resource management in Kabupaten Kupang.

In recent years GIS techniques have evolved to enhance participatory planning processes or collaborative decision making, which counter some of the criticisms of the potentially disempowering nature of mainstream GIS (Elwood 2006). This has included ‘counter-mapping’ techniques where local communities produce their own map ‘truths’ showing traditional tenure and land use to ‘counter’ state maps and support claims for greater local management rights to local resources. Another example of this type of inclusive, community led GIS is 3D participatory mapping. In Timor Leste, for example, topographic models, created out of cardboard and paper by representatives from catchment communities, are being used as a focal point for people to discuss and negotiate land use, land tenure and management issues and to see interrelationships (Capelao & Merza 2009). In Kabupaten Kupang, where forest management has been hampered by poor communication and community engagement there could be great benefits in using such participatory
mapping approaches for developing negotiated land management outcomes such as respected forest management boundaries (Kawasan Hutan), integrated catchment management planning and community/government action plans to deal with the cause and effects of uncontrolled deforestation and forest degradation.

Maps can add authority to local knowledge and help communities or local governments to engage in dialogues that promote their issues and concerns to higher level authorities and economic forces. Conversely Fox (2009b) argues that if local people do not have control of their maps, they could be worse off than before their lands were mapped. Currently most assessments of land resources based on satellite imagery (such as this one) are conducted by outsiders. Ideally a functioning capacity for data collection, archiving and analysis should exist at the Kabupaten level, as skills held by people aware of local issues. Satellite imagery, in this context, could be a powerful tool to monitor landscape change as an indicator of policy outcomes, development activities and management decisions. However through the process of regional autonomy, there has been a devolution of budgeting and planning powers to the Kabupaten level without a corresponding provision of the base data and analysis skills required for good decision making (Jepson et al. 2001) Along with initiatives at a national level driven by globally important, concerns there is an opportunity for a parallel development supporting the capacity for local governments to map and monitor natural resources to directly inform decision making. The successful operational implementation of satellite remote sensing monitoring in West Timor will require the following:

- Training of mid and senior level managers from local natural resource and agriculture departments in remote sensing applications that could assist their planning and management tasks. It needs to be clearly shown how this tool will empower decision makers in order to engender top-down support.
- Lobbying of national and international funding agencies to promote the benefits of local capacity in the use of remote sensing tools for good governance.
- Developing regional skill sharing networks and development of clear national and regional data sharing protocols.

As the international pressure mounts and support for a reduction in deforestation in Indonesia through, primarily satellite based monitoring and verification programs
(WWF 2010), there should be concurrent social science analysis to provide social and historic context to the mapping. Effective management strategies can only be developed through on-ground investigations of the complex, and often locally specific, variables involved in deforestation. The decentralisation of forest monitoring could promote the implementation of social analysis and its incorporation into improved forest management.

It is clear why mixed method projects of this type are generally undertaken by multi-disciplinary teams. Nevertheless it is useful for the spatial scientist and the social scientist to have a good understanding each other’s methods and outputs and to find potential synergies that form successful research projects.

**Catchment**

Efforts to restrict the impact of shifting cultivation on upland forest through resettlement and restrictive zoning is clearly not working in some areas of Kabupaten Kupang. New economic and population pressures and less policing are driving agricultural expansion into increasingly marginal land. Most policy planning aimed at protecting upland forests has been prohibitive rather than proactive. Various authors have argued that for sustainable and improved catchment management there needs to be payment for the environmental services provided by forest dwellers (Dudley & Stolton 2003) and/or a focus on conservation as a means of increasing productivity and managing risks (Shiferaw 2006). It has also been argued that limited shifting agriculture is the most sustainable land use for upland regions. Furthermore it is possible, depending on geomorphology and tree species used that, increasing forest cover in upper catchments, the stated goal of many catchment management programs, may increase evapotranspiration, lower water tables, reduce water flow from springs and creeks and exclude upland dwellers from their traditional lands. With these issues in mind policy should seek to:

- To find mutually supportive methods to support the enforcement of both traditional and government forest management laws.
- Invest in proactive, collaborative forest use policing and support partnerships between forest guards and local communities.
- Develop cooperative management strategies supporting negotiated land use/tenure arrangements.
• Educate and, where appropriate, employ local people to support forest conservation and rehabilitation.

Livelihoods
When planning projects aimed at improving livelihoods, it is important to consider the link between poverty and the environment (Fig 7.2). This is particularly pertinent in the seasonally dry tropics where environmental risks are high and livelihoods are precarious. A healthy landscape makes communities and local economies more resilient to environmental and economic perturbations. Activities supporting sustainable environmental management and farming practices, even when de-coupled from the cash economy, should be classed as a livelihood improvement.

When seeking to improve livelihoods through the economic analysis of investment and market opportunities, fundamental environmental constraints must be fully considered. Conversely, agricultural enterprise development should not be pursued without thorough market analysis. The poorly planned development of commercial crops in areas with poor access to markets, for example, can do more harm than good to the environment and to peoples livelihoods, as was described in the failed Amfoang *lahan compak* program (Chapter 6.4). An example of agricultural innovation for improved livelihoods was evident in Letkole (#4) where forests products such as fuel wood and building timber had been largely replaced by agro-forestry alternatives such as lomtoro or teak (Chapter 6.4). Policies aimed at supporting small-scale community agroforestry for fuel, timber and fodder could reduce pressure on forest resources and improve the long term sustainability of local communities.

Biodiversity and carbon storage
The lack of a representative conservation reserve system needs to addressed in order to sufficiently protect the variety of ecosystems and biodiversity in Kabupaten Kupang. Ideally policy requiring a protected area system, which encompasses representatives from all regional natural ecosystems, should be developed and comprehensive fauna and flora surveys should be conducted to highlight areas of high conservation value.

Biodiversity was generally not identified as an asset by local communities, other
than for hunting and wild harvest, by local communities, however they often appreciate the ‘natural beauty’ and, in some cases, the spiritual value of the forests around them. Although currently ecotourism is not a source of income for rural people in Kabupaten Kupang the Bipolo community could see the potential for developing tourism around their forest (Chapter 6.2). The only national park in Kabupaten Kupang (Yohannas Grand Forest Park in Amarasi) is not promoted as a tourism location and thus its conservation status contributes little to the livelihoods of the local people. Obvious opportunities exist to further develop ecotourism at both Bipolo and Amarasi although significant government support would be required to make this possible. Bipolo in particular requires urgent action to protect what remains of the once extensive forest. Bipolo forest should be rezoned as a protected conservation reserve, and active support provided to the local community to enable forest protection and rehabilitation. The development of ecotourism infrastructure would be one way of doing this. The amount of the land zoned for tourism or recreation in Kabupaten Kupang (3.6%) could be increased substantially to bring it closer to the national average (14%).

To date permanent forest conversion for agriculture in Kabupaten Kupang has been mostly small scale although any future development plans could factor in possible REDD investment opportunities. There may also be scope for profiting on a future carbon market in Kabupaten Kupang through reforestation projects. The development of driven projects driven by carbon markets must be carefully negotiated so as to have minimal negative impacts on the rights and livelihoods of local communities. The results from this study suggest that reforestation and plantation projects in the past have not been well socialized.

### 8.4 Further research

**Expanding the extent and depth of the ‘socialised pixel’**

The extent of land cover change data in this study that has been validated was spatially limited. The opportunity exists for expansion of the on-ground social surveys to extend these data to all of Kabupaten Kupang and thus provide a more comprehensive dataset on forest cover change. One way to do this would be to conduct interviews in all villages near forest cover change ‘hotspots’. A cover change ‘hot-spot’ could be defined as areas greater than a certain size where cumulative forest cover change has been significant. The size threshold of forest
cover change would be determined through an iterative process based on the need for a representative coverage of sites with forest cover change and the need to fit within the limits of the research resources. A more comprehensive survey would allow an assessment of how representative the sites chosen for this study were of situations elsewhere in the Kabupaten. Field work to gather further social and biophysical ground truth data should begin at Ratrean (Site 1) and Letkole (Site 4) to clarify the forces behind the FCC mapped in these areas.

In addition to extending the breadth of the social data, the depth could also be improved to make it more representative of the whole community, i.e. including women and poorer residents of the community. Research should be conducted into developing effective methods for rapid community field surveys to accompany developing national satellite based monitoring and verification initiatives. A range of formal rapid assessment techniques have been developed in a variety of disciplines that may be relevant to satellite based studies including Rapid Rural Appraisal, and Rapid Assessment Procedures for anthropological studies (Manderson & Aaby 1992). The development of rapid assessment procedures would allow the broad scale adoption of social survey standards to link with satellite data potentially allowing trained field staff, rather than requiring specialist social scientists, to carry out this work.

**Increasing the spatial and temporal resolution of forest cover mapping.**
The use of high resolution imagery to increase differentiation between land cover types would substantially increase the utility of the land cover mapping. New, low cost, high resolution satellite data, such as the Japanese ALOS imagery used in this study, provides an affordable opportunity for more detailed land cover mapping. New ‘object oriented’ image classification systems in tandem with local knowledge, existing and expanded field surveys could provide the pattern recognition technology and field data required for mapping such high resolution data.

There are also opportunities to extend the temporal extent and resolution of the forest cover mapping through using more recent imagery and continuous mapping every year. Yearly snapshots of forest cover would allow the contemporary validation of detected change, through field investigation, and thus avoid problems with retrospective assessments. This would also allow for more proactive management of forest cover change. Recent changes in the distribution of Landsat
imagery, making all new and archived acquisitions free, mean that developing on-going forest monitoring would be inexpensive.

**Catchment management research**

Catchment hydrology modelling would be valuable for informing the likely impact of reforestation projects on water flow and quality, and to identify degraded land most in need of stabilisation work. Another important input into catchment management planning would be research into upland catchment use by local communities allowing for controlled traditional shifting agriculture whilst providing payment for environmental services to protect and rehabilitate specific areas that are degraded or prone to degradation or of high conservation value. Participatory mapping exercises would also be useful to develop collaborative management plans, define agreed tenures and reduce potential conflict within and among communities, and between communities and government.

There are currently plans for a large reafforestation project in the Timau-Mutis region (upper Noelmina catchment), as a means of supporting current Indonesian government catchment reforestation objectives and to form the basis of a carbon offset scheme (pers comm. Kab Kupang forestry Dept staff). The research proposed above would increase the effectiveness and equality of such a project.

**Livelihoods**

Efforts to restrict the extent of agricultural expansion into new forest areas will partly depend on the development of alternative livelihoods. Livelihood research based around the forest rehabilitation, as described above, and conservation should also be pursued as options for improving forest governance.

Research into, small scale agroforestry species for timber, fuel, fodder and cash would provide information about options for livelihoods. Environmental, market and governance opportunities and constraints need to be assessed with regards to the development of new agroforestry systems. In particular research needs to focus on the following influencing variables:

- **Environmental**
  - Water availability
  - Soils fertility
  - Pests and diseases
Fire regimes

Governance
- Traditional and government tenure issues
- Government reforestation agriculture programs.

Economic
- Physical access to markets.
- Market chain analysis.

In rural and remote regions with limited market access, such as Letkole (#4), research should focus on non-commercial species. There may be a net environmental and economic benefit in assuring sustainable subsistence livelihoods in remote regions commensurate with that gained by developing commercial agroforestry in less isolated areas.

Biodiversity and carbon considerations
Currently Kabupaten Kupang does not have a representative Protected Area system protecting major habitat types. Improving mapping of land cover and land cover change, as described above, coupled with baseline fauna and flora surveys, would form the basis for developing recommendations for redefining the Protected Area system. Furthermore, there is the opportunity to develop ecotourism in Kabupaten Kupang in tandem with Protected Area development. Bipolo, Timau and Amarasi, have immediate potential for forest based tourism. Further research into opportunities and constraints with regard to: domestic and international market development, and government and community engagement is needed to guide the development of such an industry.

Research into the opportunities and constraints presented by the developing carbon economy would be useful for local government, to inform their engagement with this growing market. To facilitate this the carbon storage capacity of the various forest cover types needs to be determined and the net carbon loss or gain of different types of land use should be calculated. It would be valuable to specifically assess the carbon balance difference between rotational shifting cultivation and pioneer cultivation into previously uncultivated forest. This research could be linked to the development of forest management strategies aimed at supporting those activities with a net carbon gain, or neutral carbon balance. Such strategies
should encourage forest communities to develop agroforestry alternatives to opening shifting cultivation in new forest areas.

8.5 Concluding remarks

When compared to some other parts of Indonesia, the rate and extent of deforestation in West Timor is not large, and a satellite based assessment alone might conclude that it is not a critical issue. However this study has shown that when coupled with on-ground social data a much more complex picture emerges, related to key livelihood issues. The application of local knowledge to the analysis of satellite data was found to be particularly useful in the case study sites where the biophysical and social-economic situation is complex and unique. The causes of forest cover change were found to be multivariate and location specific. Increasing pressure on West Timor’s forests might be expected to increase environmental degradation, food insecurity and poverty. However, new opportunities to develop better collaborative forest management strategies are also evolving out of democracy and regional autonomy.

The decentralisation of technologies that enhance transparency and promote common interests in sustainable environmental management and economic wellbeing could be an important component of regional development in eastern Indonesia. Wise natural resource management could increase landscape health, and consequently, food security and access to clean water, as well as protecting important biodiversity. The land cover change issues investigated in the current study may not be important on a global scale, but are critical to developing a sustainable future for people in this poor and often overlooked part of South East Asia.
References


Barham, BL, Coomes, OT & Takasaki, Y 1999, 'Rain forest livelihoods: income generation, household wealth and forest use', Unasylva (FAO).

Barr, C 2001, 'Banking on sustainability: structural adjustment and forestry reform in post-Suharto Indonesia'.


Congalton, RG & Green, K 1999, Assessing the accuracy of remotely sensed data: principles and practices, CRC Press.

Cook, I & Crang, M 1995, *Doing ethnographies*, University of East Anglia.


Datta, FU 1993, ‘Socio-economic survey of communities adjoining forest areas on Sumba.’ Widya Mandira Catholic University., Kupang, NTT.


FAO, Rome.


Lentz, C, Mallo, M & Bowe, M 1998, 'Environmental Management in Gunung Mutis: A Case Study from Nusa Tenggara, Indonesia ', paper presented to Crossing Boundaries, the seventh annual conference of the International Association for the Study of Common Property, Vancouver, British Columbia, Canada, June 10-14


deforestation and the global carbon budget', *Annual review of energy and
the environment*, vol. 21, no. 1, pp. 293-310.

Monk KA, dFY, Reksodiharjo-Lilley G 1997, *The ecology of Nusa Tenggara and
Maluku*, Periplus Editions: Hong Kong.

Morwood, J, Soejono, RRP, Roberts, RRG, Sutikna, TT, Turney, CCSM, Westaway,
KKE, Rink, WWJ, Zhao, JJX, van den Bergh, GGD, Due, RARA, Hobbs, DDR,
Moore, MMW, Bird, MMI & Fifield, LLK 2004, 'Archaeology and age of a
new hominin from Flores in eastern Indonesia', *Nature*, vol. 431, no. 7012,
pp. 1087-91.

Morwood, M 1999, 'Stone tools and fossil elephants: the archaeology of eastern
Indonesia and its implications for Australia', *Museum of Antiquities Maurice
Kelly lecture; no. 2.*, vol. 2.

Muslimatun, S 2009, *A Brief Review on The Persistent of Food Insecurity and
Malnutrition Problems in East Nusa Tenggara Province, Indonesia*, Institute
of Indonesia Tenggara Timur Studies.

Myers, N, Mittermeier, RA, Mittermeier, CG, da Fonseca, GAB & Kent, J 2000,
'Biodiversity hotspots for conservation priorities', *Nature*, vol. 403, no. 6772,
pp. 853-8.

Nixon, R 2004, 'Indonesian West Timor: The Political-Economy of Emerging Ethno-
Nationalism', *Journal of Contemporary Asia*, vol. 34, no. 2, pp. 163-85.

Noske, R & Saleh, N 1996, 'The conservation status of forest birds in West Timor.'
paper presented to Eastern Indonesian: Australian Vertebrate Fauna,
Manado, Indonesia.

Noske, RA 1997, 'The Ecology of Timor Birds', in KA Monk (ed.), *The ecology of
Nusa Tenggara and Maluku*, Periplus Editions, Hong Kong.

Nugroho, DK, Widodo, Rudy, Lusiana, Beta 2008, 'Monitoring Hidrologi dengan
Indikator Perubahan Tutupan Lahan (1989-1999)', paper presented to GIS
Applications for Sustainable Development and Good Governance in Eastern
Indonesia and Timor Leste, Kupang.

occupation history and the impact of the Last Glacial Phase in East Timor
and the Aru Islands, eastern Indonesia', *Archaeology in Oceania*, vol. 42, no. 3,
pp. 82-90.

London.

Orangutan Outreach, 2009, New York, viewed December 2009,

of carbon released from peat and forest fires in Indonesia during 1997', *Nature*,
vol. 420, no. 6911, pp. 61-5.

Pattanayak, SK & Kramer, RA 2001, 'Worth of watersheds: a producer surplus
approach for valuing drought mitigation in Eastern Indonesia', *Environment
and Development Economics*, vol. 6, no. 01, pp. 123-46.

Pattanayak, SK & Sills, EO 2001, 'Do Tropical Forests Provide Natural Insurance?
The Microeconomics of Non-Timber Forest Product Collection in the
Brazilian Amazon', *Land Economics*, vol. 77, no. 4, p. 595.

Pattanayak, SK & Subhrendu 2004, 'Valuing watershed services: concepts and
empirics from southeast Asia', *Agriculture, Ecosystems & Environment*, vol.
104, no. 1, pp. 171-84.


Wengraf, T 2001, *Qualitative research interviewing: Biographic narrative and semi-structured methods*, Sage Pubns Ltd.


APPENDICES

Appendix I

Image classification

Each land-cover type has a spectral signature representing its reflectance properties over multiple wavelengths of light. For example, in figure 1a, forest cover (a) has an s shape with its highest reflectance in the Near Infrared (NIR) then blue (B) wavelengths whilst ocean (b) has very little and decreasing reflectance from the blue through to the infrared wavelengths. The blue wavelength has a high reflectance value primarily due atmospheric scattering (Rayleigh scattering) of short wavelengths. Using automatic classification algorithms the spectral signature for each pixel to be classified is compared to the spectral signature of the reference ‘training sites’. A closest fit probability of each pixel belonging to a land cover class is then calculated. Each pixel is then assigned its most probable land cover class accordingly. The most useful information to differentiate any set of land cover types is usually contained in a sub-set of the total available bands.

![Figure I Examples of the spectral signature from two surfaces; (a) forest (b) deep ocean.](image)

Appendix II

Interview Questions

To what extent does the forest benefit the villagers?

Sejauh mana hutan bermanfaat bagi penduduk setempat?

1.1. Do the villagers still cut and burn the forest to open new farming fields? In what season do they usually do that? Why do they practice shifting cultivation? Why don’t they practice permanent cultivation?

*Apakah penduduk masih biasa menebang dan membakar hutan untuk *membuat ladang? *Pada musim apa biasa dilakukan? *Mengapa membuat ladang harus*
menebang dan membakar hutan? Mengapa tidak berladang secara menetap?

1.2. Do the villagers cut the trees and take the wood for building materials? Do they sell them or they use them for themselves? What kind wood is used for building materials? Is this activity allowed or prohibited?  
Apakah penduduk menebang pohon di hutan untuk diambil kayunya untuk bahan bangunan? Apakah kayu banhan bangunan tersebut untuk dipakai sendiri atau dijual? Jenis pohon apa saja yang ditebang untuk bahan bangunan? Apakah hal ini boleh dilakukan atau sebenarnya tidak boleh?

1.3. Do they usually take wood from the forest for firewood? Do they use the firewood themselves or they sell it? Do they take dead branches or living branches? Do they take it every day or on certain days?  
Apakah penduduk biasa mengambil kayu bakar dari dalam kawasan hutan? Apakah untuk digunakan sendiri atau dijual? Apakah yang diambil kayu yang sudah mati saja atau yang masih hidup juga? Apakah pengambilan setiap hari atau hanya pada hari-hari tertentu?

1.4. Do the villagers hunt or catch the animals in the forest? In what season do they usually do that? What animals are usually hunted? Do they sell the hunted or caught animals, or eat them?  
Apakah penduduk biasa berburu atau menangkap binatang di hutan? Pada musim apa biasa dilakukan? Binatang apa saja yang biasa diburu? Apakah hasil buruan atau tangkapan tersebut untuk dimakan sendiri atau dijual?

1.5. Do the villagers take food besides animals from the forest? What foodstuffs do they take? What season do they usually take it? How do they process the foodstuffs before they eat it?  
Apakah penduduk biasa mengambil bahan makanan dari dalam hutan selain binatang buruan? Bahan apa yang diambil? Pada musim apa biasanya dilakukan? Bagaimana bahan tersebut diolah sebelum dimakan?

1.6. What are other materials usually taken from the forest?  
Apa lagi yang biasa diambil penduduk dari dalam hutan? Apakah bahan untuk obat-obatan, untuk pewarna kain, untuk racun ikan/tuba, atau apa lagi?

1.7. Is there any customary law regulating it? If there is, how is it regulated? Is it still obeyed?  
Apakah ada aturan adat mengenai hal itu? Kalau ada bagaimana aturan adat tersebut? Apakah aturan tersebut masih diikuti?

2. What is your opinion about the change of forest for the last 25 years?  
Bagaimana pendapat Bapak/Ibu tentang perubahan hutan selama 25 tahun terakhir?

2.1. Is there any conversion of the forest function and if there is, from what and to what function (e.g. conservation, protection, production, etc)? Where do you get information about the conversion from? In what year did the conversion happen? Were the villagers asked for their opinion about it? What are their opinions about the conversion?  
Apakah ada perubahan fungsi hutan dan jika terjadi dari fungsi apa menjadi apa? (misalnya fungsi konservasi, lindung, produksi, dsb.). Dari mana informasi perubahan fungsi tersebut diperoleh? Pada tahun berapa perubahan fungsi itu
2.2. Is there any deforestation and if there is, in what year, and which part? What is the deforestation for? Who did the deforestation, the villagers or the government?
Apakah ada penebangan hutan dan jika ada terjadi pada tahun berapa, di bagian mana? Untuk apa penebangan hutan tersebut dilakukan? Dari pihak mana, masyarakat atau pemerintah?

2.3. Is there any reforestation? Done by whom, in what year and how is the result?
Apakah ada rehabilitasi hutan (penanaman kembali)? Oleh siapa, tahun berapa, bagaimana hasilnya?

2.4. Is there any forest utilization that could be done in the past but not now anymore? What was it and since what year?
Apakah ada kegiatan pemanfaatan hutan yang dahulu biasa dilakukan tetapi kini tidak lagi bisa dilakukan? Kegiatan apakah itu dan sejak tahun berapa?

3. What do you think causes the conversion?
3.1. Deforestation, if that has ever happened?
Penebangan hutan, jika pernah terjadi?
3.2. Reforestation failure, if that has ever happened?
Kegagalan rehabilitasi hutan, jika pernah dilakukan?
3.3. The change of forest utilization, if it happens?
Perubahan pola pemanfaatan hutan, jika terjadi perubahan?

4. How is the impact of the change on economy and people’s food sustainability here?
Apa kira-kira yang menyebabkan terjadinya seluruh perubahan tersebut?
4.1. Does the change cause better or worse economy for the people? Example please? Apakah perubahan tersebut menyebabkan perekonomian masyarakat menjadi lebih baik atau lebih buruk? Apa contohnya?
4.2. Does the change make it more difficult or easier for the villagers to get their food? Example please?
Apakah perubahan tersebut menyebabkan masyarakat lebih mudah memenuhi kebutuhan pangan mereka atau justru lebih sulit? Apa contohnya?
4.3. What do the villagers do to overcome the problems if the change of the forest causes difficult situation?
Apakah yang dilakukan oleh masyarakat untuk mengatasi kesulitan jika perubahan keadaan hutan menyebabkan keadaan menjadi semakin sulit? Apa contohnya?

5. In your opinion, if the forest is getting worse, are reforestation activities necessary?
Bagaimana akibat/dampak dari perubahan tersebut terhadap perekonomian dan ketahanan pangan masyarakat?
5.1. What can be done? Who should initiate? Will the people support or not?
Apa yang kira-kira dapat dilakukan? Siapa yang seharusnya memelopori? Apakah masyarakat akan mendukung atau tidak?
a) What is your reason to make the forest better than it is now?
Apa alasan bapak/ibu merasa perlu untuk mengembalikan keadaan hutan menjadi lebih baik dari sekarang?
### Appendix III Forest type and distribution

**Table III.1 Forest type breakdown of species composition**

<table>
<thead>
<tr>
<th>Vegetasi</th>
<th>Dominan</th>
<th>Domin_1</th>
<th>Domin_2</th>
<th>Domin_3</th>
<th>Domin_4</th>
<th>Rendah</th>
<th>Rend_1</th>
<th>Invasif_1</th>
<th>Invasif_2</th>
<th>Invasif</th>
<th>Pmf_hutan</th>
<th>Pmf_hutan3</th>
<th>Pmf_huta</th>
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<td>Savanna Terbuka</td>
<td>Acacia nilotica</td>
<td>Schleicher a oleosa</td>
<td>Nauclea orientalis</td>
<td>Zizyphus mauritiana Lamk.</td>
<td>Pterocarpus indicus</td>
<td>Schleicher a oleosa</td>
<td>Corypha utan Lamk.</td>
<td>Nauclea orientalis</td>
<td>Sungkai (Chromolaena odorata)</td>
<td>ToEo (Callitropsis proceras)</td>
<td>Hu blua ()</td>
<td>Senna siamea</td>
<td>Eucalyptus urophylla</td>
<td>Nauclea orientalis</td>
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<tr>
<td>Hutan Terpencar</td>
<td>Mallotus ricinoides</td>
<td>Hibiscus timoriensis</td>
<td>Grewia koordersiana</td>
<td>Stryclonal muricata</td>
<td>Pittosporum umbilatum</td>
<td>Alstonia spectabilis</td>
<td>Corypha utan Timoni</td>
<td>Sufmuti (Leucaena leucocephala)</td>
<td>Sufmuti (Chromolaena odorata)</td>
<td>Pankase (Lantana camara)</td>
<td>Artocarpus cf. pomiformis</td>
<td>Alstonia scholaris</td>
<td>Casuarina junghuhniana</td>
<td>Acacia leucophloe a</td>
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<td>Savanna Palma</td>
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<td>Nangkai kase (Delonix regia)</td>
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<td>Tricalysia javanica</td>
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Table III.2
The extent of forest, the percent forested and the contribution to total forest for each Kecamatan.

<table>
<thead>
<tr>
<th>Name</th>
<th>Hectares</th>
<th>% of Kecamatan Forested</th>
<th>% of total forest</th>
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<td>3459</td>
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</tr>
<tr>
<td>Kec. Sulamu</td>
<td>1373</td>
<td>6.0</td>
<td>1.6</td>
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<td>Kec. Tabenu</td>
<td>478</td>
<td>4.9</td>
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<tr>
<td>Kec. Takari</td>
<td>4983</td>
<td>10.2</td>
<td>5.8</td>
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</table>
Appendix IV Population and forest cover by Kecamatan.

Figure IV. Population density and forest cover per Kecamatan sorted by ascending percentage forest cover.