NATIONAL ECOLOGICAL GAP ASSESSMENT FOR TIMOR-LESTE 2010

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Executive Summary

On 10 October 2006, the Timor-Leste government signed the Convention on Biological Diversity (CBD) and became a Party to the Convention on 8 January 2007. As a signatory to the CBD, Timor-Leste is required to fulfil the CBD's Programme of Work on Protected Areas (PoWPA), adopted by the 7th CBD Conference of Parties in 2004. The PoWPA is a global action plan to address the impediments to establishment of protected areas. It is an ambitious programme with 92 different activities, of which 13 are deemed critical. One of these activities is to assess ecological gaps in the protected area network. As Timor-Leste is a new country it is currently at the beginning of building their protected area network. This report provides the first ecological gap assessment of the protected area network and outlines recommendations on future activities that we hope will aid the implementation and building of formal marine and terrestrial protected area networks.

There have been a number of achievements in the process of developing this report:

- For the first time, the future protected area network for Timor-Leste has been mapped. This network is not yet implemented. The boundaries are only estimates and the final boundaries for each protected area are still being finalised. Several protected areas are not yet legislated. The total area of the protected area network including marine areas is ~3200km^2. The total area of terrestrial protected area network is ~2000km^2, which is around 15% of the nation's land area.

- A database that captures all known ecological GIS data for Timor-Leste and bibliography of all known scientific literature has been collated for the first time.

- The first classification of Timor-Leste's terrestrial biodiversity has been achieved. We have identified 24 general forest types based on geological formations that are hypothesised to correlate well with species distribution patterns and evolutionary patterns.

- Using data from the Sustainable Land Management project conducted by UNDP, landcover maps for Timor-Leste at a 10m^2 resolution have been developed. Using these data, we calculated that Timor-Leste has lost between 50-70% of its original forest cover (depending on how forest is defined).

- Timor-Leste is within the Coral Triangle which is the epicenter of global coral reef diversity. A new classification of coral reefs was identified which enabled us to

divide the coral reefs that cover over 100km^2 of Timor-Leste's coastline into seven types.

- Other important habitats have been mapped including lakes, rivers, mangroves, estuaries and seagrasses. Important sites were also mapped for wetland birds, reptiles, amphibians and orchids, including the distribution of several endemic animal species.

- Using a facilitated approach, five clear goals have been developed by the government of Timor-Leste for their protected areas:

  Goal One. *Ensure full representation across biological scales and biological realms*.

  Goal Two. *Protection of all critical habitats for endemic, migratory and threatened species*.

  Goal Three. *Ensure that protected areas are the right size to ensure the persistence of biodiversity*.

  Goal Four. *Ensure that protected areas play a role in mitigating climate change*.

  Goal Five. *Design protected areas so that they are resilient and able to withstand stresses and changes such as human-forced climate change.*

- More specific medium-term objectives have been developed against each of these goals which are intended to be achieved by 2020.

- DPANP staff now has excellent understanding of the principles of systematic conservation planning and how to undertake a National Ecological Gap Assessment (NEGA). DPANP staff has understanding of spatial priorization software, particularly Marxan, that can help systematically plan protected areas.

The key findings of the Timor-Leste National Ecological Gap Assessment are as follows:

- *Forest coverage*. We identified two classifications of forest cover that estimated forest cover at between 30-50%. We classified two different scenarios (optimistic and pessimistic) based on the level of forest cover left. For the optimistic scenario, we found ~10% of the original extent of forests would be protected by the protected area network (which amounts to 20% of the current distribution of forests) with four forest types close to meeting the 30% target (original cover). However, three forest types were not represented at all. For the pessimistic scenario of forest cover we found 6% of original forest cover would be protected (which amounts to 20% of

current distribution of forests). Three were not represented at all with one of those having no forest cover left.

- *Other habitats*. Lakes, seagrasses and most coral reef types have their target levels achieved in the protected area network, whereas mangroves, rivers and estuaries did not. Rivers and estuaries had low representation in the protected area network.

- *Threatened species*. We found a number of species were well represented in the protected area network but the level of representation varied among taxonomic group. For example, 13 (out of 16) Important Bird Areas and 5 (out of 15) important wetlands for birds were located within protected areas whereas 1 (out of 5) important areas for reptiles and frogs was within protected areas. The important site for orchids is completely inside the protected area network. Two endemic species (freshwater fish and turtle) are only found at Lake Iralalara in Nino Konis Santana National Park. Data from DPANP confirms at least 32 endemic and threatened birds are within the protected area network

- *Carbon*. Overall around 22% of terrestrial carbon is within the protected area network which is below the target level of representation (which is 30%).

Priority areas were identified based on setting quantitative targets for coverage of ecosystems and species in protected areas whilst maximizing connectivity and avoiding people. This was achieved using computer software and expert opinion. These analyses identified a number of Areas of Interest (AOI) outside the protected area network that can be further assessed in the future.

A similar analysis was completed to prioritise the management planning activities of the protected areas to ensure all threatened species get the most immediate attention.

Recommendations:

1. The protected area network contains high conservation value areas. The network contains a relatively high representation of ecosystem and species of conservation concern. The network also contains valuable watersheds that protected water systems critical to people downstream. Developing management plans for this suite of protected areas should continue to be the first priority of the DPANP.

2. There are gaps in the protected area network and other areas are need to be added to the system. These areas are important for endemic reptile and frog species and habitats for species living in estuarine and wetland ecosystems.

3. Once the protected area network is formally established, connectivity between protected areas should be considered a priority to help species and ecosystem adapt to climate change.

4. Lake Iralalara is a particularly important site in Timor-Leste and is a globally recognized site for its ecological value. It contains at least one endemic freshwater fish species and an endemic turtle species confined to its waters. Proposed development such as dams should be very carefully considered and the precautionary principle should apply to any Environment Impact Assessment. Furthermore, the introduction of new fish species is likely to be a serious threat and should not permitted under any circumstances.

5. Further assessment outside of the protected area network should focus on the AOI identified in the spatial prioritisation analysis. If they are found to have high conservation value, new protected areas should be considered or complementary conservation management strategies (e.g. community-led projects) implemented.

6. A moratorium on large development projects should be placed on these AOI before formal assessments take place as reducing the value of these areas might have significant on Timor-Leste's biodiversity.

7. We encourage the Locally Managed Marine Area model of marine conservation that is currently being considered as a management tool. Similar community-based approaches could be considered for terrestrial areas as complementary to protected areas, particularly on community and private land.

8. Current boundary delineation is a key problem to implementing the protected area network, as at the current rate it will take decades to finish. This process needs to be accelerated and more appropriately funded.

9. The management planning processes still needs to be developed for the protected area network. This is currently starting with component two of the POWPA focussing on Nino Konis Santana NP.

10. A management plan needs to be developed for all protected areas. Without regulations and zoning, the conservation values of these protected areas cannot be ensured. The planning process for Nino Konis Santana NP is currently being conducted and we propose the priorities (if based on threatened species) should be Mount Manoleu/Area Mangal Citrana, Mount Cutete, Ribeira de Clere/Lake Modomahut, and New Diatutuo. Others to be considered are Mount of Taroman, Mount of Tapo/Suburai, Mount of Cablaque/Lake of Welenas, Mount of Builo, Mount of Ruilo and Mount of Burabo. These

collectively would ensure each threatened species are adequately protected in several protected areas.

11. The current budget, at US$60,000 per annum, is woefully inadequate for protected area implementation. It is estimated at least US$500,000 per annum would be required to finance the protected area network based on rough estimates from DPANP. Sources of potential funding include increasing the budget from the current government, Lifeweb, AusAID, GEF, UNDP, international NGOs, international agencies, donors and the carbon market.

12. The protected area network contains over 20% of the countries terrestrial carbon. Protected areas are likely to contribute to avoided deforestation and with reforestation in protected areas, the amount of carbon is going to increase. The CDM and REDD+ programs being developed at the UNFCCCC should be seriously considered to help finance protected areas.

13. The need for policies, laws and regulations, including enforcement of existing regulation, is urgent for the DPANP to work effectively. All policies and laws on protected areas, threatened species, wildlife trade and national parks should be reviewed and updated to meet standards set by the international community.

14. The information and database system generated by this report should be centralized. Regulations should be in place so that data collected by academics, NGOs and other researchers be given to the government. There is a need for more capacity for this type of data collation (both in terms of skill sets and also the number of people doing it) and this should be developed as a high priority.

15. A national ecological classification of ecosystem should be formally developed, particularly for forest type mapping and benthic habitats in marine ecosystems.

16. Funding should be allocated to assist the government in updating the NEGA every five years to assess progress in protected area planning. Training should be continued on GIS and conservation planning capabilities.

17. For protected area planning, there should be increased coordination between government ministries and agencies, and between the government and non-governmental organisations.

Contents

Acronyms used in this report

ALGIS	Agricultural Land Use Geographical Information System - Ministry of Agriculture, Forestry and Fisheries Geographic Information Systems department
AOI	Areas of Interest
ATSEA	Arafura and Timor Seas Expert Forum
EU	European Union
CBD	Convention on Biological Diversity
CDI	Capacity Development Initiative
CDI	Capacity Development Initiative
CNRM	Conservation and Natural Resource Management
CTI	Coral Triangle Initiative
DPANP	Department of Protected Areas and National Parks
GEF	Global Environmental Facility
GIS	Geographic Information Systems
GTZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
IW	International Waters
JICA	Japan International Cooperation Agency
LCDs	Least Developed Countries
LMMA	Locally Managed Marine Areas
NBSAP	National Biodiversity Strategy and Action Plan
NDCF	National Directorate of Coffee and Forestry
NDES	National Directorate of Environmental Services
NDIEA	National Directorate of International Environment Affairs
NEGA	National Ecological Gap Assessment
NDFA	National Directorate of Fisheries & Aquaculture.
NPAN	National Protected Area Network
NGO	Non-Governmental Organisation

MAF	Ministry for Agriculture and Fisheries
PEMSEA	Partnerships in Environmental Management for the Seas of East Asia
POWPA	Program of Work on Protected Areas
SEPE	Timor-Leste State Secretariat for Energy Policy
SIDS	Small Island Development States
UNESCO	United Nations Education, Scientific and Cultural Organisation
UNDP	United Nations Development Programme

Definitions for key terms used commonly in this report

Climate change adaptation. Climate change adaptation is a response to climate change that seeks to reduce the vulnerability of natural and human systems to climate change effects. For example, a commonly used climate change adaptation action is maintaining and improving ecosystem connectivity so that species can naturally move their distribution to suit the changing climate.

Climate change mitigation. Climate change mitigation is an action (or set of actions) aimed at decreasing the intensity of radioactive forcing in order to reduce the potential effects of global warming. Most often, climate change mitigation involve reductions in the concentrations of greenhouse gases, either by reducing their sources or by increasing their sinks. In this report, when we refer to climate mitigation, we are referring to those actions that are focused on protecting vegetation as a carbon sink (and as such, stopping carbon entering the atmosphere through the process of deforestation) and those reforestation and restoration activities that will lead to new carbon sinks.

Conservation Goals. Conservation goals are broad qualitative aims for that are to be achieved by the planning authority often within a specific time frame. An example of a goal is the protection of all threatened species in some form of protected area.

Conservation Objectives. Conservation objectives are specific quantitative (see conservation targets) aims that are to be achieved by the planning authority often within a specific time frame. An example of an objective is to maximise connectivity between protected areas.

Conservation Targets. Conservation targets are specific quantitative amounts that are to be achieved by the planning authority often within a specific time frame. An example of a conservation target is for protected areas to cover 30% of the current extent of coastal wetlands.

Habitat. Habitat is an area that is inhabited by a particular species. It is the natural environment in which an organism lives, or the physical environment that influences and is utilized by a species population.

Habitat connectivity. Habitat connectivity is the size and distribution of patches of habitat, and the relative ease with which typical species can move through the landscape between the patches. Maintaining and improving connectivity is important to ensure the long-term survival of biodiversity in a fragmented landscape, especially under a changing climate. Ensuring connectivity does not mean that all vegetation in an area has to be retained but it

does have to be sufficient to enable species to move and carry out important life history processes.

Protected Area. A clearly defined geographical space, recognised, dedicated and managed, through legal or other effective means, to achieve the long-term conservation of nature with associated ecosystem services and cultural values. Protected areas are often managed according to specific regulations and management plans. In Timor-Leste, regulations and management plans are still being developed.

Representation. Representation is a measurement of how well protected area networks contain representative samples of every feature of biodiversity that are to be protected. Biodiversity features normally reflect some combination of genetic, species and community diversity.

Suco. Sucos are the subdistricts of Timor-Leste.

Introduction

Background to the Report

Following an agreement from the Head of the Department of Protected Areas and National Parks (DPANP), the United Nations Development Programme (UNDP) contracted the Australian-based company *CNRM Solutions Pty Ltd* to help undertake a National Ecological Gap Assessment (NEGA) for Timor-Leste. Specifically, the UNDP asked *CNRM Solutions Pty Ltd* to provide assistance to the Timor-Leste's government to addresses Activity 1.1.5 of the Programme of Work on Protected Areas (PoWPA) to conduct a National Ecological Gap Analysis, through application of state of the art conservation planning to support the design of the National Protected Area Network (NPAN). *CNRM Solutions Pty Ltd* were also asked to provide capacity and systems development, technical direction, support for ecosystem approaches, protected area planning, management planning and socio economic monitoring to DPANP.

In particular, *CNRM Solutions Pty Ltd* was asked to conduct the following activities:

- Identifying and mapping key areas for biodiversity;
- Mapping existing protected areas;
- Identifying gaps by comparing information sets;
- Develop strategies to fill the gaps;
- Prepare a report including supporting maps, graphics and data sets
- Work closely with the DPANP staff; and
- Capacity development of the project team on data collection, assessment and analysis.

The aim of this report is to outline the major findings of the National Ecological Gap Assessment and the broad strategies that are needed to fill these gaps.

The report is comprised of six separate sections:

1. Introduction, background and aims of the report
2. The process of conducting the National Ecological Gap Assessment
3. Data used in the National Ecological Gap Assessment
4. National Ecological Gap Assessment
5. Conclusion: where to from here?
6. Appendices containing data and 2D and 3D images of protected area network

We hope that this report, and the supporting material, be used by the DPANP and other conservation advocates sponsoring and/or developing plans for expanding the NPAN, so that a representative cross section of Timor-Leste's biodiversity endowment is conserved.

Setting the context for the National Ecological Gap Assessment

In 2002, the Democratic Republic of Timor-Leste (hereafter Timor-Leste) became the world's newest country when its independence was restored after 24 years of Indonesian occupation and three years of United Nations Transitional Administration. Since independence, Timor-Leste has confirmed its commitment to the conservation of it s national biodiversity in a number of ways. First and foremost, the nation's new constitution (Anon. 2002) states upfront that the protection of the environment and preservation of natural resources are among the fundamental objectives of the nation, with Section 61 stating:

1. *Everyone has the right to a humane, healthy, and ecologically balanced environment and the duty to protect it and improve it for the benefit of the future generations.*
2. *The State shall recognise the need to preserve and rationalise natural resources.*
3. *The State should promote actions aimed at protecting the environment and safeguarding the sustainable development of the economy.*

Since independence, Timor-Leste has become a signatory to three Multi-lateral Environment Agreements – the *Convention to Combat Desertification* (CCD) in 2003; the *Convention on Biological Diversity* (CBD) in 2006; and the *UN Framework Convention on Climate Change* (UNFCCC) in 2007. As a party to these Conventions, Timor-Leste is eligible to receive assistance via the Global Environment Facility (GEF), to develop environment and conservation programmes in compliance with guidance from the Conventions, and thus to contribute to global environmental management.

In addition, over the past two years, without the benefit of having completed the series of initial Enabling Activities under the Multi-lateral Environment Agreements, Timor-Leste has started to participate with its neighbours in a number of major regional environment initiatives, notably the Arafura and Timor Seas Expert Forum (ATSEA), Partnerships in Environmental Management for the Seas of East Asia (PEMSEA) and Coral Triangle Initiative (CTI), which are also supported by the GEF and various donors. These initiatives are concerned with the countries' natural resource governance and management of coastal, island and marine environments and biodiversity, and like the Multi-lateral Environment Agreements, are also aimed at national capacity development, and strengthening of

institutional, policy and regulatory frameworks for environmental governance and conservation.

Several multi-lateral and bilateral aid agencies are also supporting actions in Timor-Leste that are relevant to environment, energy and natural resources management, conservation, climate change adaptation and sustainable development (Table 1). These include, among others, activities under the Rural Development Programmes of the European Union (EU) and Deutsche Gesellschaft für Internationale Zusammenarbeit (GTZ); local land-use and community development planning as part of the Government's decentralization and Suco development initiatives; renewable energy projects by SEPE (Timor-Leste State Secretariat for Energy Policy) and some non-government organisations (NGOs); watershed management actions by JICA (Japan International Cooperation Agency); protected area planning and management by the United Nations Education, Scientific and Cultural Organisation (UNESCO); Natural Disaster Risk Reduction actions coordinated by NDMD (National Disaster Management Directorate); community-based climate adaptation actions involving NGOs and Australia's international aid program (AusAID) support; and the Ministry for Agriculture and Fisheries (MAF) *Seeds for Life* program supported by AusAID.

On 10 October 2006, the Timor-Leste government signed the Convention on Biological Diversity (CBD) and became a Party to the Convention on 8 January 2007. As a signatory to the CBD, Timor-Leste is required to set aside at least 10% of their country in protected areas to slow the global loss of biodiversity. The country is also required to fulfil the CBD's Programme of Work on Protected Areas (PoWPA), adopted by the 7th CBD Conference of Parties in 2004. The PoWPA is a global action plan to address the impediments to the establishment of at least 10% of each country as protected areas. The underlying premise of the PoWPA is that governments should identify and then fill gaps in their existing protected area network to ensure that all native species and ecosystems are represented in protected areas of sufficient size, number and distribution to guarantee their long-term survival. The PowPA program gives priority to Small Island Development States (SIDS) and Least Developed Countries (LDCs) of which Timor-Leste is a member.

Table 1. Summary of Timor-Leste GEF Enabling Activities and Regional Environment Initiatives (provided by Peter Hunnam UNDP).

Enabling Activities and Projects	Years	Products	Multilateral Environmental Agreements	Support Program	Lead Agencies in Timor-Leste
Environment Enabling Activities – Timor-Leste					
NCSA – National Capacity Self-Assessment	2005-2007	Capacity Action Plan	all	GEF, CDI	UNDP, NDIEA
SLM – Sustainable Land Management	2008-2010	SLM National Action Plan	CCD	GEF	UNDP, NDCF
NAPA - National Adaptation Plan of Action	2009-2010	Climate Adaptation Project plans	UNFCCC	GEF	UNDP, NDIEA
POWPA – Program of Works for Protected Areas	2009-2011	Conservation/ Protected Areas Strategy & tools	CBD	GEF	DNPPA
NBSAP – National Biodiversity Strategy & Action Plan	2010-2011	Biodiversity Conservation Strategy & tools	CBD	GEF	UNDP, NDES
INC – Initial National Communication	2010-2013	Climate Change Mitigation + Adaptation Strategy	UNFCCC	GEF	UNDP, NDIEA
Regional Environment Programs in Timor-Leste					
PEMSEA Partnerships in Environmental Management for Seas of East Asia	2006-2012	Coastal and marine environment management	-	GEF	NDFA
ATSEA – Arafura-Timor Sea Ecosystem Action Program (ATSEA)	2010 –	Trans-boundary Diagnostic Analysis Strategic Action Program	-	GEF IW	NDFA
CTI – Coral Triangle Initiative /CT Support Program / CTI Pacific	2010 –	National Program of Action CTI Knowledge Mgt.	-	GEF, ADB, USAID, CI-WWF-TNC	NDFA

Background to Timor-Leste

Geography, geology and climate

Timor Island is the second largest oceanic island in the Indonesian archipelago and the largest of the Lesser Sundas. Timor is north of Australia and one of the easternmost Sunda Islands. Timor Island spans 470 km in length and up to 95 km in width with an overall terrestrial area of c. 31,000 km^2. Timor-Leste occupies the eastern half of Timor Island, the enclave of Oecussi (or Ambeno) in north-west Timor Island, and several offshore islands (Fig. 1). The remainder of Timor Island is in the Indonesian province of Nusa Tenggara Timur. The nation of Timor-Leste is about 260 km in length and up to 80 km wide with a total area of 14,874 km^2.

Timor island lies on a convergence of the Australo-Papuan and Oriental tectonic plates. The island was created by an uplifting 4 million years ago caused by the northward movement of the Australo-Papuan plate and subsequent collision with the Oriental plate. The bedrock is primarily sedimentary calcareous rock, with fossil coral reefs found at high altitudes (up to 2000 m) (Monk et al. 1997). The topography is dramatic, with mountain peaks reaching as high as 3000 m. Steep slopes (those that have an incline >40%) characterize as much as 44% of the total area (Monk et al. 1997). Lakes are relatively few and small, apart from the Iralalaru Lake basin. Few of the approximately one hundred rivers flow regularly throughout the year.

The island's climate varies greatly across the nation with the south coast considered to be "permanently moist" with more than 2,000 mm of rain for greater than nine months of the year, whereas the northern part is "permanently dry" with rainfall of 500 to 1,000 mm a year, occurring in only four months or less (Trainor 2010). Torrential rain storms are commonplace which cause a high degree of surface runoff and increased soil erosion. The temperature is warmer along the coast with average temperatures decreasing with increasing altitude.

Biogeography

Timor is part of the Walleacean biogeographic region (Fig. 2), on the Australian side of Wallace's Line but on the Asiatic side of Weber's and Lydekker's Lines – all three are biogeographical boundaries between divergent assemblages of plants, birds, mammals, reptiles and insects (Braby & Pierce 2007).

The biogeographic region of Wallacea is globally recognised as an important region for its unique and diverse biodiversity (Myers 2000). The region is characterised by a large number of endemic species, including at least 1,500 plants, 262 birds, 127 mammals, 33 frogs, 99

reptiles and 50 freshwater fish species found nowhere else on earth (Wikramanayake et al. 2002a; Wikramanayake et al. 2002b). Despite its global significance, many islands in Wallacea have been the subject of low biological research effort and the island of Timor is arguably the least known of all the main islands. The lack of local researchers, restricted area of forest, lack of charismatic threatened wildlife, and the limited accessibility of Timor-Leste during the Indonesian era, and periods of ongoing disturbance since independence have all acted as obstacles to further biological research on Timor Island (Trainor 2010).

From those scientific studies conducted on the island of Timor, researchers have found that the island fauna to be characterised by low overall species richness but with relatively high levels of endemism. Owing to its close proximity to Australia and to continental Asia, the origins of the fauna are derived from those two regions. Of the 168 resident birds, 32 are endemic to the Lesser Sundas, and eight are endemic to the island. At least two mammals (of 35 native species) and one reptile (of 40 species) are currently known to be endemic. These numbers are likely to increase with more intensive surveys and re-examinations of taxonomic distinctiveness for many taxa (Trainor 2010). Recent botanical surveys in Timor-Leste have recorded more than 1,000 plant species, and it is predicted (based upon a comparison with many other Malesian islands) that around 2,500 species might occur on Timor Island (Cowie 2006)

Vegetation

Forest and woodland of several structural types are the predominant original vegetation throughout much of Timor-Leste. Tall evergreen forest grow in areas with high moisture while semi deciduous and tropical dry forests occur where the climate is drier and conditions are more extreme. Montane forest is found above 1,000 m (but sometimes as low as 500 m), where it occurs in mosaics with treeless areas characterised by low vegetation. Some distinct vegetation types are found along the coast, including beach forest and coastal strand habitats. Woodlands and savannas occur extensively along the north coast from sea level to low-mid altitudes. These include savanna woodlands with an open, low over-storey dominated by *Eucalyptus alba*, palm and/ or acacia. Open forest dominated by medium to tall *E. urophylla* is found at higher altitude.

Figure 1. Timor-Leste showing bathymetry and topography along with the major towns and districts.

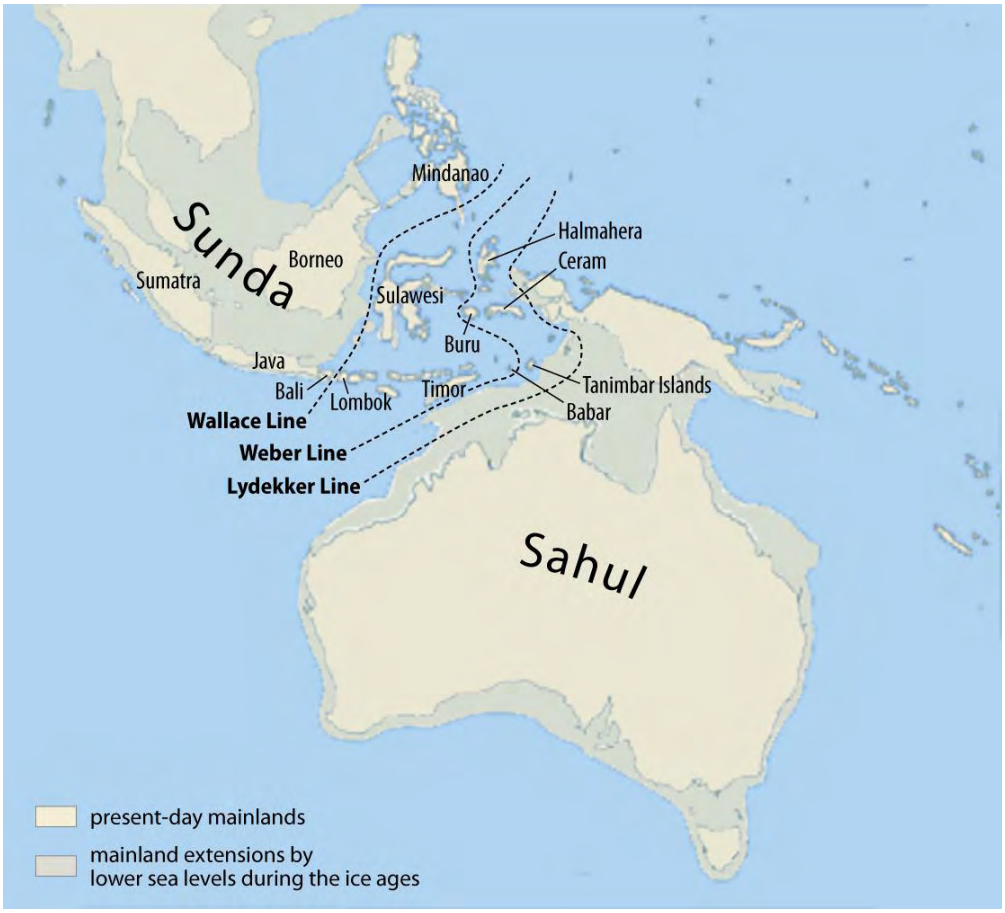

Figure 2. The location of Timor in relation to Wallace's, Weber's and Lydekker's Lines. Source: Wikkipedia, viewed January 15 2011.

People and resource uses

Austronesian settlers first settled the island about 7,000 years BP, bringing with them a suite of mammals that they introduced to the countryside and a culture of slash and burn agriculture. The Dutch and Portuguese colonised West Timor and East Timor, respectively, from the 15th century onwards, primarily to exploit Sandalwood *Santalum album,* slaves and timber. Portugal continued to administer Timor-Leste until 1975. De-colonisation precipitated the invasion by Indonesia and a prolonged civil war, with Timor-Leste formally gaining independence in 2002.

In 2007, the population of Timor-Leste was about 1,040,000 with the population growth (~ 5.36% per year) among the highest in the world. Around 40 percent of the population is under the age of 15, and two-thirds are under 25. During the 2004 census, when the population was 924,642, the density of people was 64 persons km^2, with the most densely settled districts

being the capital, Dili with 167,000 people in 372 km^2 at 466 people km^2. About 85% of the population is considered agrarian (Valdivieso 2001) with poverty levels higher among the rural population than urban populations (Ministry of Agriculture et al. 2003). Approximately 50 percent of the population live in rural areas and most of these practise subsistence agriculture. The main agricultural crops are rice, corn, tubers with some livestock. A rural family holds on average about 1.2 ha of land. Just under 45% of the population lives below the poverty line (World Fact Book. 2010) making Timor-Leste among the poorest countries in the world.

The dominant land uses on Timor include: shifting or swidden agriculture; use of non-timber forest products for house construction; grazing by goats, sheep, cattle, buffalo, horses; and more recently, agricultural crops such as rice, coffee, vegetables particularly maize, fruit and agro-forests. The populous north coast of Timor-Leste is dry, but many rivers bring regular water for agriculture (Fox 2003). The rugged topography of the mountains has meant that there are few large populations away from the coast, with most communities generally living in small and scattered villages along the coastline.

There are currently disputes about land tenure and a lot of uncertainty about who owns what land. There are current programs by the government to resolve land tenure disputes but this is a slow process.

There are strong customary natural resource management systems in place. D'Andrea et al. (2003) found in their review of customary management in Timor:

1. Despite the upheaval of resettlement and years of hardship under Indonesian rule, customary systems of resource management are robust. Cultural and spiritual values of Timorese social institutions provide the basis of customary resource management. Ownership of the vast majority of rural land is determined by clan-inherited *usufruct* rights under traditional customary law. The concept of *lisuk*, or communal rights (e.g. land management), remains strong. Sacred or *lulic* places remain very important to the everyday lives of most rural Timorese. Tenure arrangements can be complex. There are multiple levels of ownership that relate to different levels of access to and control over resources within family and clan land. Individuals may own, or co-own, many non-contiguous plots of land in different degrees.
2. Communities across the country are attempting to reintroduce customary prohibitions or *tara bandu* as a way to protect resources. Government officials from sub-district to national levels are eager to support these efforts as a low-cost way of strengthening protection of resources.

3. There are certain constraints on the ability of communities to protect and manage resources the way they once could. Many communities have been resettled onto land over which they have no ancestral claims. The systems of control of the harvest of trees and forest products and of maintaining watersheds in these areas are no longer effective. This is of particular concern to communities who have a new settlement of 'outsiders' on their ancestral land. There is a general sense of anxiety among customary communities over 'outsiders' getting titles to land.
4. Where customary management of resources has not been significantly disrupted, systems of control remain intact. Among these communities, there is desire for greater authority, from government, to handle the management of natural resources, or some form of territorial recognition from the government of their capacity to manage natural resources within their ancestral boundaries.

Land tenure places a constraint on the location of new protected areas as they are gazetted on public land. It currently takes time to work with communities to delineate which are their boundaries and that of public land. Strong customary natural resource management systems create opportunities for the government to initiate community-based conservation initiatives.

Climate change

Human-induced climate change has the potential to alter temperature and humidity level, sea level, rainfall patterns and frequency of extreme weather events in Timor-Leste. Kirono (2010) evaluated likely future scenarios for climate change impacts on Timor-Leste. They found that:

1. The central estimates (multi-model median) of projected changes in annual temperature are +0.8^{o}C, +1.5 ^{o}C and +2.2 ^{o}C for 2020, 2050 and 2080 respectively, relative to 1990;
2. The central estimates of projected changes in annual rainfall are +2%, +4% and +6% for 2020, 2050 and 2080 respectively, relative to 1990. By 2080, small increases are projected for December-February and March-May, with a small decrease for June-August, and no change for September-November;
3. Sea level pressure, wind speed, relative humidity and solar radiation show little change;
4. Annual potential evaporation, represented as pan evaporation, decreases by up to 5 mm/day by 2090;
5. The heat wave duration index is projected to increase by 2 days per year by 2050;
6. Extreme rainfall events are projected to become fewer but more intense;
7. The occurrence of wet spells is projected to decrease by 5% in 2041-2060 relative to 1971-2000;

8. Although on average the number of tropical cyclone is projected to decline, increases in intensity are indicated;
9. Sea surface temperatures are projected to increase by 0.6-0.8oC by 2030 and 1.0-1.5^{o}C by 2050, relative to 1990;
10. The projections for sea level rise are 3.2-10.0cm by 2020, 8.9-27. cm by 2050, and 18-79 cm by 2095, relative to 1990;
11. Ocean acidification is expected to increase;
12. The interannual variability of the Asian monsoon is projected to increase, but the uncertain role of aerosols complicates the nature of future projections; and
13. It is not yet possible to state whether ENSO activity will be enhanced or dampened, or if its frequency will change.

Climate change is likely to change the environment where people live and the natural values of places. Vulnerability will not be even across Timor-Leste and a key initiative of the government in the future will be increasing the adaptive capacity of communities dependent on the natural environment and the resilience of ecosystems to adapt to climate change.

Threats to biodiversity

While a lot is still not known about the biodiversity of Timor-Leste, a number of key threats to the persistence and health of the country's natural values have been identified by those who have conducted research in the country.

Deforestation. Deforestation is arguably the most serious problems facing the biodiversity of Timor-Leste. Forest cover in East Timor, for example, has decreased by almost 30% over the period of 1972 to 1999 (Sandlund et al. 2001) and only 6% of the remaining cover is believed to be primary forest. Valuable timber species have been nearly logged out during the colonial and occupation periods. Other pressures on forests are driven primarily by the need for firewood, clearing for agriculture and escaped fires during land clearing or hunting.

Degradation. Another major threat is the gradual degradation of productive landscapes and up to 50% of the country is considered degraded. This degradation is due, in part, to unsustainable agricultural practices. Subsistence farmers practice swidden agriculture by clearing forests for new fields in a cyclical manner. At low human population densities and long fallow periods, swidden systems are sustainable. However, despite relatively low population density in Timor-Leste, the amount of suitable agricultural land available per person is insufficient. Farmers regularly cultivate areas with slopes of more than 40 degrees and landslides and flash floods are common. Given Timor-Leste's sloping terrain and the rainfall pattern of short, intense rains, soil

erosion have negative impacts on both terrestrial and aquatic biodiversity. Conservation impacts of high erosion include loss of forest habitat through landslides and degradation of river and coastal habitats through sedimentation. Livestock grazing also contributes to erosion and also increases the spread of invasive species that are difficult to eradicate. Demand for firewood in urban areas has also increased the amount of degradation of vegetation around the country.

Poaching. Poaching of wildlife is also a major problem and threatened species are hunted for food, medicine, and ornaments, and also collected live for the pet trade. While there have been efforts to protect threatened species through the formulation of UNTAET regulation 2000/19, actual enforcement of this policy has been lacking.

Introduced species. While the specific details of how the invasions of foreign species are affecting native species is unknown, it is believed to potentially have a significant impact on native biodiversity. Recent estimates suggest that that one third of the 52 mammal species are introduced on the island of Timor. Of these, the Common Spotted Cuscus *Phalanger orientalis*, Long-tailed Macaque *Macaca fascicularis*, Common Palm Civet *Paradoxurus hermaphroditus*, Eurasian Wild Pig *Sus scrofa*, Rusa Deer *Cervus timorensis*, House Mouse *Mus musculus*, House Rat *Rattus tanezumi*, Brown Rat *Rattus norvegicus*, Polynesian Rat *Rattus exulans* and House Shrew *Suncus murinus* are thought to have accelerated the decline of some of the endemic fauna, through predation, competition, introduction of new diseases and/or consequential habitat change (Trainor 2010).

Overfishing. Development and expansion of commercial and subsistence fisheries are top priorities for economic development in Timor-Leste. Short-term and medium term plans are in place to facilitate the development of the fisheries sector so that it contributes to economic growth, incomes, employment and export earnings. In the short term, the north coast of East Timor will be the main focal area for industry development. Currently the maximum sustainable yields are unknown for most fisheries. There is a high risk of overfishing if fisheries are developed too quickly, with increased capacity of local fishing and handout of fishing licences to foreign fishers also adding to an important consideration.

Threatened species

According to the IUCN, three tree species, four birds, three mammals and one butterfly on Timor are considered threatened with extinction generally due to loss of tropical forest habitat upon which these species depend (Table 2). the IUCN's assessment is however, almost certainly an underestimation as almost nothing is known about the status of reptiles,

amphibians and flora across the island of Timor, let alone what species might be threatened in its marine environment.

Table 2. The IUCN list of the threatened plants and animals of Timor-Leste and the processes that threatened them (Source: adapted from Trainor (2010)).

Common name	Scientific name	IUCN status	Threatening process
TREES			
Sandalwood	*Santalum album*	VU	Habitat loss, fires, agriculture, extraction
Borneo Teak	*Intsia bijuga*	VU	Habitat loss, selective logging
Burmese Rosewood	*Pterocarpus indicus*	VU	Habitat loss, agriculture, selective logging
BIRDS			
Timor Green Pigeon	*Treron psittaceus*	EN	Habitat loss, hunting, agriculture
Timor Imperial Pigeon	*Ducula cineracea*	EN	Habitat loss, hunting, agriculture
Wetar Ground-dove	*Gallicolumba hoedtii*	EN	Habitat loss, hunting, agriculture
Yellow-crested Cockatoo	*Cacatua sulphurea*	CR	Habitat loss, harvest for pet trade, agriculture
MAMMALS			
Thin Shrew	*Crocidura tenuis*	VU	Habitat loss, degradation, restricted range
Western Naked-backed Bat	*Dobsonia peronii*	VU	Habitat loss, extraction, restricted range
INSECTS			
Timor Yellow Tiger	*Parantia timorica*	EN	Severely fragmented population with ongoing decline

Protected area legislation and protected area implementation

Several natural resource assessments, relevant to the development of Timor-Leste's Protected Area Network, were conducted during the period of Indonesian rule. The *National Conservation Plan for Indonesia: Nusa Tenggara* (FAO/UNDP 1982) included conservation assessments of eight sites in (then Indonesian controlled) Timor-Leste, with general information on their biodiversity significance, threats and potential for effective management. The *Review of Phase 1 results, Maluku and Nusa Tenggara* (RePPProT 1989) was a comprehensive analysis of natural resources, current uses and recommended land uses, including protected area recommendations.

This was superseded by *Regulation No.2000/19 On Protected Places* passed by UNTAET in 2000. It declared 15 'Protected Wild Areas' among other important conservation measures and was adopted by the new Government under the Constitution of Timor-Leste on transfer of administration from the UN at restoration of independence in 2002.

These are:

1. Total land area of Jaco Island together with surrounding rocks, reefs, and other surface and subsurface features;
2. Tutuala Beach together with forest adjacent to the beach;
3. Cristo Rei Beach and the hinterland;
4. Summit of Tata Mailau Mountain, all elevations on Tata Mailau Mountain above 2000 meters and the surrounding forest;
5. Summit of Saburai Mountain, all elevations on Saburai Mountain above 2000 meters and the surrounding forest;
6. Summit of Talobu Mountain, all elevations on Talobu Mountain above 2000 meters and the surrounding forest;
7. Summit of Mount Diatuto and the surrounding forests;
8. Summit of Mount Fatumasin and the surrounding forests;
9. Riverlet Clere Sanctuary;
10. Tilomar Reserve;
11. Lore Reserve;
12. Monte Mundo Perdido and the surrounding forest;
13. Summit of Monte Matebian and all elevations on Monte Matebian above 2000 meters and the surrounding forest;
14. Monte Cablaque and the surrounding forest; and
15. Manucoco Reserve.

In addition to specified 'protected wild areas', the Transitional Administrator argued that areas may be designated in a directive as terrestrial or marine areas of exceptional importance based upon on the occurrence of:

1. Scenic and natural qualities,
2. Biological resources including rare or threatened animals and plants; or
3. Habitats of endangered species.

While the naming of these areas provides an important baseline, in the absence of land use management and planning maps and because of ongoing issues regarding land ownership in

Timor- Leste, UNTAET intentionally provided only generally defined boundaries for these areas via a series of low resolution maps . The issues of land ownership remain unresolved, which means that the 15 'Protected Wild Areas' are not consistently recognised in land use planning. Furthermore, *Regulation 2000/19* does not provide an adequate framework for the long-term management of a national protected area network. There is also a lack of marine protected areas in legislation.

Despite these limitations, since the passing of these regulations much progress has been made especially around establishment of the country's first national park. This activity culminated in August 2008 when the *Nino Konis Santana National Park* in the Monte Paitchau–Iralalaro area was declared. The park covers 680 km^2 and includes the most pristine tropical evergreen forest on Timor Island, and is contiguous with primary and secondary drier tropical forests in the vicinity of Tutuala, Mehara and Com. This national park also incorporates the Jaco Island (number 1), the Lore reserve (number 11) and Tutuala Beach (number 2), outlined in *Regulation 2000/19*, which means that 12 more protected areas remain as the highest priorities to the country.

Since 2007, the DPANP have identified a further 17 landscapes that are in the process of being gazetted as protected areas (Table 3). These sites were identified using a bottom-up process based on habitat quality (identifying forests ecosystems that are in good condition) and threat (those ecosystems likely to become degraded or deforested). Locations were also identified where threatened species were located and for other lands of high conservation value (e.g. Important Bird Areas), and for watershed and water source protection (e.g. mountain areas).

The boundaries of Nino Konis Santana NP marine section and some potential marine protected areas were delineated with help by The Nature Conservancy during several workshops with staff from the Department of Fisheries during 2008-2009 during the TNC Ecoregional Assessment for Lesser Sundas (Wilson et al. 2009).

In summary, Timor-Leste has one formal national park and 28 other protected areas that are being planned for in Timor-Leste's terrestrial area estate. Timor-Leste is currently starting the process of developing a National Biodiversity Strategy and Action Plan (NBSAP) and several other projects that will help refine protected area strategies over the coming years (Table 1). While progress has been made on protected areas over the past decade, Timor-Leste is a new country and there is still much to do.

Table 3. The designation status of protected areas in Timor-Leste.

Protected Area Name	Basic Designation	Stage	Legislated
Area Protegida Reserva De Tilomar	Regulamento Untaet 19/2000	Complete demarcation	Implemented
Diatuto and Lian Bau Protected Area	Regulamento Untaet 19/2000	Preliminary survey was conducted and a consultation with community	Implemented
Manucoco Protected Area	Regulamento Untaet 19/2000	Preliminary survey was conducted and a consultation with community	Implemented
Nino Konis Santana National Park	Resolusaun do Govervo, no. 8/2008 Kria PNNKS,Regulamento Untaet 19/2000	Declaration on August 1, 2008 - including protected areas Reserva de Lore, Jaco Island and Tutuala	Implemented
Mount of Matebian	Regulamento Untaet 19/2000	Declared	Implemented
Mount of Mundo Perdido			Implemented
Ribeira de Clere	Regulamento Untaet 19/2000	Declared	Implemented
Mount of Fatumasin	Regulamento Untaet 19/2000	Declared	Implemented
Mount of Cablaque	Regulamento Untaet 19/2000	Declared	Implemented
Mount Tatamailau	Regulamento Untaet 19/2000	Declared	Implemented
Cristo Rei Protected Area	Regulamento Untaet 19/2000	Declared	Implemented
Talobu /Laumeta	Regulamento Untaet 19/2000	Declared	Implemented
Mount Cutete		Candidate for declaration	Proposed
Mount Manoleu		Candidate for declaration	Proposed
Area Mangal Citrana		Candidate for declaration	Proposed
Mount of Tapo/Saburai		Candidate for declaration	Proposed
Mount of Taroman		Candidate for declaration	Proposed
Mount of Kuri		Candidate for declaration	Proposed
Mount Lequmau		Detailed survey	Proposed
Mount of Laretame		Detailed survey	Proposed
Mount of Builo		Detailed survey	Proposed
Mount of Guguleur		Preliminary Survey	Proposed
Mount of Loelako		Preliminary Survey	Proposed
Mount of Burabo		Preliminary Survey	Proposed
Lake of Maurei		Preliminary Survey	Proposed
Mount of Aitana		Planned	Proposed
Mount of Bibileo		Planned	Proposed

Lake of Modomahut	Planned	Proposed
Lake of Welenas	Planned	Proposed

Previous and current conservation assessments

FAA REPORT on CONSERVATION OF TROPICAL FORESTS AND BIOLOGICAL DIVERSITY IN EAST TIMOR JUNE 2004

This report provided a broad overview of the institutional structure of the government; regulations related to environmental management; broad overview of ecological characteristics; forest cover estimates; broad land cover; threats to biodiversity; and an overview of protected areas. It also included suggested short, medium and long term objectives for environmental management. The report did not complete and NEGA but did provide a good context for this report.

Coral Triangle Initiative (CTI)

CTI is a new multilateral partnership to safeguard the region's marine and coastal biological resources. There are numerous projects currently ongoing related to protected area planning, mostly for marine and coastal areas. CTI are currently completing a state of the Coral Triangle report which will complement this assessment and provide region-wide context for gaps in protected areas.

TNC Lesser Sunda Ecoregional Assessment

The Nature Conservancy completed an ecoregional assessment for Timor-Leste and the surrounding region (see Wilson et al. 2009). This was a gap assessment applied for the Lesser Sunda region which includes parts on Indonesia and Timor-Leste. The marine protected areas and Areas of Interest (AOI) used in this assessment was based on this planning process.

Sustainable Land Management (UNDP, MAF)

The Sustainable Land Management (SLM) project is a partnership with the Government of Timor-Leste, UNDP as the implementing agency and funding from the Global Environment Facility. The SLM project aims to enhance the enabling environment and capacities for minimising land degradation and establishing sustainable land management practices so as to contribute to enhancing ecosystem health, integrity, functions and services while promoting sustainable livelihoods in Timor-Leste. This SLM project focuses on mainstreaming, institutional and technical capacity building as well as establishing sustainable financial mechanisms and

resource mobilisation for sustainable land management. SLM provided useful data for this assessment.

Birdlife International

Birdlife International have identified Important Bird Areas (IBAs Trainor et al. 2007). These were developed in partnership with the government. They have also completed vegetation surveys of Nino Konis Santana NP. IBAs are useful indicators of areas important for birds. The limitation is that they are mapped at a broad scale.

Charles Darwin University, Australia

Researchers from Charles Darwin University and Northern Territory government (Australia) have completed a number of studies useful for this assessment including:

- Conservation Values, Issues and Planning in the Nino Konis Santana Marine Park (Edyvane et al. 2009a)
- Coastal and Marine Ecotourism Values, Issues and Opportunities on the North Coast of Timor-Leste (Edyvane et al. 2009b)
- Marine Megafauna Surveys in Timor-Leste: Identifying Opportunities for Potential Ecotourism (Dethmers et al. 2009)
- Marine and Coastal Habitat Mapping in Timor-Leste (North Coast) (Boggs et al. 2009)
- Fisheries Development in the Com-Tutuala- Jaco Island area (Lloyd et al. 2008)
- River Catchments and Marine Productivity in Timor-Leste – Caraulun Catchment to Coast (Alongi et al. 2009)

The limitation of all of these studies is that they were not applied at a national scale. For example the mapping on the north coast is useful for this region but the data could not be used in this assessment because it did not cover all coastal areas in Timor-Leste.

Institutional framework and capacity for protected area planning and management

Here we provide a very brief overview of the institutional framework and governance for protected areas planning and management. Please refer to component three of PoWPA currently underway for a much more comprehensive assessment.

The Ministry of Agriculture and Fisheries (MAF) has the general mandate for biodiversity conservation but other ministries are also involved particularly the Ministry of Development

and Environment. Within MAF/National Directorate for Forestry lies DPANP and is mandated for protected area planning and management. The National Directorate for Fisheries and Aquaculture is also working on protected area planning in marine areas. For example, their main goal for 2011 is to advance community based spatial planning in Nino Konis Santana NP.

The staff in DPANP include 1) Manuel Mendes (Head of Department), 2) Pedro Pinto (Head of Nino Konis Santana National Park), 3) Gil Fernandez (Head of Planning and Policy), 4) Fernando Santana (Head of Survey and Inventory Section), and 5) Luis Ribeiro (Head of Ecotourism Section). The current budget is US$60,000 per annum.

The process of conducting the National Ecological Gap Assessment (NEGA)

Background to Ecological Gap Assessments

Developing an ecologically-representative network of protected areas that also achieves other ecological, social and economic objectives requires an approach that is based on the best available science (Dudley & Parish 2006; Watson et al. 2010). A key component of such an approach is conducting a gap assessment to ascertain what is missing in the current network of protected areas (Cowling et al. 2008; Margules & Pressey 2000; Moilanen et al. 2009; Pressey et al. 1996; Scott et al. 1992). In its simplest form, a gap analysis involves comparing the distribution of biodiversity with the distribution of protected areas and finding where species and ecosystems are left unprotected or under-protected (Fig. 3). Conceptually, this is not a difficult process, but it does require assembling a wide variety of information, which is often unavailable in many countries, and using sound ecological knowledge and rigorous analysis to make sure the outcome is meaningful in a conservation context. It then involves a separate analysis to identify where and how these gaps might be filled, and where the conservation priorities lie. The final component is the development of a strategy to implement actions that fill the gaps in the protected area network (Fig. 3).

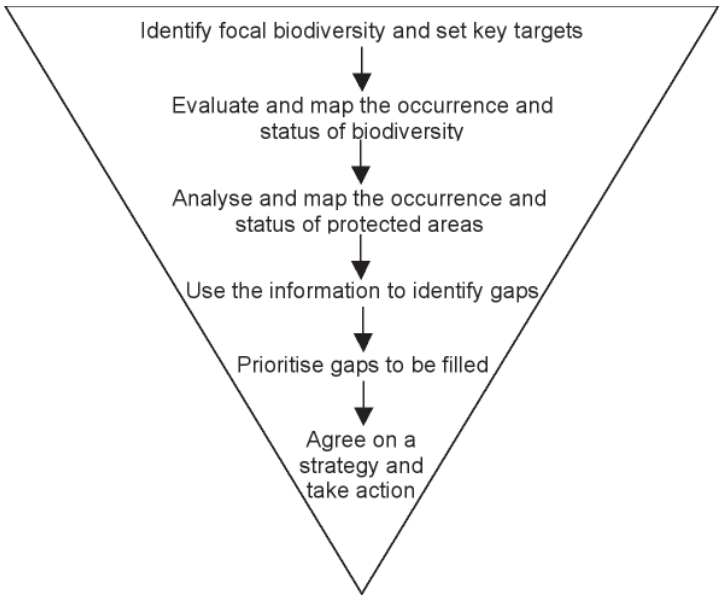

Figure 3. The six general steps to an Ecological Gap Analysis according to Dudley et al. 2006.

The methodology used in Timor-Leste's National Ecological Gap Assessment

The methodology used for Timor-Leste's National Ecological Gap Assessment was based on Dudley et al.'s (2006) protocol which was developed for the Convention on Biodiversity (CBD) as a guide for all countries to follow. However, we added a number of additional analyses which will feel greatly strengthened the analysis and also will allow for an easier transition into an implementation phase. The following describes the methodological steps used in this gap assessment.

1. Build capacity of government to help undertake National Ecological Gap Assessment.
2. Develop clear goals and objectives for protected area network.
3. Gather data related to objectives (i.e. what the protected area should achieve).
4. Conduct a protected area network gap analysis that assesses achievement of objectives within the coverage of protected areas
5. Conduct an analysis that identifies priorities for protected area expansion through the identification of Areas of Interest (AOI) that could help fill the gaps and ultimately achieve objectives.
6. Conduct an assessment of management gaps by prioritising new protected area management plans.
7. Identify strategies that enable the government to fill the gaps and create a world-class ecologically-representative protected area network.

Stage 1: Build capacity of government

An important component of undertaking Timor-Leste's National Ecological Gap Assessment was to build the capacity of DPANP and MAF staff, so that they could develop and explore options and take ownership of the final products of this assessment. *CNRM solutions Pty Ltd* therefore ensured that government officials from key departments were significantly involved with all steps of the analysis, primarily through participation in technical workshops. In these workshops, *CNRM Solutions Pty Ltd* staff took Timor-Leste policy and technical staff through the gap analysis process from inception to the final product. Timor-Leste policy and technical staff have also been centrally involved in the development of processes that will allow for the implementation of the recommendations outlined in the report. A summary of the workshops (and the dates they were held) are as follows:

Workshop 1 – *An introduction to conducting an ecological gap assessment* – August 2010

The primary aims of the first one-day workshop were to: (1) provide an introduction to Gap Analysis and (2) to obtain agreement on the framework, process and key inputs. The meeting included presentations and discussions on: (1) Introduction to Gap Analysis based on CBD Guidance (based on Dudley et al. 2006), (2) Introduction to basic principles of systematic conservation planning focusing on the key criteria of representation, persistence, efficiency and flexibility (based on Watson et al. 2011), and (3) Options for different objectives and targets for the Timor-Leste gap analysis. Participants included DPANP, National Directorate for Fisheries and Aquaculture and Department of Environment and Development.

Workshop 2– *Introduction to decision support tools* – August 2010
The primary aim of the second two-day workshop were to provide an introduction to decision support tools in general and the spatial analysis tool, *Marxan* in particular. In this workshop, staff worked through the process of (1) setting objectives, (2) setting targets to these objectives, (3) understanding the need to develop 'costs' to achieving these objectives, and (4) the use of appropriate planning units (candidate areas for considering the placement of protected areas) when conducting spatial prioritisation analyses. During the second day of this workshop, participants were shown how to use *Marxan* using a dummy example. Participants included DPANP, National Directorate for Fisheries and Aquaculture, and Department of Environment and Development.

Workshop 3 – *Developing objectives and targets for the gap analysis* – August 2010
The primary aim of the third one-day workshop was to work through the key objectives that the government wanted to assess in this ecological gap analysis. Using Dudley et al. (2006) as a starting point, participants were asked to prioritise objectives and to develop short term targets for these objectives. Participants included DPANP.

Workshop 4- *Mapping current and protected areas* – August 2010
The primary aim of this multi-day workshop was to map the existing and protected areas. Whilst this sounds simple enough, there has been no previous attempt to do this and both DPANP and other MAF staff had no access to these important spatial data. As such, this mapping had to be developed from the beginning. This, we believe, is a significant achievement as it is the first spatially explicit protected area network for Timor-Leste. Participants included DPANP.

Workshop 5 – *Reviewing the Gap Analysis* – November 2010
The primary aim of this workshop were to work with government staff to refine the gap analysis framework, (e.g. objectives, criteria and targets) to make sure they support the development of Protected Areas in way the government of Timor-Leste ultimately wanted. During the

workshop, the *Marxan* outputs were refined and some draft gap analysis products were produced. A key component of this workshop was the development and utilisation of an expert-driven process to identify areas of interest for terrestrial protected areas. Experts were the planners DPANP and National Directorate for Fisheries and Aquaculture. We also started to develop an appropriate draft process for stakeholder consultation and mainstreaming outcomes.

Workshop 6 - *Final report and products* – February 2011
The primary aim of the final workshop was to refine the interim report and products so the best possible product is developed with which to engage key stakeholders. Participants included various government departments and NGOs.

Stage 2. Developing goals and objectives for protected area network

A key component of systematic conservation planning is the development of clear conservation goals and objectives (Fig. 3). The following goals for terrestrial, marine and freshwater realms were determined by Timor-Leste government officials from MAF and DPANP during workshops 1, 2 and 3 outlined above, and in an internal meeting held in January 2011 with DPANP and National Directorate for Fisheries and Aquaculture.

Goal One. *Ensure full representation across biological scales and biological realms*.

Goal Two. *Protection of all critical habitats for endemic, migratory and threatened species*.

Goal Three. *Ensure that protected areas are the right size to ensure the persistence of biodiversity*.

Goal Four. *Ensure that protected areas play a role in mitigating climate change*.

Goal Five. *Design protected areas so that they are resilient and able to withstand stresses and changes such as human-forced climate change.*

Specific medium-term specific objectives were developed against each of these goals. These are intended to be achieved by 2020. Objectives are more specific outcomes expected from planning than the broader goals. Some objectives are targets, specific amounts to the included within the protected area network. Goals three and five do not have actual targets but did have specific objectives.

Targets for Goal 1. Ensure full representation across biological scales and biological realms.

The medium-term 2020 objectives set for this goal are:

1. A minimum of 30% of the original extent for each major vegetation type to be placed in protected areas;
2. A minimum of 50% of the current extent of estuaries; and
3. A minimum of 30% of the distributions of each known taxa to be within a protected area.

These three objectives will be called the *representation objectives* throughout the rest of the report.

Targets for Goal 2. Protection of all critical habitats for endemic, migratory and threatened species.

The medium-term 2020 objectives set for this goal are:

1. 100% of the critical habitat (areas critical for their survival) for terrestrial threatened species to be captured in a protected area, and 50% of critical habitat for marine threatened species to be captured in a protected area;
2. 100% of the known range of terrestrial endemic species to be captured in protected areas, and 50% of the known range of marine endemic species to be capture in protected areas;
3. Where possible protect 100% fish spawning areas, and 80% mangroves given their importance as fish nurseries; and
4. 100% of the known range of terrestrial migratory species to be captured in a protected area and 50% of the known range of marine migratory species to be capture in a protected area.

These four objectives will be called the *persistence objectives* throughout the rest of the report.

Targets for Goal 3. Ensure that protected areas are the right size to ensure the persistence of biodiversity.

The medium-term 2020 objectives for this goal are to minimize fragmentation of habitat within protected area boundaries and maximize the protection of habitat connectivity between protected areas. The fundamental aim is to maintain/restore 100% habitat connectivity within and around terrestrial protected areas and 50% of marine protected areas. These were set to

ensure maintenance of the ecological and evolutionary processes which are critical to the persistence of biodiversity in Timor-Leste.

Targets for Goal 4.Ensure that protected areas play a role in mitigating climate change.

The medium-term 2020 objective for this goal is to ensure that 30% of the nation's sequestered carbon found in living terrestrial vegetation is captured inside protected areas. A separate target was set for mangrove forests, with 80% of their current distribution to be protected in protected areas based on securing the carbon of these mangroves.

These objectives will be called the *climate mitigation objectives* throughout the rest of the report.

Targets for Goal 5. Design protected areas so that they are resilient and able to withstand stresses and changes such as human-induced climate change.

The medium-term 2020 objectives for this goal are:

1. Where possible, ensure that protected areas are as large as they can possibly be;
2. Where possible, ensure that protected areas are connected to one another, especially along elevation gradients for terrestrial protected areas; and
3. Where possible, and where there are areas representative of major geological features in the protected area system, to ensure climate refugia are protected.

These objectives will be called the *climate adaptation objectives* throughout the rest of the report.

Stage 3. Gather data related to the objectives and targets

A summary of the data (and their sources) used to assess each of the targets are outlined in Table 4. We describe the data used for this project in more detail in the next chapter, including an overview of their specific attributes and how they were collected. Please note that a copy of these data are contained in the attached CD.

Table 4. Summary of data used in this project and its source

Data	Sources
Land types	ALGIS (Geoformations), UNDP SLM project (landcover)
Rivers	ALGIS
Estuaries	The Nature Conservancy
Coral Reefs	Millenium Ecosystem Mapping Project (University of Miami)
Broad marine classes	GEBCO
Mangroves	The Nature Conservancy
Seagrasses	The Nature Conservancy
Carbon	Ruesch et al.
Records of birds of conservation concern	Colin Trainor (Charles Darwin University)
Important Bird Areas	Birdlife International
Important wetlands for birds	Colin Trainor (Charles Darwin University)
Important sites for reptiles and frogs	Hinrich Kaiser (Victor Valley College)
Important site for orchids	Paulo Silveira (Universidade de Aveiro)
***Chelodina timorensis* (turtle)**	McCord et al. (2007) Reptilia
***Crateroscephalus Laisapi* (fish)**	Helen K. Larson (Museum and Art Gallery of the Northern Territory)
Biological survey of protected areas	Fernando Santana (DPANP)
Household points (2004)	ALGIS
Mining	ALGIS
Roads	ALGIS

Stage 4. Conduct a protected area network gap analysis that assesses the coverage of protected area against objectives and targets

Analysis of the achievement of the objectives and targets in the protected area network is central to an ecological gap assessment. We first overlaid the distributions of ecosystems and species with the distribution of the protected area network (a detailed description of the data is provided in the next chapter). Using these data, we were able to calculate the amount of each ecosystem and species that is protected by the protected area network against the objectives and targets described above. We also provide an individual assessment of the contribution of each protected area to specific objectives in Appendix One.

Stage 5. Conduct a spatial prioritisation analysis that identifies those Areas of Interest that could achieve objectives

We identified potential Areas of Interest (AOI) to fill ecological gaps using two different approaches: expert opinion and spatial prioritisation software. AOI are broad areas identified as likely containing important habitat that achieve protected area objectives.

Expert opinion. This represents information about the physical or social environment based upon the knowledge of local and regional experts. There are two advantages to using expert opinion. First, it can overcome the problems of data limitations (e.g. incomplete and missing data) and second, people can often better understand (when compared to a computerized system) the socio-economic context of where protected areas might be suitable. The disadvantages are that people often have bias in their knowledge toward particular ecosystems, species and places (Gaston & Rodrigues 2003). The experts identified AOI for new terrestrial protected areas during a workshop in November 2011. The experts in attendance were Manuel Mendes, Fernando Santana, Gil Fernandez, Pedro Pinto, Luis M. Ribeiro (all members of the DPANP).

In the marine realm, AOI were identified during workshops organised by The Nature Conservancy in December 2008 and April 2009. At the first two day workshop, the following attended: Abilio de Deus de Jesus Lima, Rafael Pereira Goncalves, Augusto Fernandes, Adalfredo Do and Rosario Ferreira (all members of MAF). At a second scientific workshop held in Bali in April 2009, Augusto Fernandes and Ancellmo attended the workshop where maps were further refined.

Spatial prioritisation software. Spatial prioritization software is specialist software to identify spatial priorities for protected areas. We used the freely available software *Marxan* (Ball et al. 2009), software that has been used for identifying proposed conservation areas throughout the world (e.g. Carwardine et al. 2008; Smith et al. 2009; Klein et al. 2009) to identify areas of interest based on objectives outlined above. *Marxan* uses a selection algorithm to select multiple alternative sets of areas that meet pre-specified species or ecosystem targets whilst trying to minimise overall cost and whilst maximising clustering (Ball et al. 2009). We conducted a number of spatial prioritisation analyses to explore solutions for achieving the short term targets for both species and vegetation described above, as well as the target set for carbon. For our *Marxan* analyses, we created planning units of 1km^2 in terrestrial and coastal areas. When running *Marxan* a cost layer is used to preference selection towards particular areas. Our cost layer was the distance to the nearest house based on the household survey 2004 (see data chapter below for a description of the dataset). We used this as a cost metric because increased population mean it is both less likely to contain public land or more people to deal with for

implementing a protected areas, both increase the cost of protected area implementation. Not all data were used in the analysis, only data we were confident enough could guide planning of protected areas. The list of data and targets is provided in Table 7.

Marxan produces many different good solutions to the problem. We ran *Marxan* 100 times to produce several different solutions. We then used the frequency an area was selected to determine priority areas. We classified the areas using the following: high priority (selected 76-100% of time), high priority (selected 51-75% of time), low priority (selected 26-50%) and very low (selected 1-25%) and not priority (never selected). We then used this to delineate the Marxan AOI based on high priority areas and priority areas. The advantage of this software is that it is systematically assesses the location of new protected areas based on data. The disadvantage is the data might not distinguish areas that are the most socially and economically feasible to implement new protected areas in.

Stage 6. Conduct an assessment of management gaps by prioritizing new protected area management plans.

Normally a protected area gap assessment would incorporate an assessment of how effectively protected areas are managed (Dudley et al. 2006). Timor-Leste is in a unique situation in that is only a new country and consequently has not started to develop any formal management plans. As such, a traditional approach to assessing protected area management effectiveness would is not applicable. Instead, we developed a novel analysis using the spatial tool *Marxan* to prioritize which protected areas (within the protected area network) should highest priority in developing their management plans. This was based on which areas would protect each threatened species in three protected areas. We chose three as an insurance factor. If one population should decline, it will likely still be secure in two other protected areas. We did this based on ecological survey data carried out by the DPANP described in the next section. One protected area, the Nino Konis Santana NP is currently already starting to develop its management plan.

Marxan produced a number of different solutions to this problem. We ran *Marxan* 100 times to produce several different solutions and used the frequency a protected area was selected to determine priority. We classified priority using the following ranks: very high priority (selected 100% of time), high priority (selected 51-99% of time), priority (selected 1-51%) and not a priority (never selected).

Stage 7. Identify all the strategies that will help enable the government fill the gaps and create a world class ecological protected area network.

Together with DPANP we discussed current strategies that are being used to implement the protected area network and ways this might be improved. The list of strategies and recommendations are found in the Conclusion chapter.

A detailed description of the data used in the National Ecological Gap Assessment (NEGA)

Data on the protected area network

As discussed previously, as far as we and the current staff at DNANP are aware, there have been no previous attempts to spatially map the extent of protected areas. This is except for DNANP that has a programme to delineate boundaries by working with relevant communities. This programme, which has only just started, is in various stages of legal development and only one boundary has been completed. Over the course of a week-long workshop, the locations of all terrestrial protected areas were delineated in GIS based on the knowledge of the DNANP staff. These protected areas are at various stages of implementation (see Table 3) with some proposed as likely to go ahead. The boundaries of marine areas were delineated by The Nature Conservancy during several workshops with staff from the Department of Fisheries during 2008-2009. It is important to note that these boundaries are only an indicative guide and in no way represent the final boundaries of the protected area network. Timor-Leste's protected area network in both the marine and terrestrial realms are shown in Figure 4 and many terrestrial protected areas described in Table 4.

The size of the protected areas range from 2km^2 (Mount of Maurei) to 675 km^2 (Nino Konis Santana NP terrestrial section), with the average size of protected areas being ~100km^2 and the median being ~65km^2 (Fig. 5). The total area of protected areas is ~3200km^2. The total area of terrestrial protected area network is ~2000km^2, which is around 14% of the countries land area.

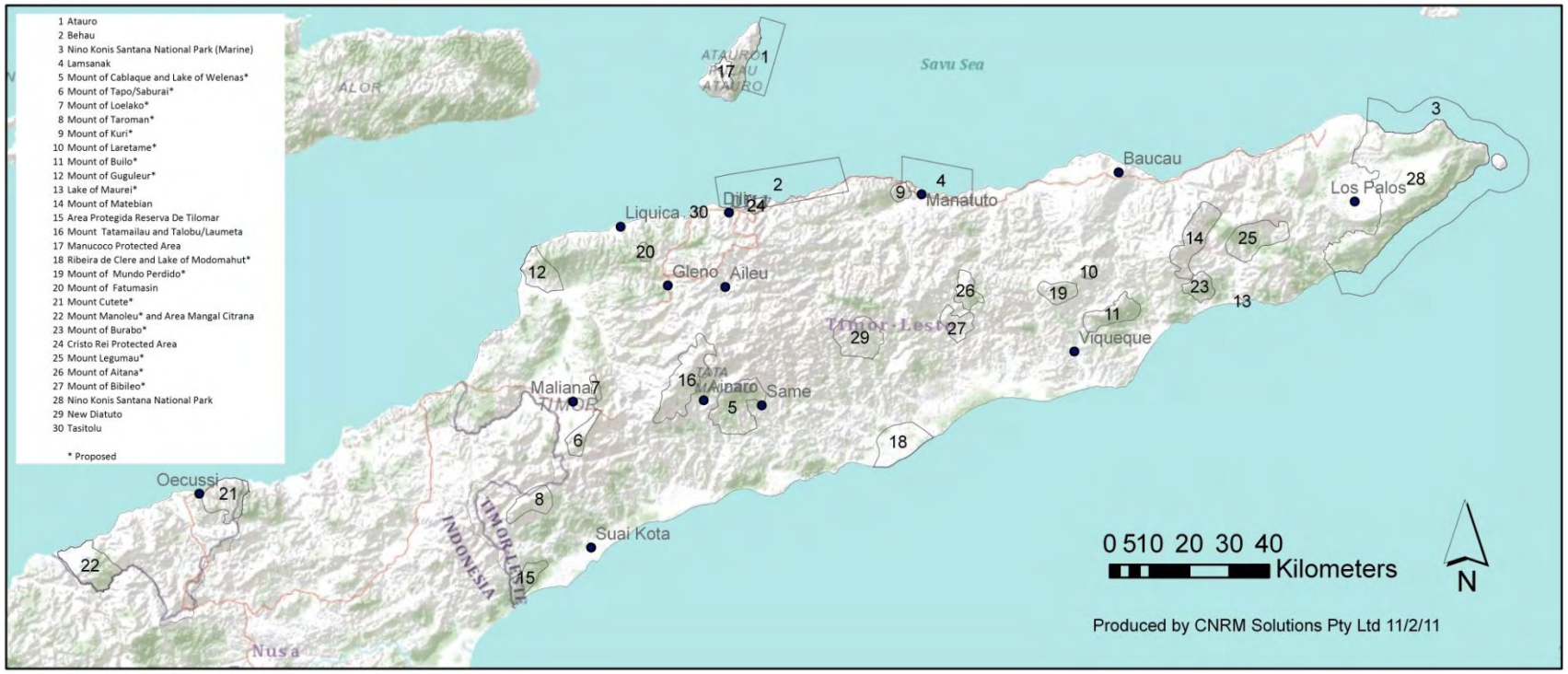

Figure 4. The protected area network for Timor-Leste are shown (and named) in relation to the major towns in Timor-Leste. Protected areas are different stages of implementation. Final boundaries have not been identified except for one so these boundaries are only a rough guide and were only developed specifically for this assessment.

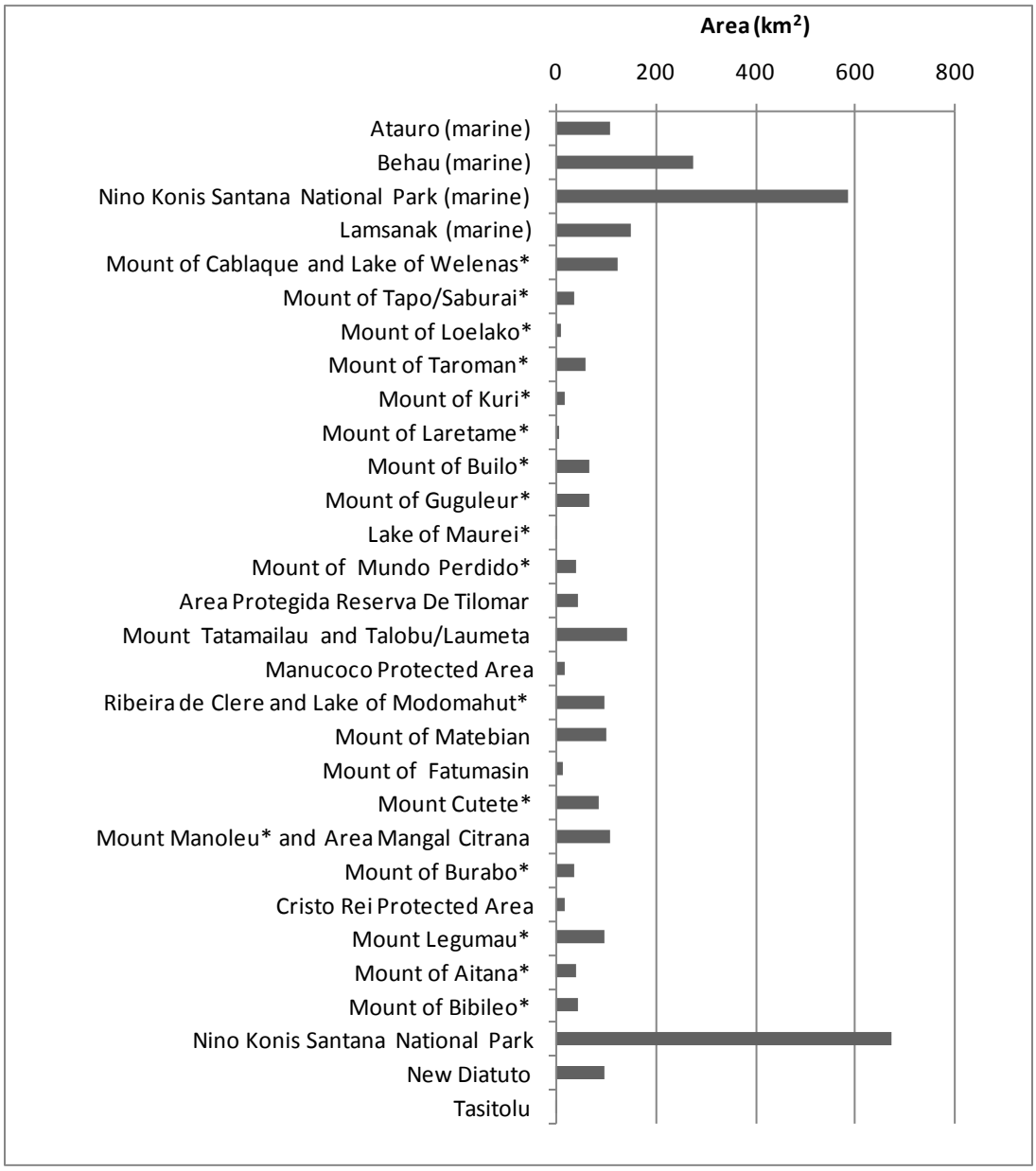

Figure 5.The size distribution (Km^2) of Timor-Leste's protected area network. *proposed (likely to be implemented)

Data on ecosystems

As discussed in the Introduction, both DNAPD have access to limited ecosystem and species data, and as such there is a serious shortfall in the spatial knowledge of almost all biodiversity in Timor-Leste. However, through the generosity of a number of international scientists, we

were able to glean together a number of important datasets on ecosystems and species. Using these data, we were able to develop the first comprehensive ecological classification for Timor-Leste's land, freshwater and nearshore marine environments, and centralise the data into a single database for the government to utilise in the future.

Forest types

Rationale for incorporating forest types into the NEGA:

Data on forest types represent the structure and coverage of different forest ecosystems in Timor-Leste. A classification of terrestrial vegetation was required to help assess the representation objectives (goal one), particularly given data on individual species are limited. Utilizing ecosystem based surrogates such as vegetation types is standard practice in conservation planning (Pressey 2004). There is an assumption that many species will be incidentally protected if different types of vegetation are used for planning areas for protection.

We focused on classifying only forest types for terrestrial areas because forests are ecosystems are of primary concern for the government because of their ecological and economic values. After much discussion, we used geological formations to delineate the different forest types. A geological formation (hereafter *geoformation*) is a fundamental unit of lithostratigraphy (the science of rock types). A geoformation consists of a certain number of rock strata that have a comparable lithology, facies or other similar properties. We used geoformations, because they are a single geology that has been formed around the same geologic time period and as such are likely to correlate to evolutionary patterns and likely to form different broad communities of species. Often geology is a contributing factor in the distribution of species and consequently can be a good surrogate for species patterns, at least at a broad scale (Cowling & Heijnis 2001). Furthermore, if geophysical diversity helps to maintain species diversity, than conserving representative examples of geophysical settings as part of regional conservation, offers an approach to conservation that will hopefully protect diversity under both current and future climates (Game et al. 2010).

Method: To delineate terrestrial forest types, we developed a land type classification based on geoformations sourced from ALGIS (Figs. 7 and 8). One class of geoformation of these data was "unknown" which we assumed were areas that have not yet been mapped. This included the entire island of Atauro and some other areas on the mainland. We determined that this island has a different geology compared to the main island of Timor and therefore added an extra class for this island, the rest kept the classification "unknown". We rapidly checked the species heterogeneity within and across the geoformations with a field trip in November 2010 that

spanned east-west (across the north coast) and north south (in the centre of the country). We found that the communities noticeablely changed in community composition between geoformations (e.g. Fig. 6) yet this was a very rapid assessment. We also compared the geoformations against environmental heterogeneity (elevation and rainfall data) across Timor-Leste. There were a small number of geoformations that could be further subdivided based on elevation and rainfall gradients but as this is largely untested (and unproven) it was decided not to take this step.

Targets were based on the original extent of forests based upon the assumption that the forest covered the entirety of each geoformation. We used the landcover data from the UNDP (2010) SLM project to identify the current extent of forests. This project identified several structural types of forests (dense forest, medium forest, medium woodland and sparse woodland). To avoid a complex analysis that assessed each of these structural types of forest, we used this data to produce two maps of current forest: an optimistic scenario and a pessimistic scenario. The optimistic scenario included “dense forest”, “medium forest” and “medium woodland”. The pessimistic scenario did not include medium woodland but rather only included “dense forest” and “medium forest”. The underlying assumptions behind this distinction is that woodier, denser forest structure with more mature stands of trees, was likely to be more intact, less fragmented and would correlate with higher species diversity, higher soil productivity and less erosion.

Figure 6. This photo is taken from the road that is on the Bobonaro Formation. In the background is Mondo Perdido consisting mostly of Cablaci Limestone.

Attributes: There are 22 geoformations identified for Timor-Leste (Fig. 7). The area for each geoformation is given in Figure 8. We used these geoformations as an environmental surrogate for forest types but added another type “Atauro” for the island of Atauro as it has a different geology to the mainland (as previously discussed). A last category was “unknown” which are areas assumed to not yet be mapped. This resulted in 24 types of forest for Timor-Leste.

The landcover data classified Timor-Leste into 10 categories. The spatial distribution of these categories is shown in Figure 9 and the area of each category in Figure 10. Based on these data Timor-Leste has approximately 50% forest cover based on the optimistic scenario for forest classification and around 30% forest cover based on the pessimistic scenario. The forests are heavily fragmented (Figs. 11 and 12).

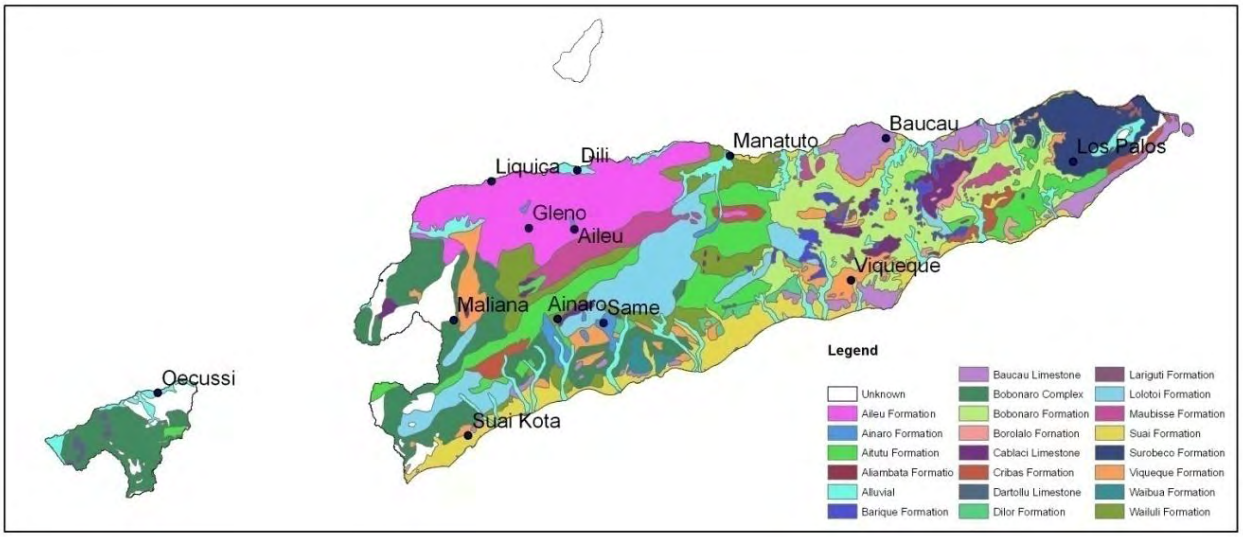

Figure 7. The spatial location of all geoformations found in Timor-Leste in relation to major towns.

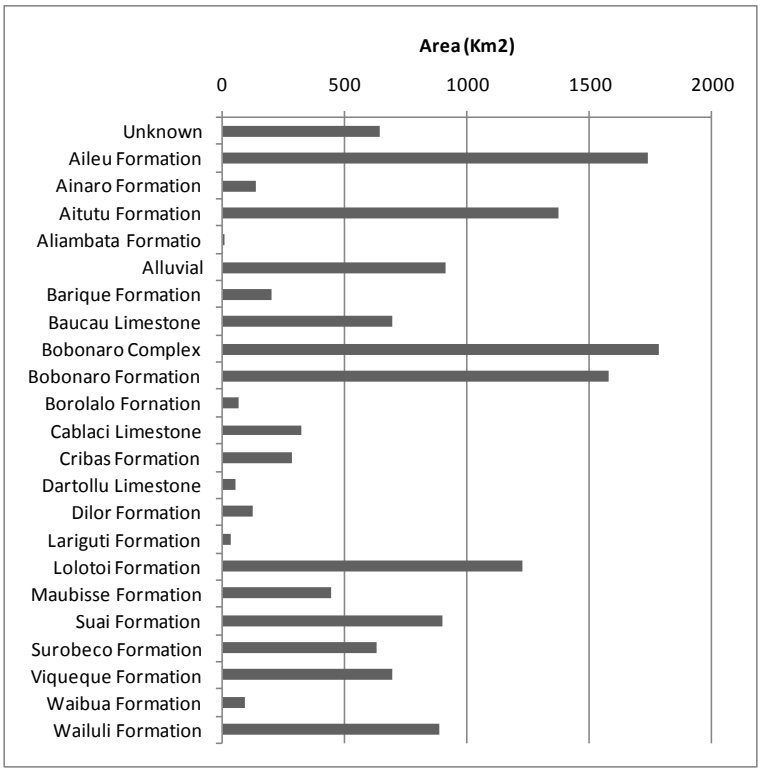

Figure 8. The area (Km^2) of each the 24 Geoformations

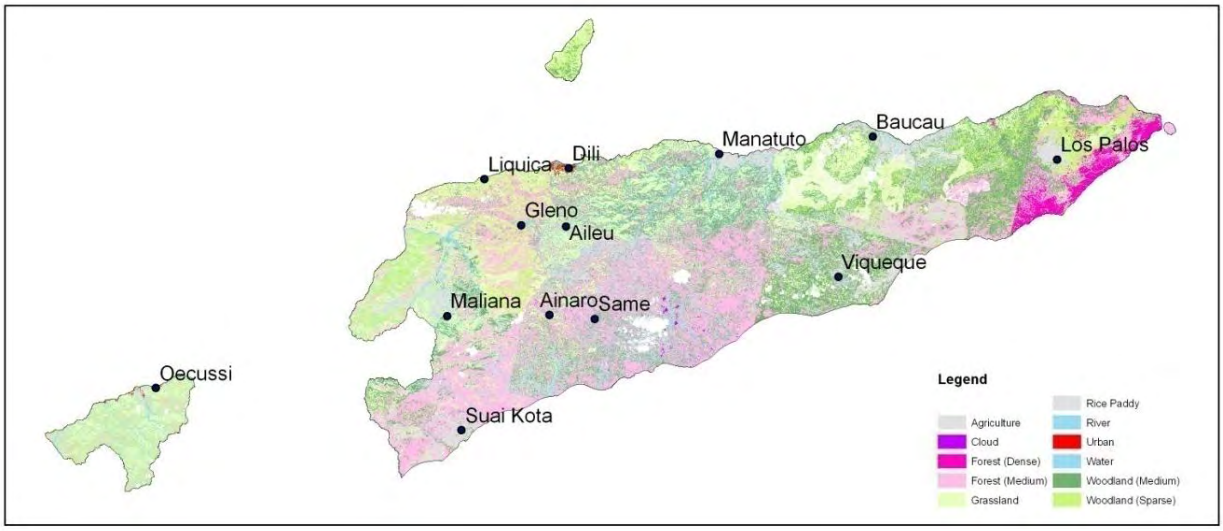

Figure 9. Distribution of landcover in Timor-Leste in relation to the major towns. Data based on the Sustainable Land Management (SLM) project (UNDP 2010).

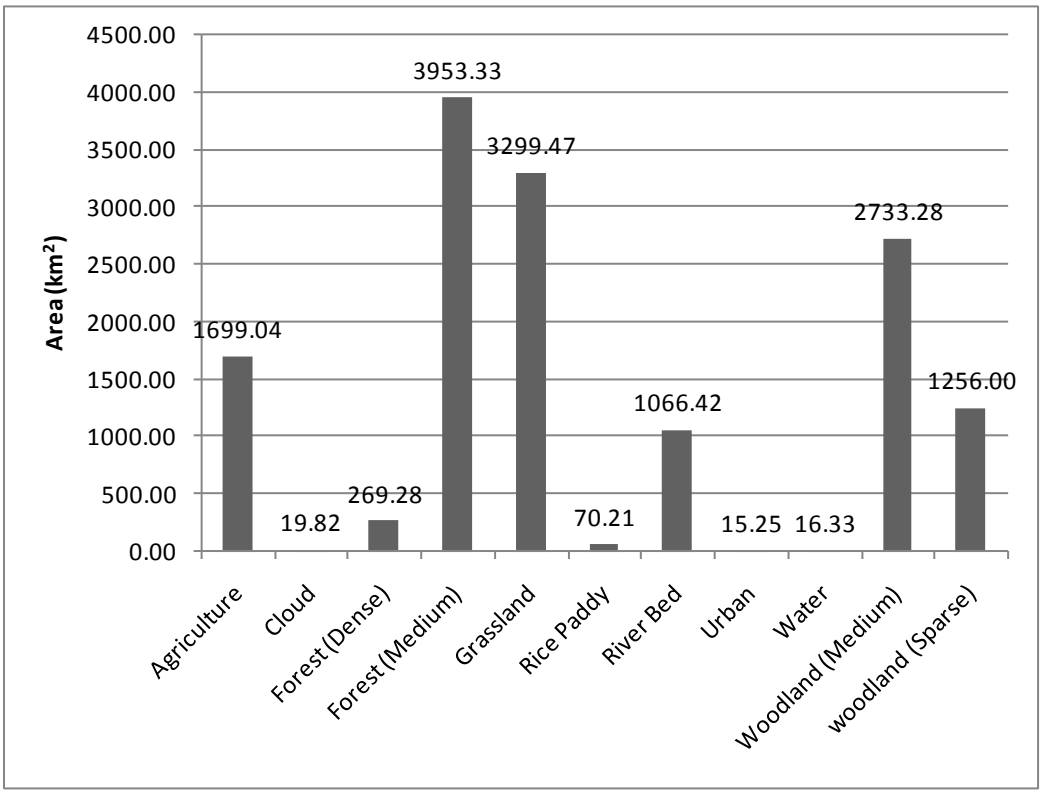

Figure 10. The area (Km^2) of each major land cover class. The data is based on the Sustainable Land Management (SLM) project (UNDP 2010) .

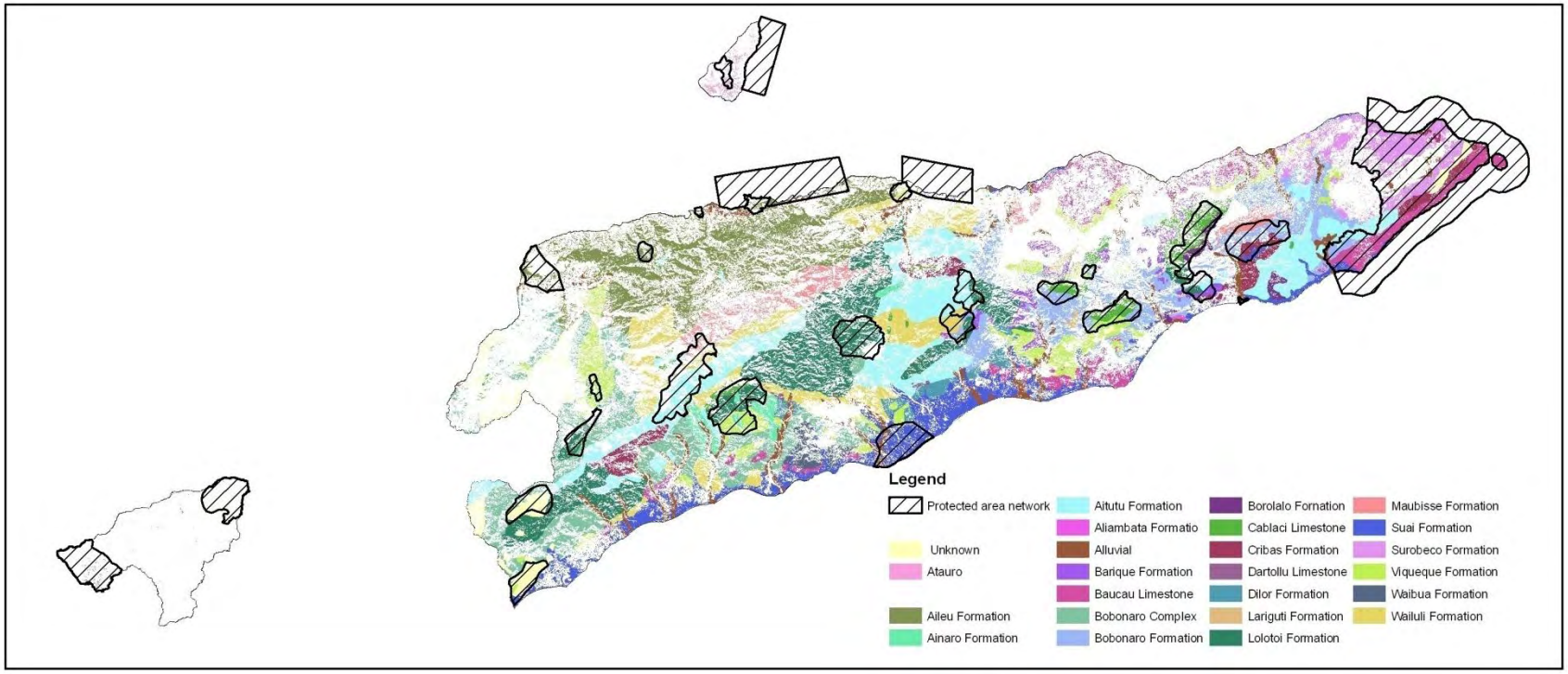

Figure 11. The spatial distribution of 24 forest types based on an optimistic forest cover classification which included dense forest, medium forest and medium woodland. The distribution is in relation to the protected area network. Forest type was classified based on geoformations.

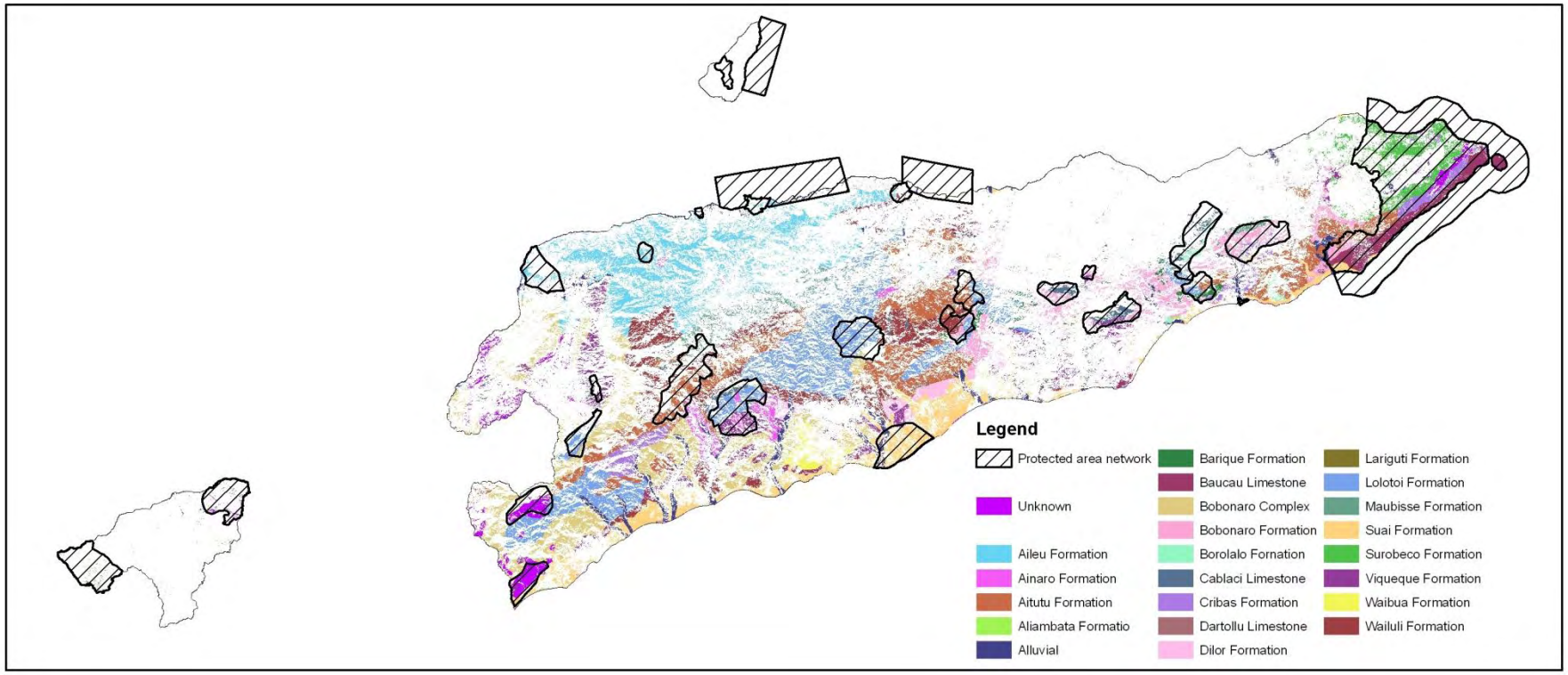

Figure 12. The spatial distribution of 24 forest types based on a pessimistic forest cover classification which included dense forest and medium forest but not woodland. The distribution is in relation to the protected area network. Forest type was classified based on geoformations.

Rivers and Estuaries

Rationale for incorporating rivers and estuaries into the NEGA: Rivers and estuaries are important habitats that need to be represented in the protected area network. This is based on the representation objectives (goal one).

Method: The river data were sourced from ALGIS and the estuary data were sourced from The Nature Conservancy.

Attributes: Timor-Leste is made up of approximately 250km^2 of braiding rivers, nearly 40km^2 of lakes and 10km^2 of estuaries (Fig. 13).

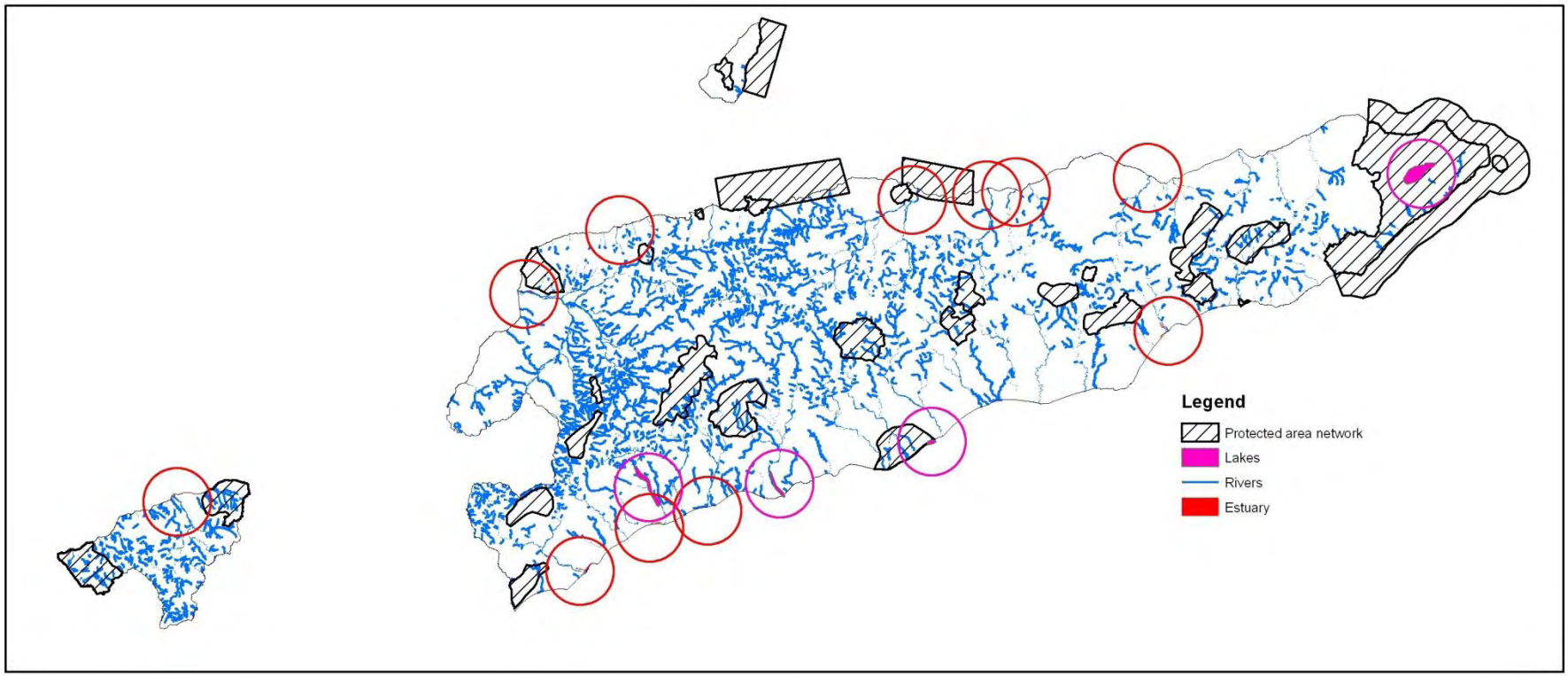

Figure 13. The spatial distribution of rivers (both linear and braiding), lakes and estuaries in Timor-Leste in relation to the protected area network.

Coral Reefs

Rationale for incorporating coral reefs into the NEGA: Coral reefs are important habitats because of their high species diversity and economic importance. They relate to the representation objectives (goal one).

Method: Coral Reef data were sourced from The Millennium Mapping Project, undertaken by the University of Miami (see http://imars.marine.usf.edu/MC/index.html). The classification scheme is based upon satellite images within the region, which have been examined to highlight all the possible configurations of reefs (by compiling catalogues of reef structures). They are classified based on geomorphology and oceanography (Table 5).

Attributes: The distributions of coral reef found in Timor-Leste are provided in Figure 15. The area of coral reefs are provided in Figure 14.

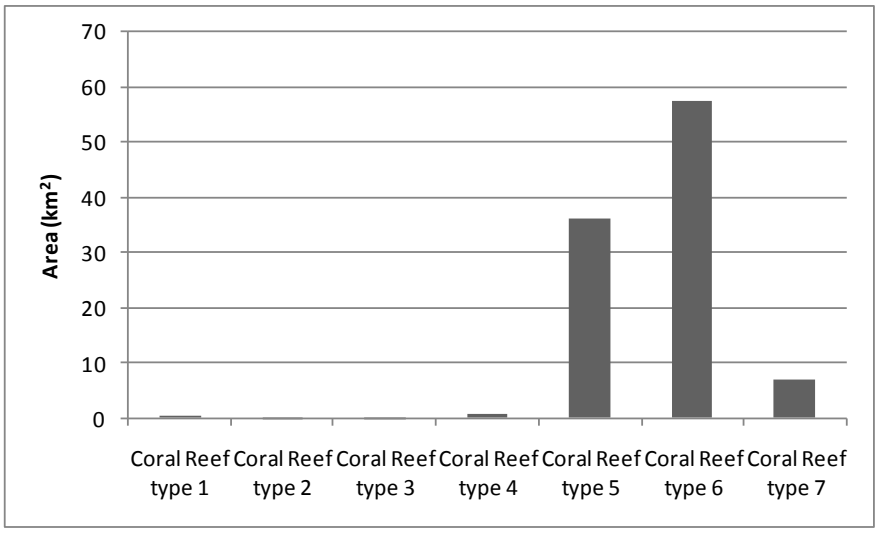

Figure 14. The area (Km^2) of the seven types of coral reefs found in Timor-Leste. The attributes of each coral reef type are described in more detail in Table 5.

Table 5. The three attributes that were used to classify coral reefs.

Name	Attribute 1	Attribute 2	Attribute 3
Type 1	Continental island	Outer Barrier Reef Complex	Subtidal reef flat
Type 2	Continental island	Shelf patch-reef complex	Forereef
Type 3	Continental island	Shelf patch-reef complex	Reef flat
Type 4	Continental island	Ocean exposed fringing	Enclosed lagoon or basin
Type 5	Continental island	Ocean exposed fringing	Forereef
Type 6	Continental island	Ocean exposed fringing	Reef flat
Type 7	Continental island	Ocean exposed fringing	Shallow terrace

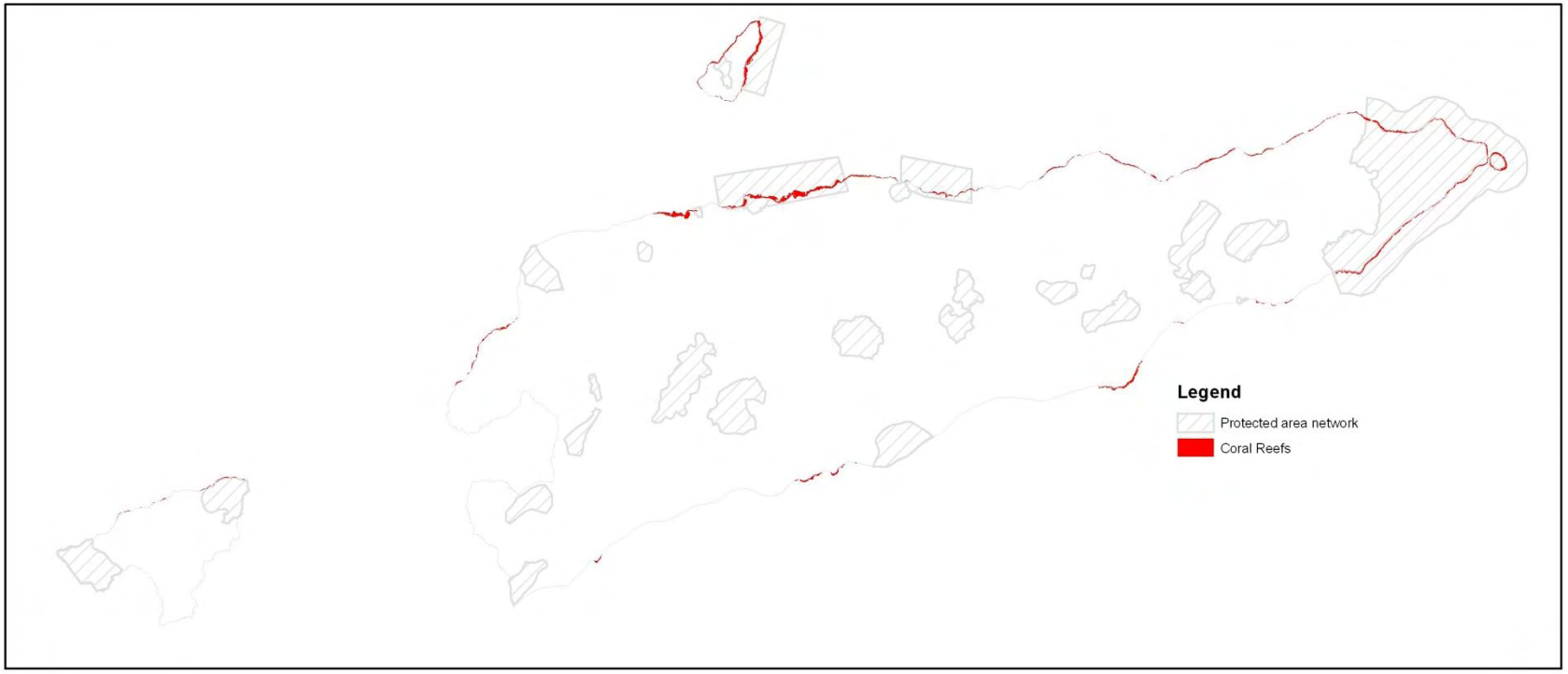

Figure 15. The distribution of coral reefs in Timor-Leste in relation to the protected area network. Coral reefs were divided into seven classes but they could not be shown here due to the resolution of the data.

Broad marine classes

Rationale for incorporating marine classes into the NEGA: We included broad marine classes as a very broad surrogate for marine biodiversity. These are important for the government's representation objectives (goal one). They are conservative and only based on depth.

Method: We used GEBCO bathymetric data to divide inshore areas into five marine classes. They were divided by depth: class one: 5500m - 501m, class two: 500m-201m, class three: 200m-101m, class four: 100m-31m and class five: <30m.

Attributes: The area of each class is given in Figure 16 and the spatial distribution of broad marine classes is given in Figure 17.

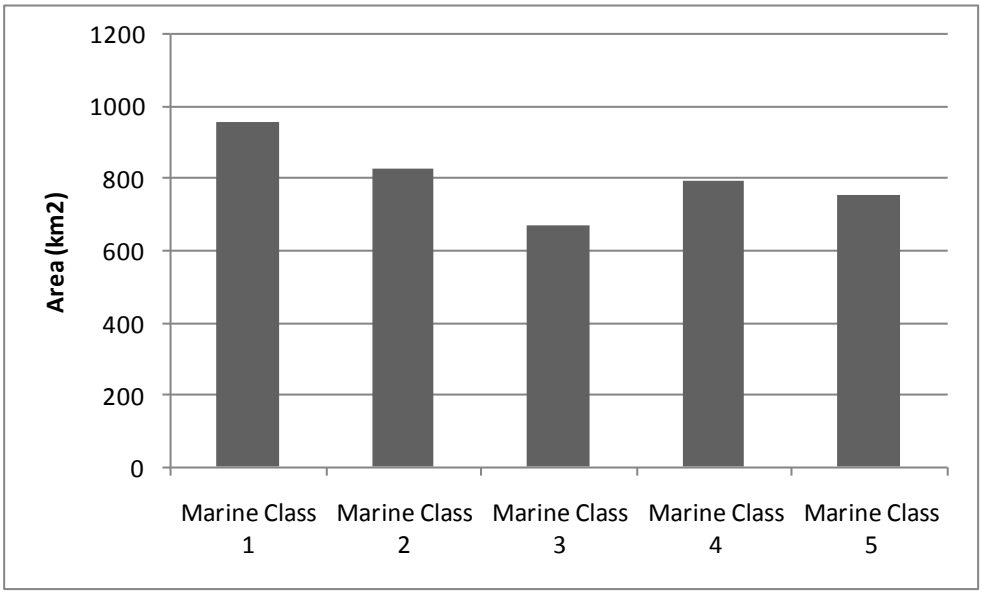

Figure 16. The area (Km^2) of each broad marine classes. The depths were class one: 5500m - 501m, class two: 500m-201m, class three: 200m-101m, class four: 100m-31m and class five: <30m.

Figure 17. The five broad marine classes based on depth in Timor-Leste in relation to the protected area network. The depths were class one: 5500m - 501m, class two: 500m-201m, class three: 200m-101m, class four: 100m-31m and class five: <30m.

Mangroves and seagrasses

Rationale for incorporating mangroves and seagrasses into the NEGA: Mangroves and seagrasses are important ecosystems to be represented in the protected area network based on the government's representation objectives (goal one).

Method: Both mangroves and seagrasses distributions were based on data from The Nature Conservancy.

Attributes: The distribution of seagrasses and mangroves are given in Figure 18. The area of mangroves is approximately 12 km^2 and seagrasses is approximately 8 km^2.

Carbon

Rationale for incorporating carbon into the NEGA: This attribute relates to the government's objective for climate change mitigation (goal four).

Method: Carbon data was sourced from (Ruesch & Gibbs 2008)

Attributes: The distribution in the abundance of terrestrial carbon is shown in Figure 19.

Figure 18. The spatial distributions of seagrasses and mangroves in Timor-Leste in relation to the protected area network.

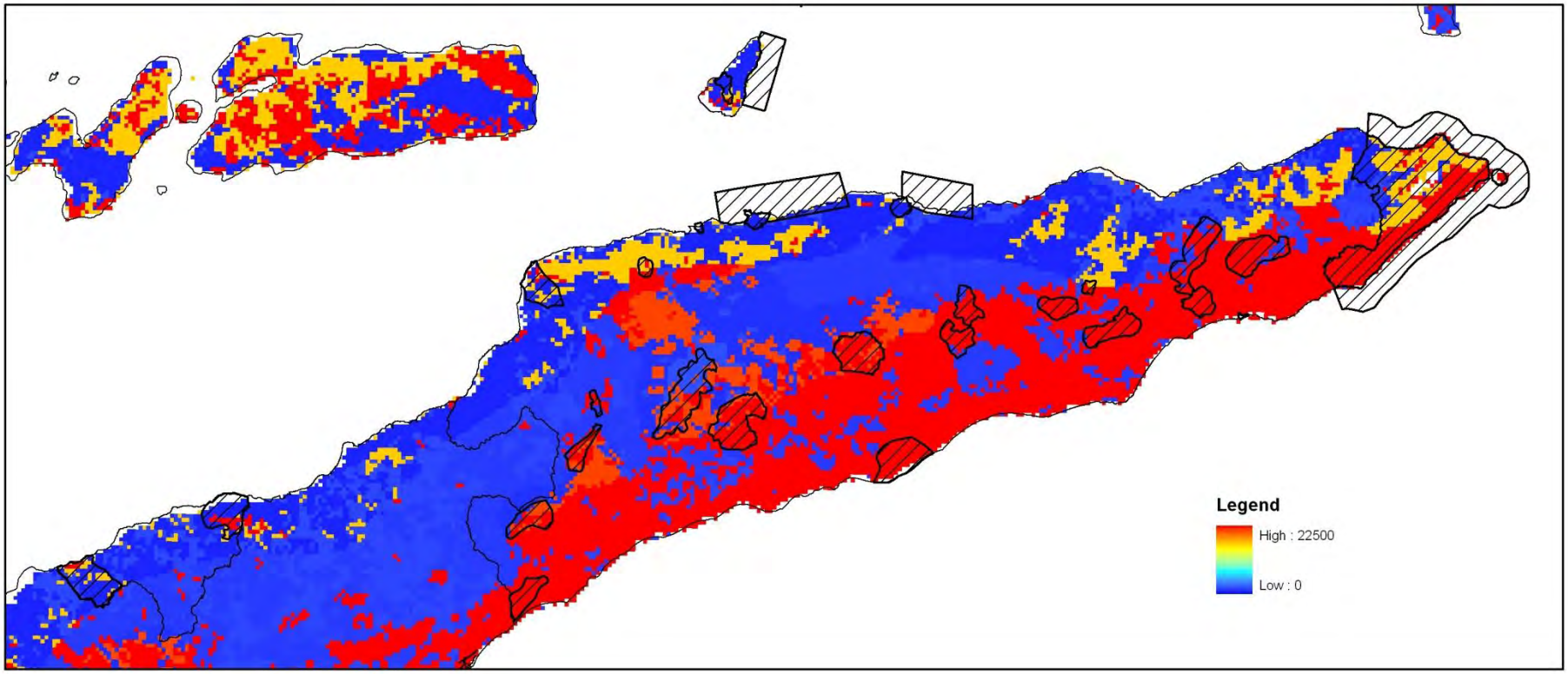

Figure 19. The abundance of terrestrial carbon (tons C/km^2) in Timor-Leste in relation to the protected area network.

Data on Species

Biological surveys of threatened and endemic species in protected areas

Rationale for incorporating surveys on threatened and endemic species into the NEGA: The data relates persistence objectives (goal two) - the protection of all critical habitats for endemic, migratory and threatened species. The data only covered protected areas so could not directly be incorporated into the gap analysis. To do so would require data outside protected areas. Whilst spatially biased, we were able to use this data in two analyses. First, we use the data to show the conservation value of the protected area network. Second, we conducted a prioritization analysis to determine which combinations of protected areas should be the focus of management plan development, based on criteria around the number of threatened species captured in each protected area.

Method: The data was sourced from Fernando Santana (Department of Protected Areas and National Parks of Timor-Leste), a co-author of this report.

Attributes: The data consisted of the occurrence of 32 bird species in each protected area. The full data is given in Appendix One showing which species is found in which protected area.

Locations of birds of conservation concern

Rationale for incorporating bird localities into the NEGA: We incorporated the locations of birds of conservation concern into the gap assessment with respect to the persistence objectives (goal two) - to protect the locations of threatened species. We did not incorporate these data into the prioritisation of new areas because these data are spatially biased.

Method: All records were sourced from Colin Trainor at Charles Darwin University. Data provided were an indication of conservation concern and were represented as an GPS coordinate of the record.

Attributes: The number of records in the Trainor database is given in Figure 20. The spatial location of records is given in Figure 21. They are not uniform across the entire country and show a clear bias toward the eastern part of Timor-Leste (Nino Konis Santana NP) and those vegetated regions close to towns and villages.

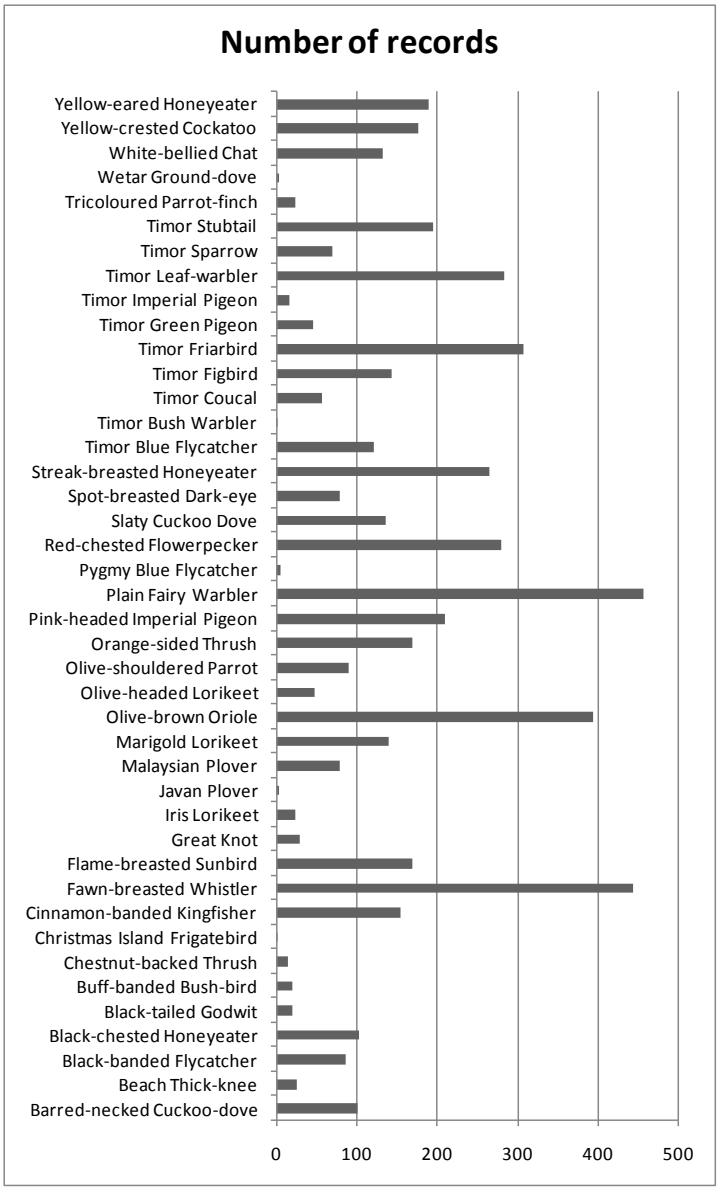

Figure 20. The number of records per bird of conservation concern.

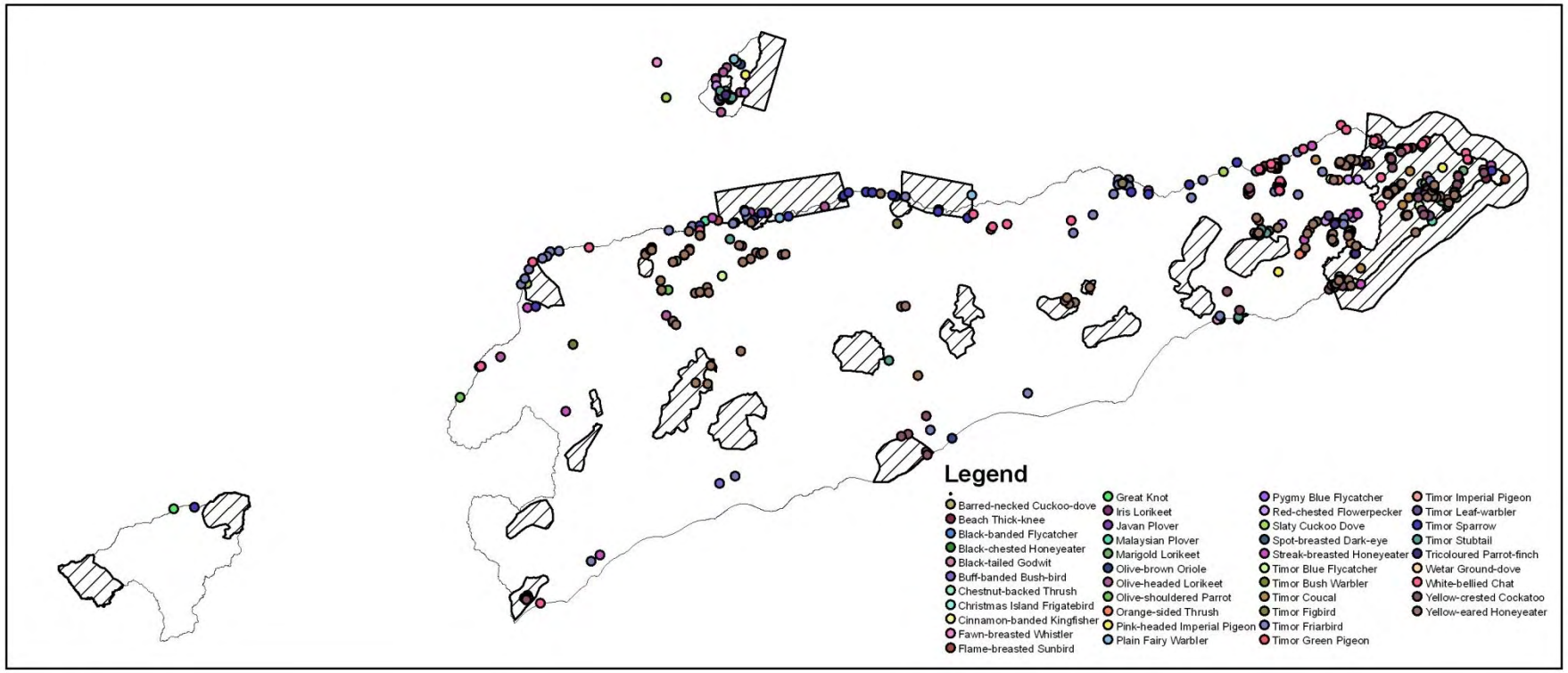

Figure 21. The spatial locations of birds of conservation concern in relation to the protected area network.

Important Bird Areas (IBAs)

Rationale for incorporating IBAs into the NEGA: An Important Bird Area (IBA) is an area recognized as being globally important habitat for the conservation of bird populations. It is based on a number of criteria (see http://www.birdlife.org/action/science/sites/). We included them in this assessment because they relate to persistence objectives (goal two) because IBAs are based partly on the location of threatened and endemic species.

Method: The coverage of IBAs were sourced from ALGIS and were the results of a previous project led by the international NGO, Birdlife International (Trainor et al. 2007).

Attributes: The area of each IBA is given in Figure 22.There are 16 IBAs found in Timor-Leste (Fig. 23).

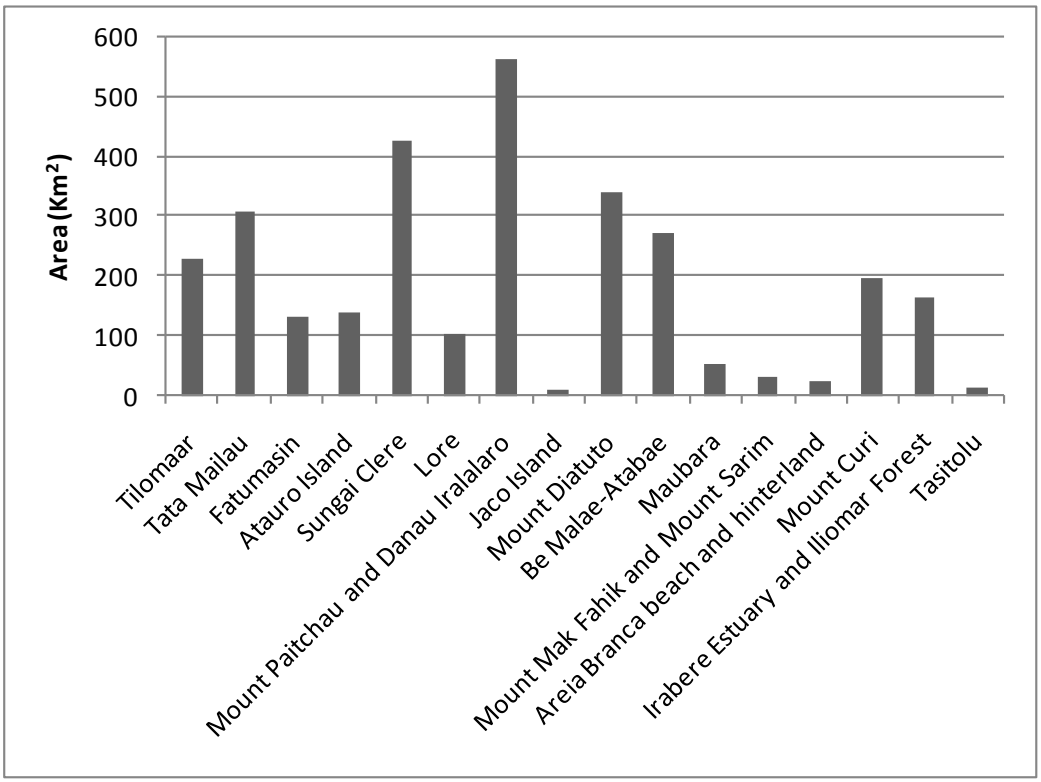

Figure 22. The area (km^2) of each Important Bird Area.

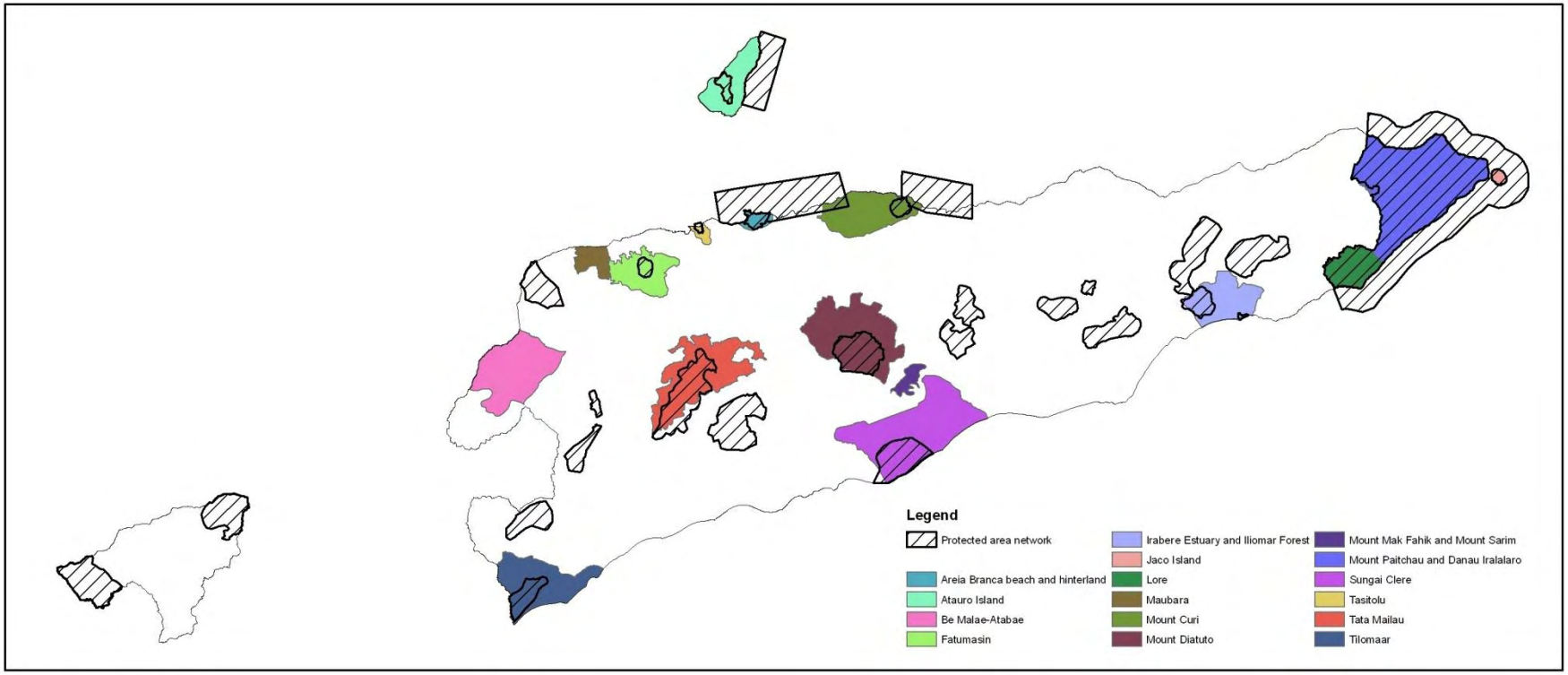

Figure 23. The spatial coverage of Important Bird Areas in Timor-Leste in relation to the protected area network.

Important wetlands for birds

Rationale for incorporating important wetlands into the NEGA: Important wetlands for birds relate to representation objectives (goal one) and persistence objectives (goal two), protection of all critical habitats for endemic, migratory and threatened species. These wetlands provide important sheltering, breeding and feeding habitats for migratory species and species of conservation concern.

Method: Data were sourced from Trainor et al. (2005)

Attributes: There are 12 important wetland areas for birds (Fig. 24).

Important sites for endemic reptiles and frogs

Rationale for incorporating important sites for reptiles and frogs into the NEGA: Incorporating important sites for endemic reptiles and frogs relate to persistence objectives (goal two) - protection of all critical habitats for endemic, migratory and threatened species.

Method: Data were provided by Professor Hinrich Kaiser of Victor Valley College (USA).

Attributes: There are seven sites. The species present in each site are listed in Table 6. Note that most of these species have not formally been described by science and do not have a scientific name. Two sites could not be clearly identified from the data and were not included in the analysis (sites E&F). The location of the five other sites are shown in Figure 25.

Table 6. Endemic species and their occurrence in important sites for endemic reptiles and frogs (sites A-G). Note that most species have not been formally described.

Species	A	B	C	D	E *	F*	G
Chelodina timorensis	X						
Cryptoblepharus n.		X					
Cyrtodactylus sp. 1			X				
Cyrtodactylus sp. 2				X			
Cyrtodactylus sp. 3					X		
Eremiascincus sp. 1						X	
Eremiascincus sp. 2		X					
Limnonectes timorensis		X					
Litoria everetti		X					

Sphenomorphus sp.	
Sphenomorphus sp.	X

* specific location currently unknown

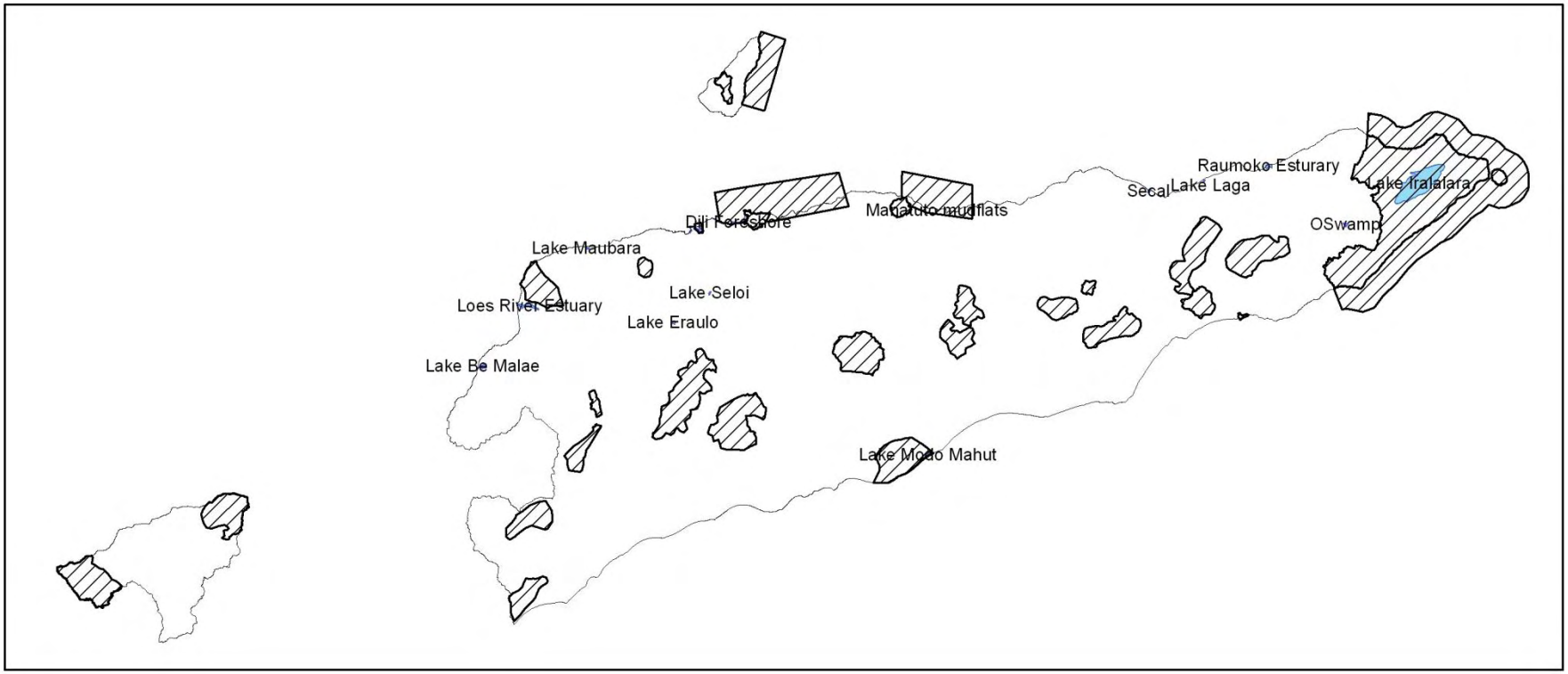

Figure 24. The location of important wetlands for birds found within Timor-Leste in relation to the protected area network.

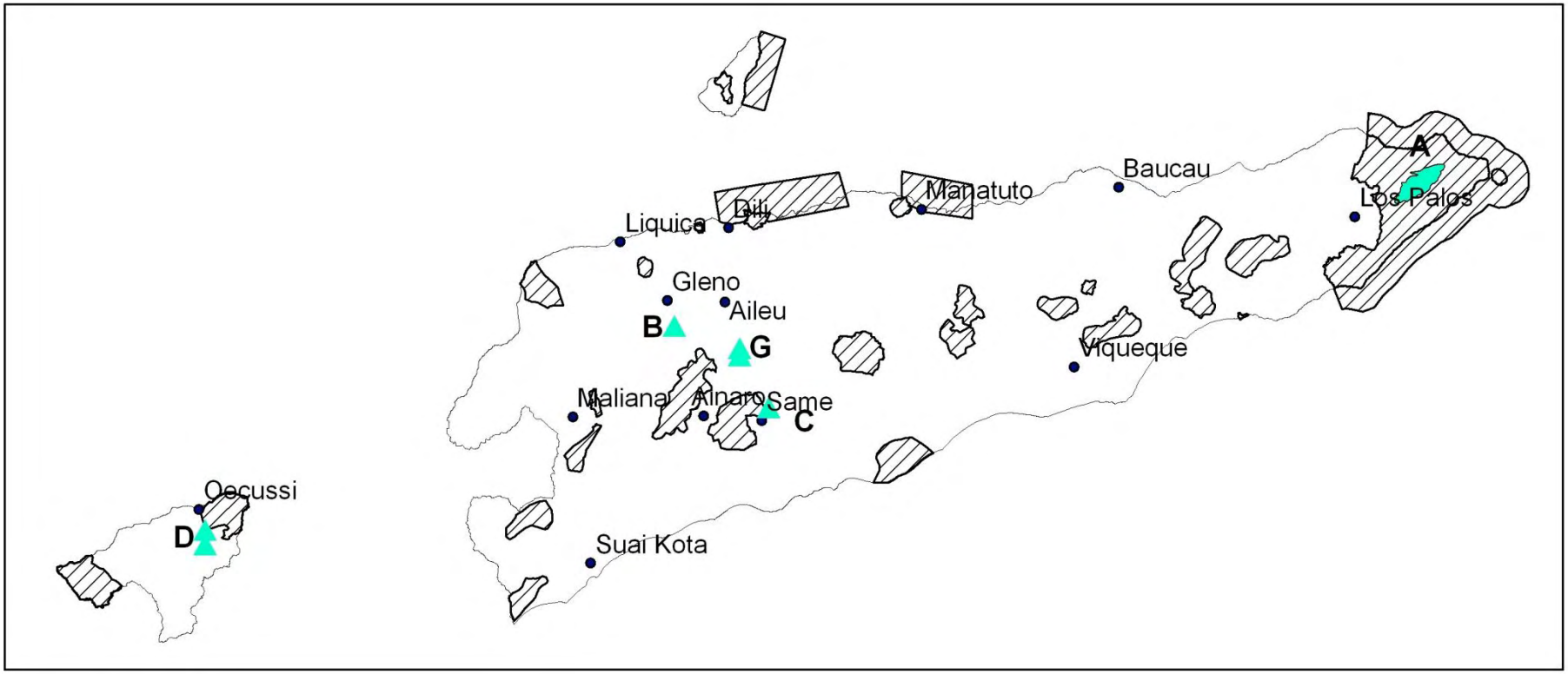

Figure 25. Locations of important sites for endemic reptiles and frogs in relation to major towns and protected area network. Some locations consist of several sites situated close together.

Important site for endemic orchids

Rationale for incorporating endemic orchids site into the NEGA: Important site for endemic orchids relate to persistence objectives (goal two).These sites are important for endemic species.

Method: Data were provided by Dr Silveira.

Attributes: There is only one site identified for orchids (Fig. 26).

Important site for *Chelodina timorensis* (endemic freshwater turtle)

Rationale for incorporating important site for an endemic freshwater turtle into the NEGA: Important site for Chelodina timorensis (freshwater turtle) relates to persistence objectives (goal two). This site is important for an endemic species.

Method: Data were sourced from (McCord et al. 2007)

Attributes: *Chelodina timorensis* is found in one location in Lake Ira Lalaro and its surrounding floodplains in Timor-Leste (Fig. 27).

Important site for *Craterocephalus laisapi* (endemic freshwater hardyhead fish)

Rationale for incorporating endemic an important site for a freshwater hardy-head fish into the NEGA: This relates to persistence objectives (goal two). This site is important for an endemic species.

Method: Data were sourced from (Larson et al. 2005).

Attributes: *Craterocephalus laisapi* is found in one location in Lake Ira Lalaro and its surrounding floodplains in Timor-Leste (Fig. 27).

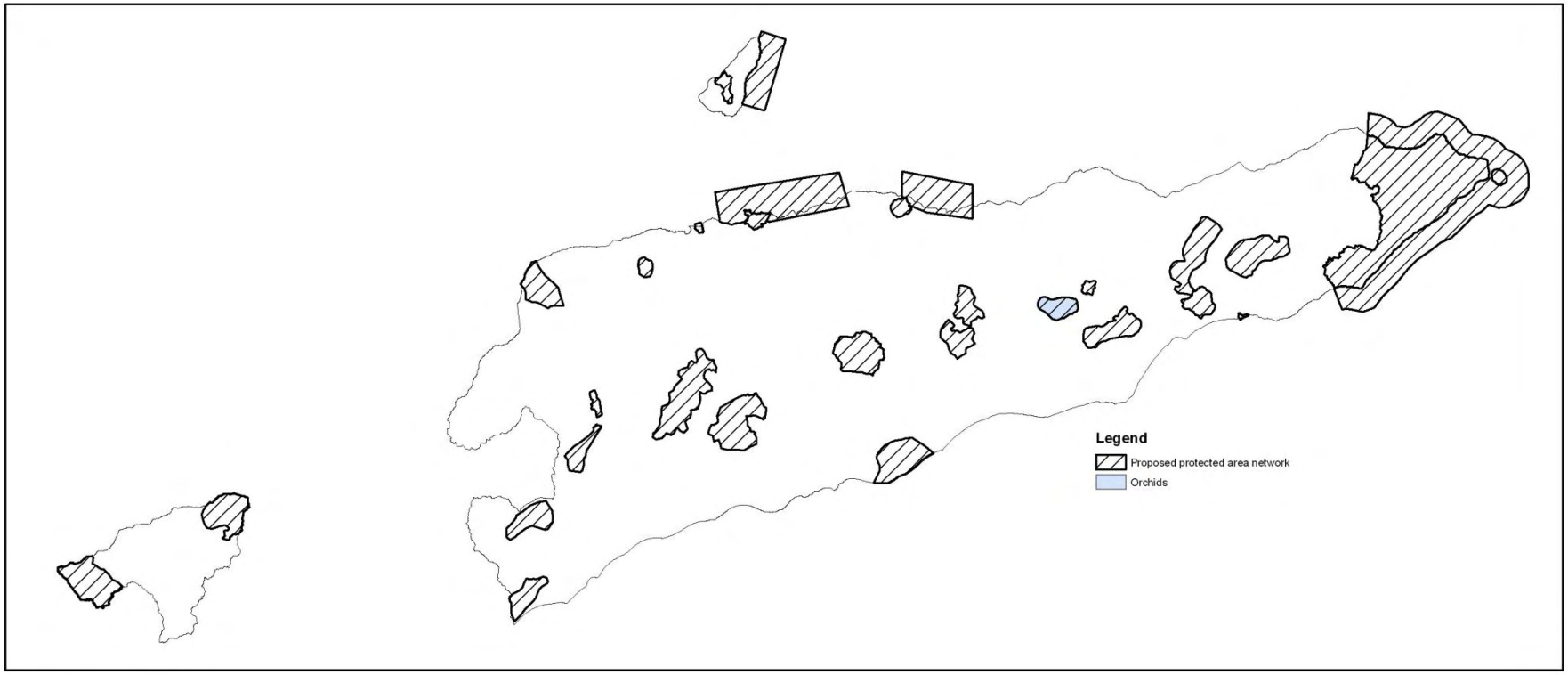

Figure 26. A site of importance for endemic orchids in relation to protected area network.

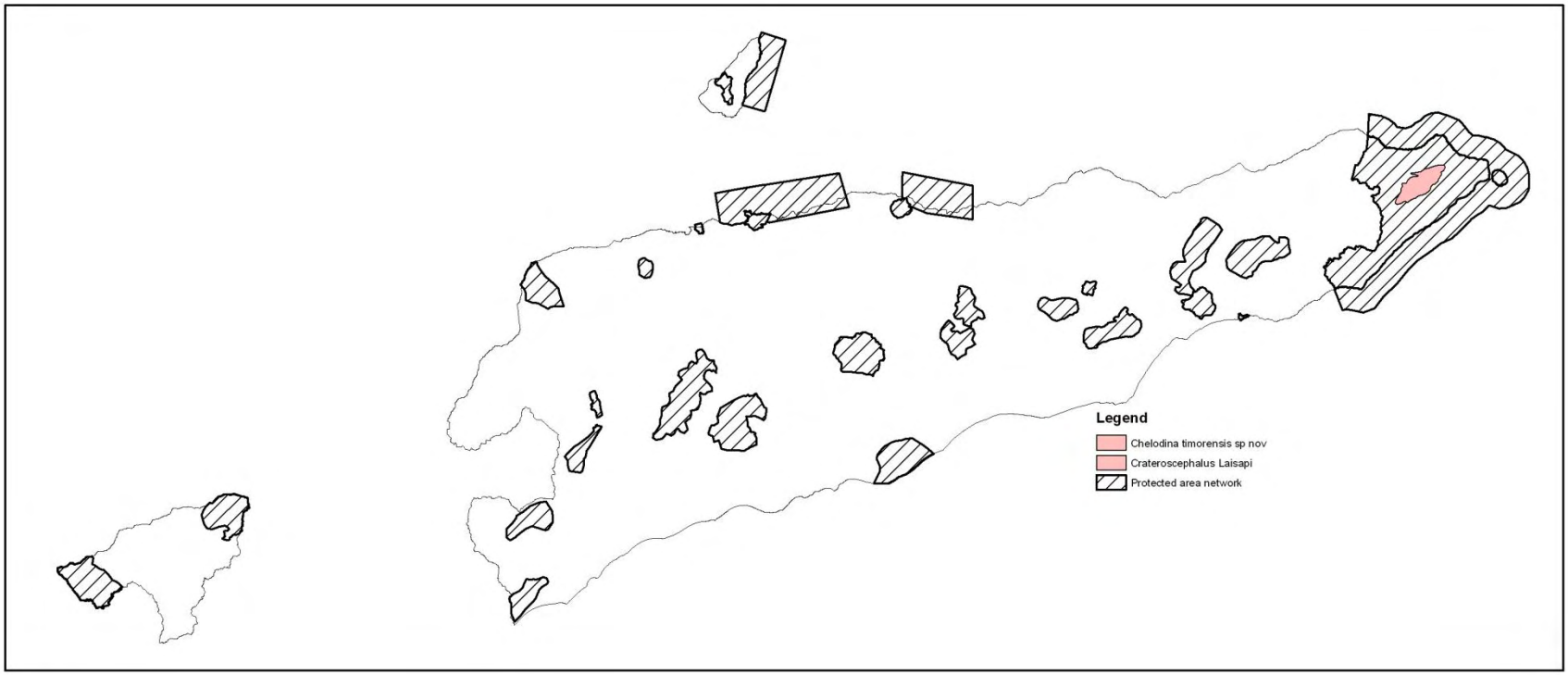

Figure 27. Location of known distributions of *Crateroscephalus laisapi* and *Chelodina timorensis* in relation to the protected area network. Note they have a similar distribution.

Data on People

Household locations

Rationale for incorporating household locations into the NEGA: Protected areas should, where possible, avoid area of human settlements. If people live in or near a likely protected area then this will likely be more difficult and costly to manage. It is also a consideration when developing management plans.

Method: The data were developed by the government through household surveys. Data were sourced from ALGIS.

Attributes: In 2004, there were 185 942 household points (Fig. 28).

Mining and Roads

Rationale for incorporating mining and roads into the NEGA: Roads and existing mining activities are an important consideration in the location and management of protected areas because they are areas that should be avoided due to the likely threats to habitat they cause (e.g. fragmentation).

Method: Data were sourced from ALGIS.

Attributes: There are 39 mines in Timor-Leste (Fig. 29). Roads run across the northern coast with several interior ones that run north- south across the mountainous interior. There are also some roads on the south coast.

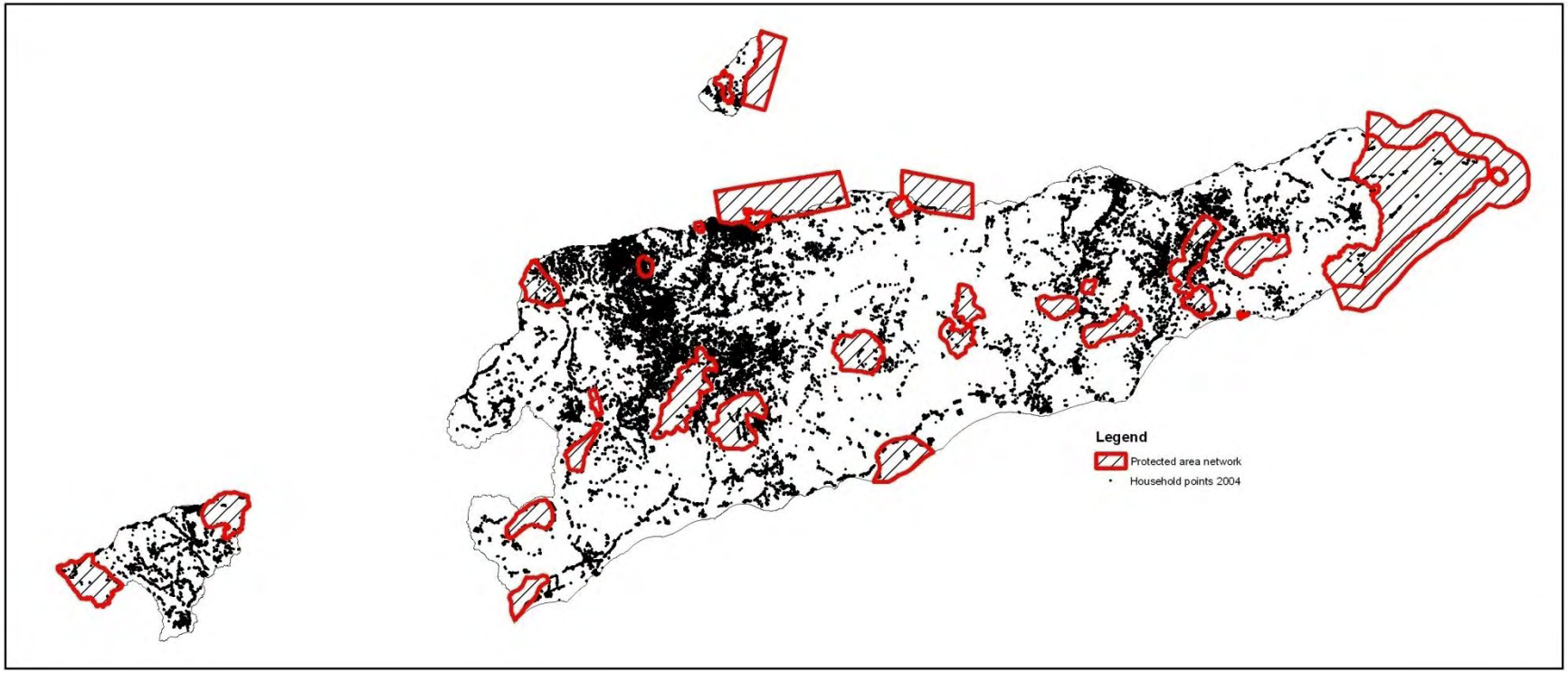

Figure 28. Location of households in relation to the protected area network.

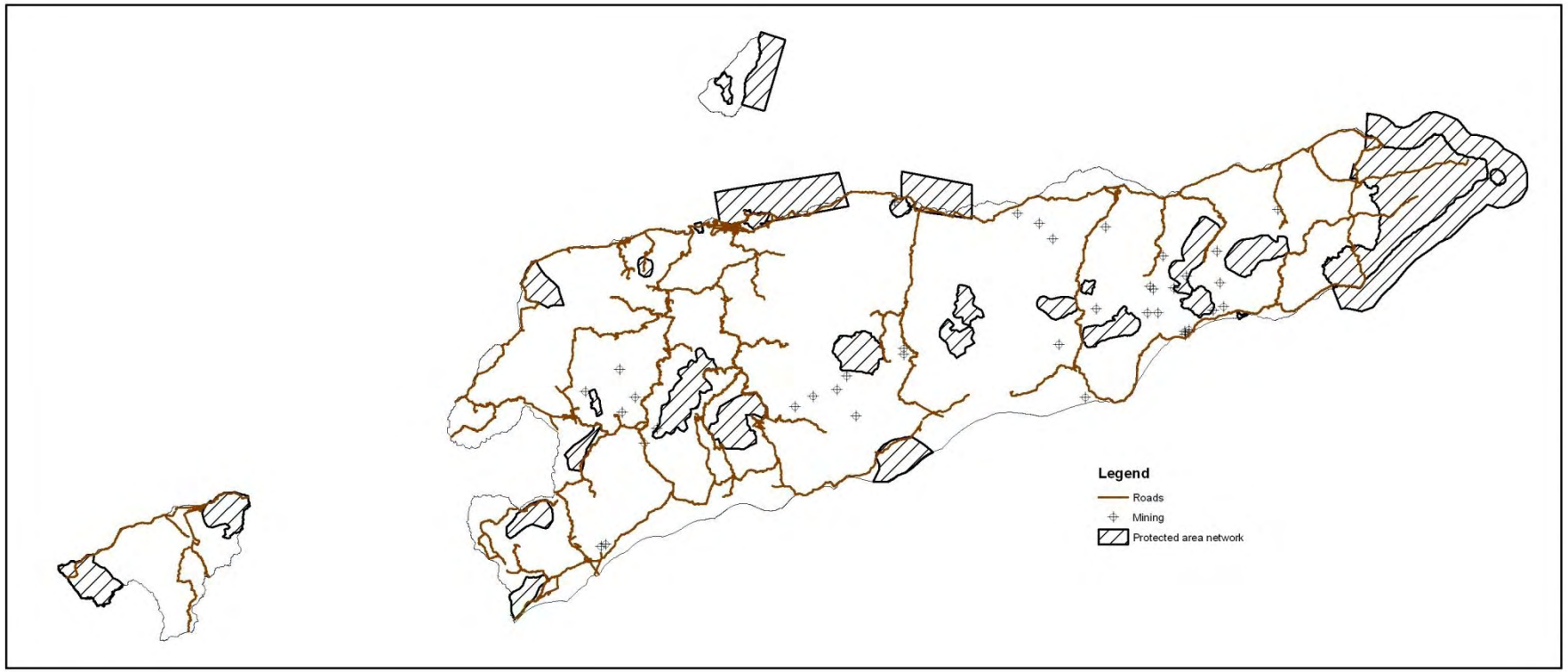

Figure 29. The location of mining and roads in Timor-Leste in relation to the protected area network.

National Ecological Gap Assessment (NEGA)

In this section, the National Ecological Gap Assessment for Timor-Leste is described. We summarise the results here.

Assessment of Ecosystems

Forest types

Two data layers of forest cover were used in this assessment which leads to the creation of two forest scenario maps, an optimistic classification of forest cover (Fig. 11) and a pessimistic classification of forest cover (Fig. 12). The actual forest types were the same but the coverage of forests were different.

For the optimistic scenario of forest cover, we found around 8.5% of the original distribution of forests would be protected assuming forests once covered 100% of each geoformation originally (Fig. 30). Of the remaining forests, nearly 20% would be protected in the protected area network leaving 80% unprotected. The representation of forest types in the protected area network is variable across the different types (Fig. 31) with four forest types close to the 30% target (original cover), while three were not represented at all (Aliamata, Lariguti and Waibua formations). Two forest types have been cleared beyond 70% of their original extent.

For the pessimistic scenario of forest cover, we found around 6% of original forest cover would be protected, assuming forests originally covered 100% of each geoformation (Fig. 30). Of the remaining forests, over 20% would be protected in the protected area network, leaving 80% unprotected. The representation of forest types was again variable across the different types (Fig. 32) with four forest types close to 20% representation and three types not represented at all (Aliamata, Lariguti and Waibua formations). One forest type is already cleared (Atauro).

The amount of protection for each forest types using the pessimistic forest cover scenario is spatially represented in Figure 33. This map can be used to determine priority protected areas for those forest types with less protection given a higher priority than those with more protection.

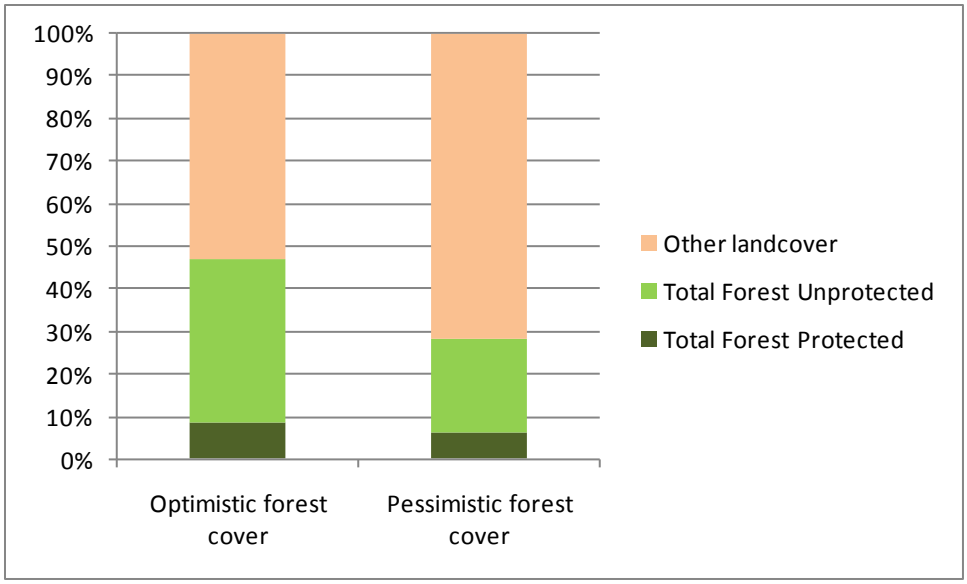

Figure 30. The proportion of forest type within the protected area network for two scenarios. The Figure also shows the proportion of clearing.

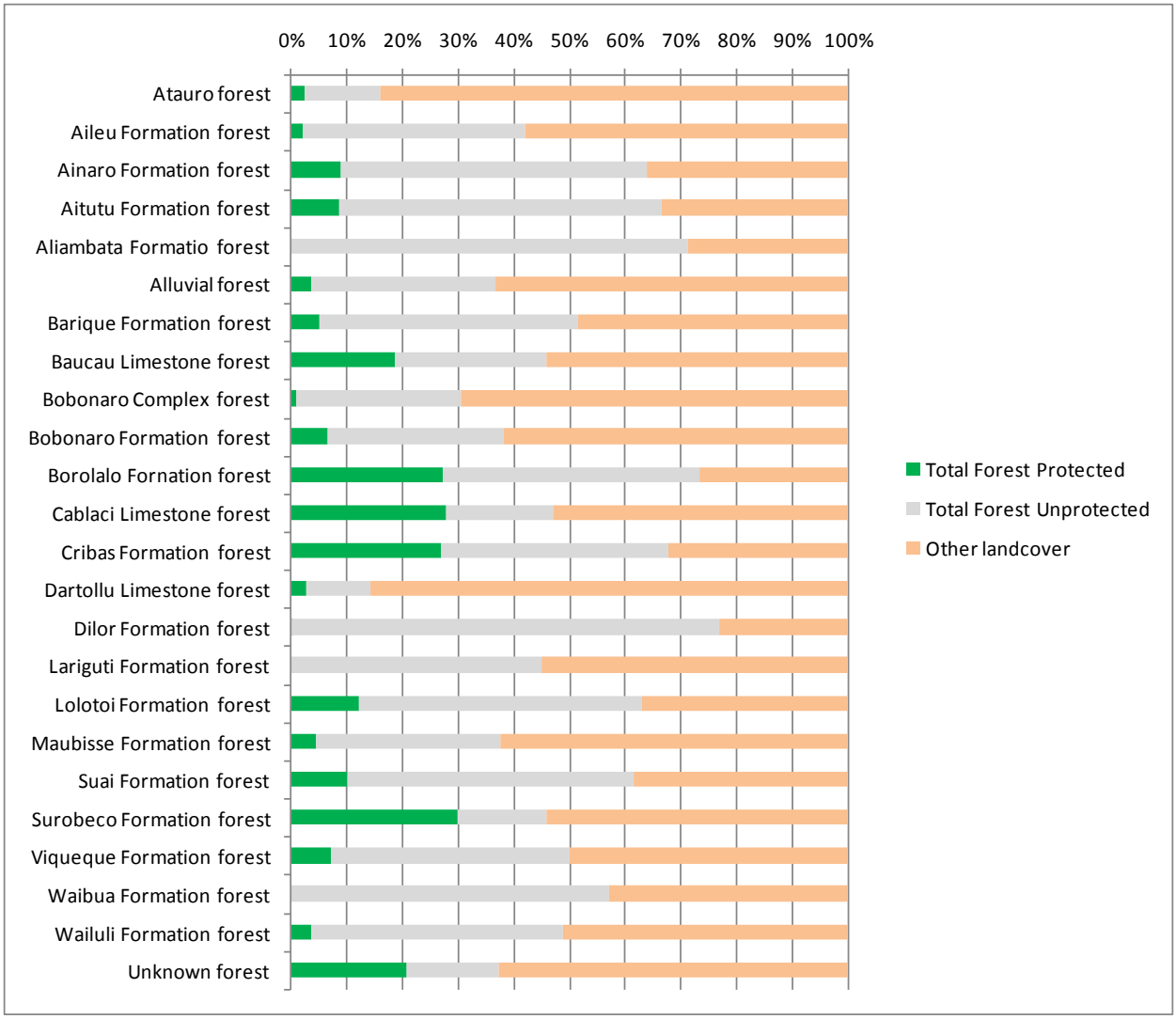

Figure 31. The proportion of forest type within the protected area network for the optimistic forest cover classification. The Figure also shows the proportion of clearing.

Figure 32. The proportion of forest type within the protected area network for the pessimistic forest cover classification. The figure also shows the proportion of clearing.

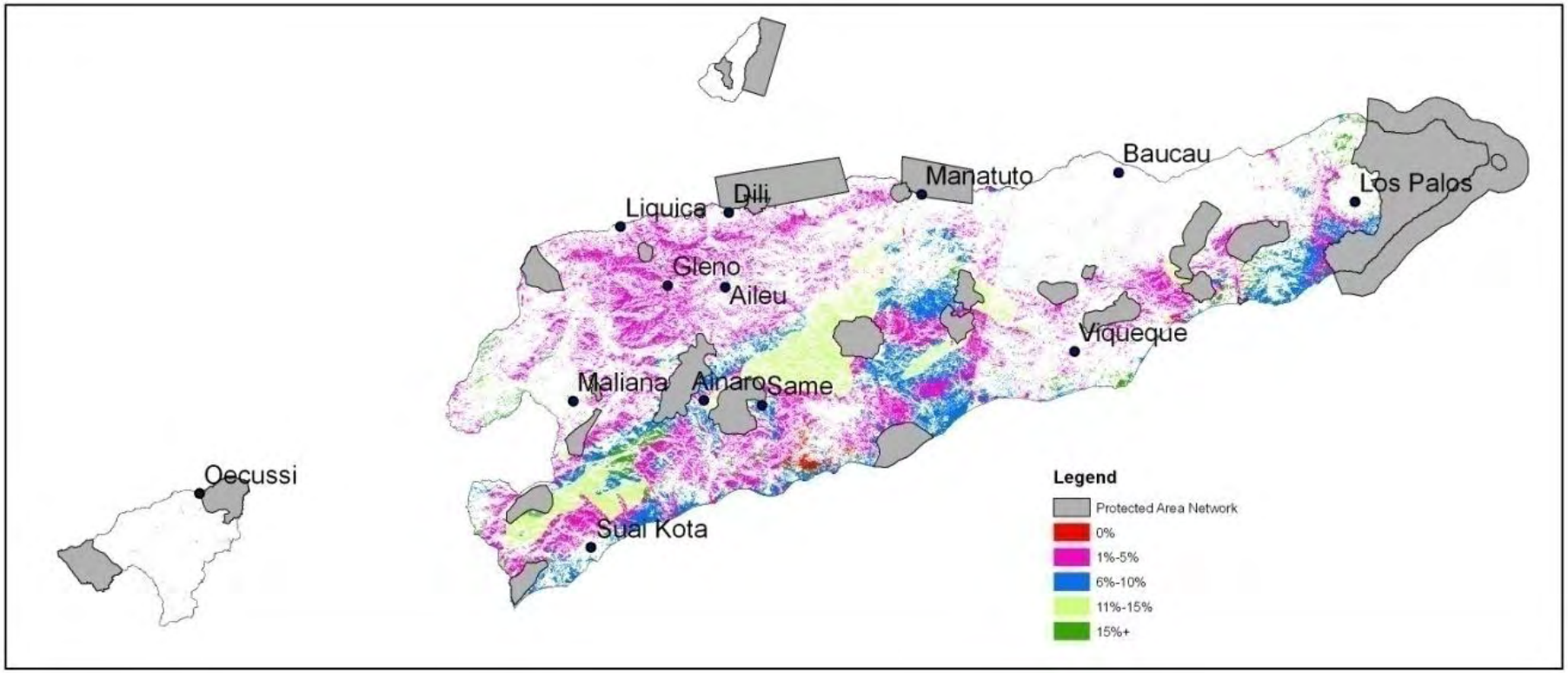

Figure 33. Using the pessimistic forest cover scenario each forest type is first classified in the proportion of its distribution protected, and this classification is then shown over its entire distribution.

Rivers and estuaries

The target for rivers and lakes is 30% of their distribution in protected areas and currently around 5% of braiding rivers and 55% of lakes are in the protected area network. The target for estuaries is 50% of their distribution in protected areas and currently 6% are in the protected area network.

Coral Reefs

The target for coral reefs is 30% of each type in protected areas. Overall, 55% of coral reefs are in protected areas. When measuring different types of coral reefs, all seven types of coral reef types have achieved their target except coral reef type four (Fig. 34). The complete distribution of coral reef type four is given in Fig. 35 showing its limited distribution in Timor-Leste. To achieve this target, one suggestion is to expand the protected area at Tasitolo as this would incorporate some of this coral reef type.

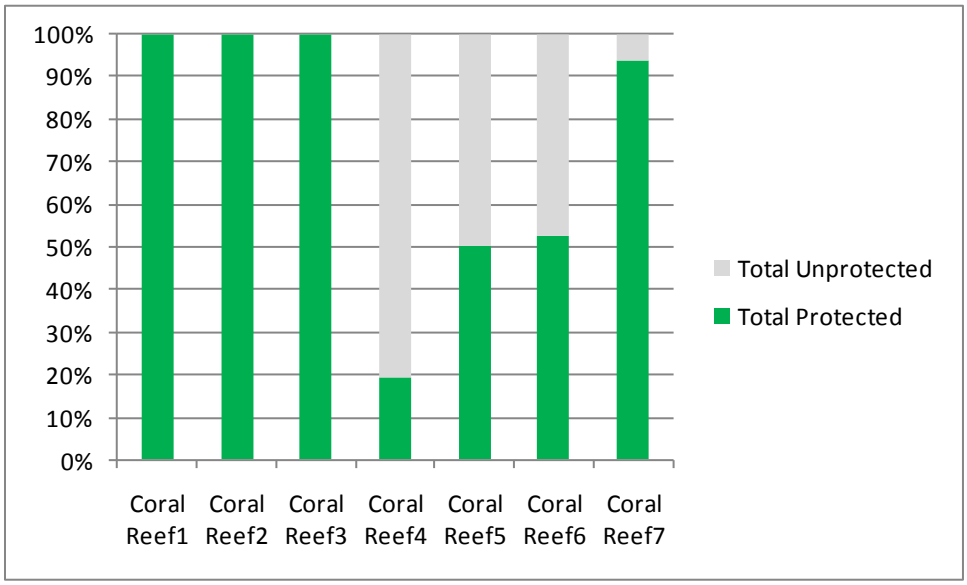

Figure 34. The percentage of seven types of coral reefs found in Timor-Leste currently the protected area network.

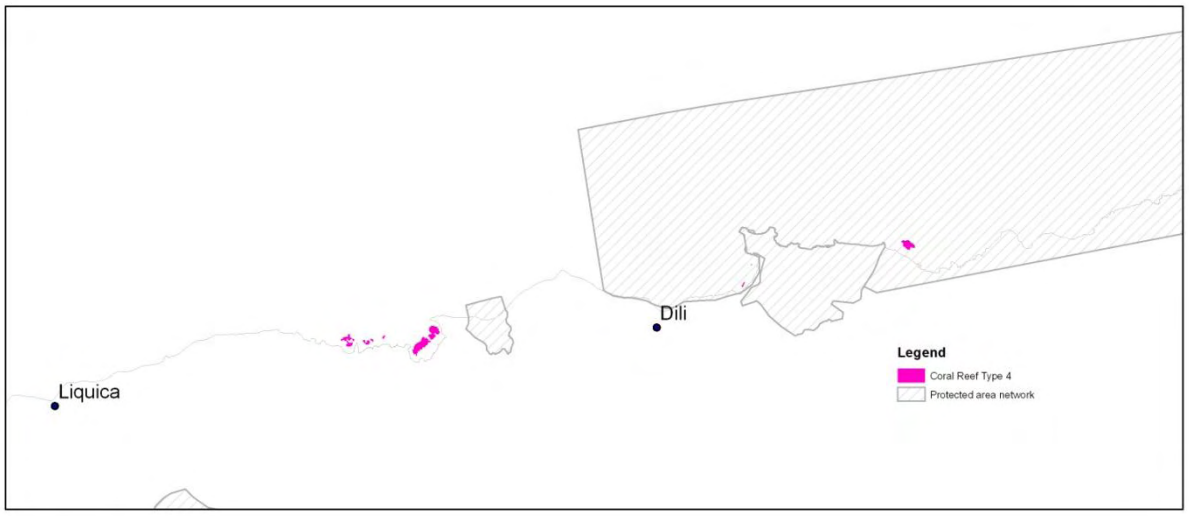

Figure 35. The distribution of coral reef type 4 in relation to the protected area network and major towns in northern Timor-Leste. This is the only coral reef class that does not have at least 30% of its distribution in the protected area network.

Broad marine classes

The target for broad marine classes is 30% of each type in the protected area network. Only two of the five classes reached this target with the other classes being quite close to the target set (Fig. 36).

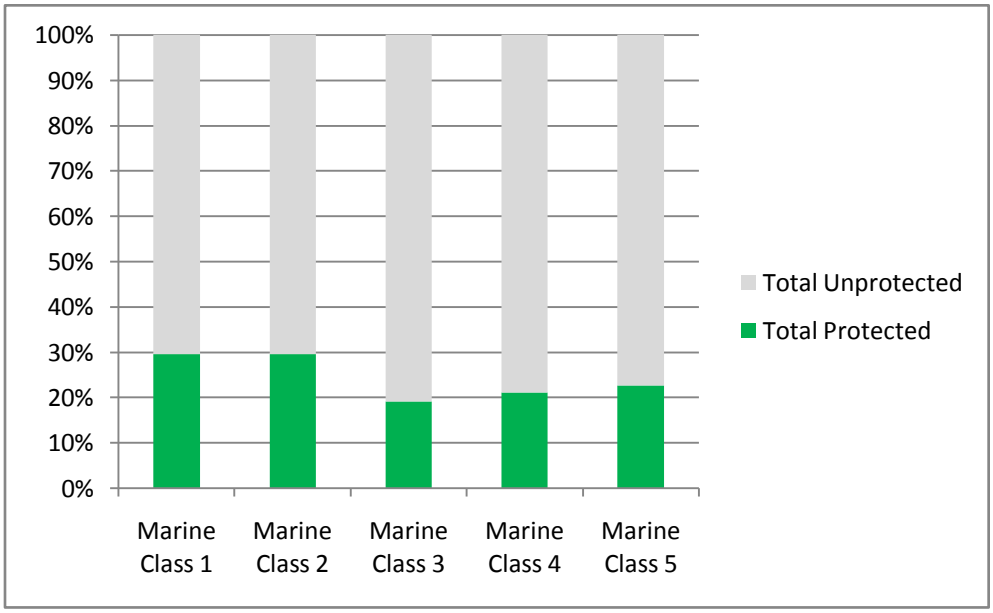

Figure 36. The percentage of each marine class currently located in the protected area network.

Mangroves and seagrasses

The target for mangroves is 80% and for seagrasses are 30% in protected areas. Currently, targets are met for seagrasses with over 70% located within the protected area network. It is not met for mangroves with nearly 50% within the protected area network.

Carbon

The target for carbon is 30% within protected areas. Overall, around 22% of carbon is within the protected area network.

Assessment of Species

Biological surveys of threatened and endemic species in protected areas

The data show that the 32 species are each found in at least two protected areas (Fig. 37). Most species are found in many protected areas, with a species occurring in on average 12 protected areas. This result demonstrates the importance for the protected area for endemic and threatened birds.

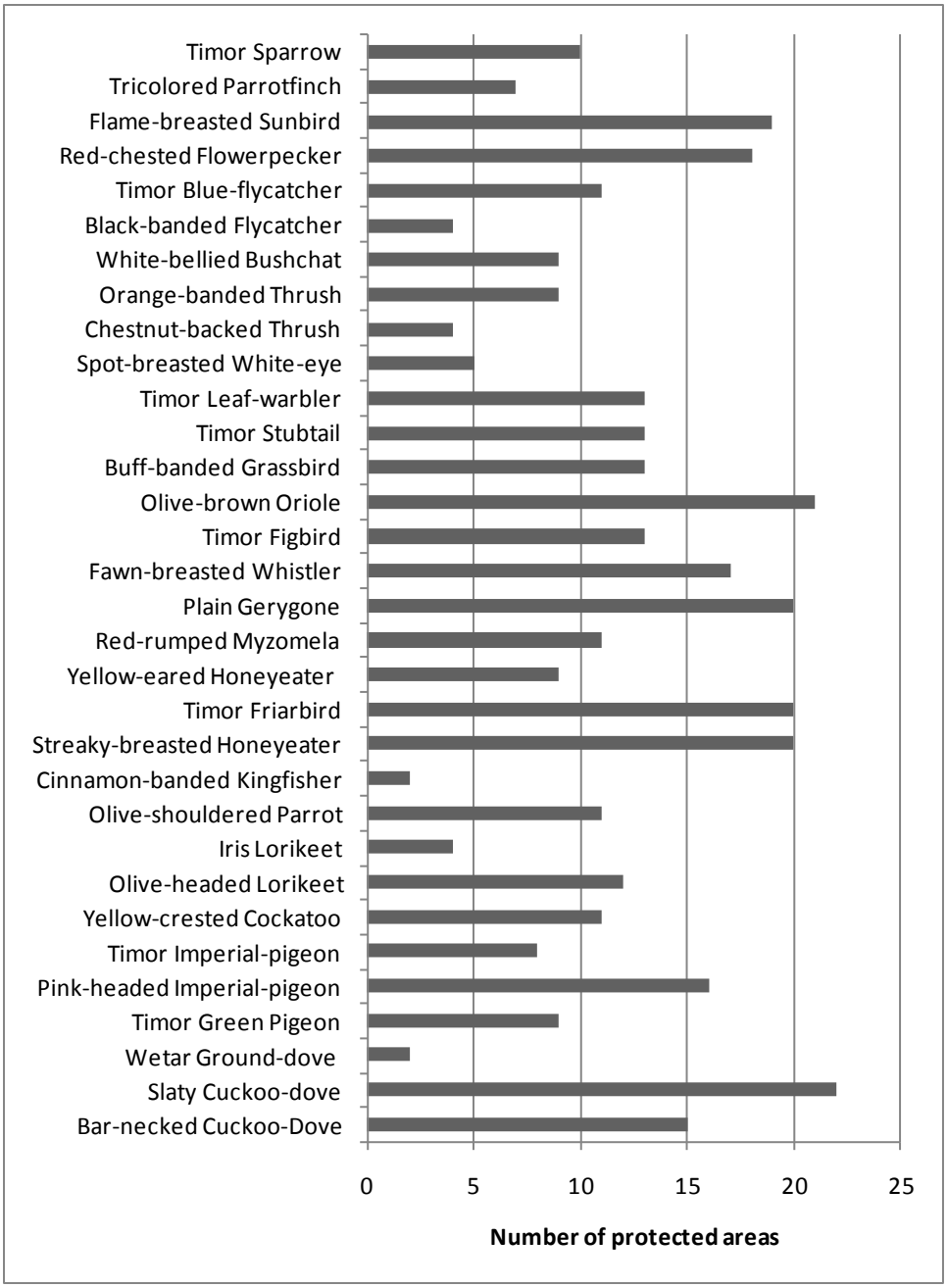

Figure 37. List of threatened and endemic species found in surveys in existing and protected areas in Timor-Leste, and the number of protected areas each species was found in.

Occurrence of birds of conservation concern

There was no target for occurrence of birds of conservation concern in protected areas. They are included here as an indication of the coverage of protected areas, although the data are spatially biased (toward Nino Konis Santana NP), which must be taken into account. While

several locations are outside the protected area network (see Fig. 21), the proportion of occurrences within the proposed area network was variable but generally relatively high (Fig. 38). Also note that several species are found within the protected area network based on Fernando Santana's data (Appendix 1).

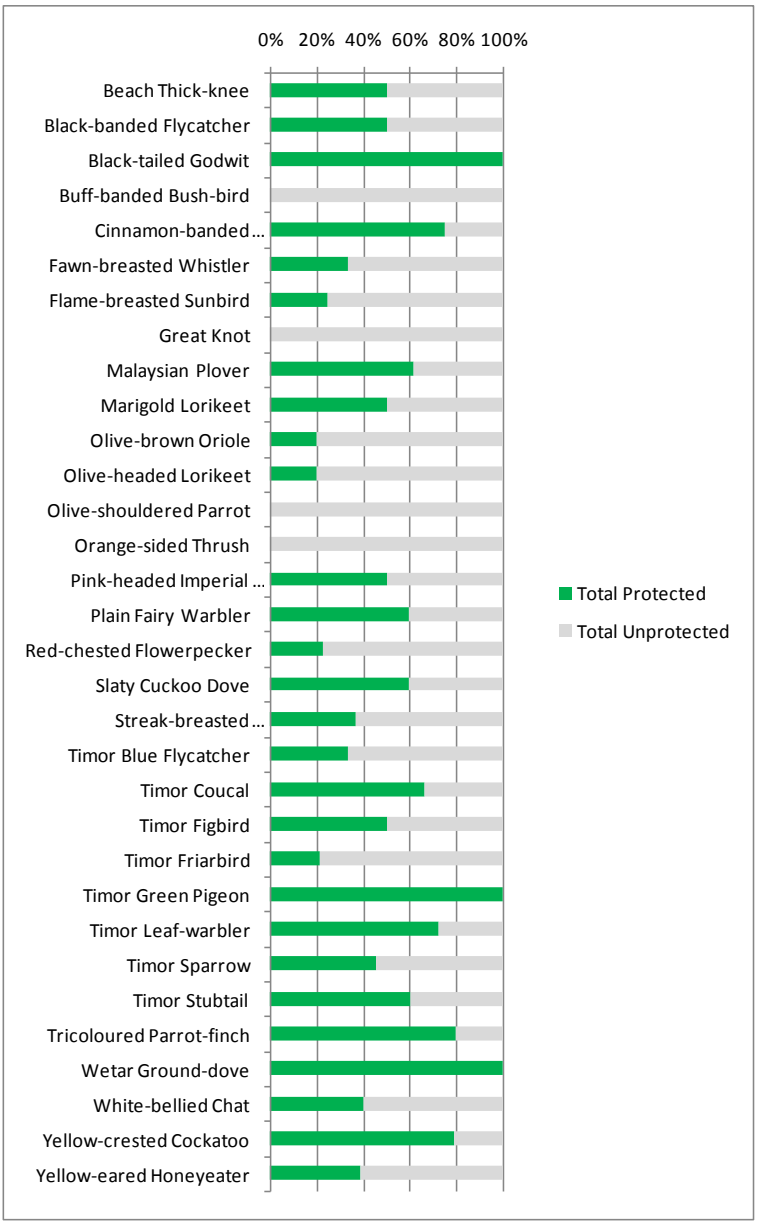

Figure 38. The proportion of records within the protected area network.

Important Bird Areas (IBAs)

There is not a specific target for IBAs as their distribution is mapped at a coarse scale. They do however give an indication of important areas for bird species. The protected area network included a proportion of 13 of the total 16 IBAs except for Be Malae-Atabae, Maubara and Mount Mak Fahik/Mount Sarim (Fig. 39). Several IBAs had the around 10-20% of their areas within the protected area network.

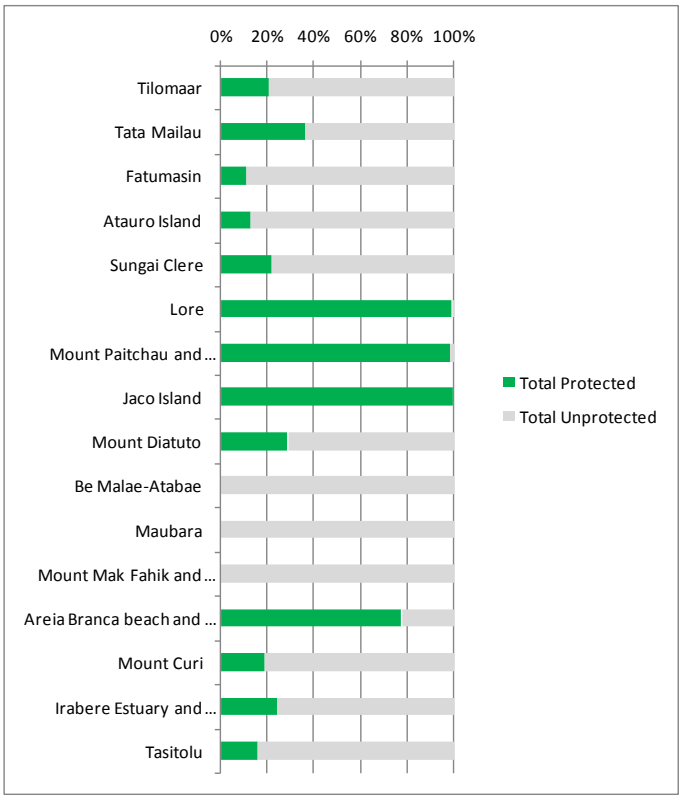

Figure 39. The proportion of each IBA within the protected area network.

Important wetlands for birds

These wetlands are important for migratory species and therefore have a 100% target. The protected area network currently includes nearly all of the distribution of 5 out of 15 important wetlands (Fig. 40). The other ten important wetlands are not included in the protected area network.

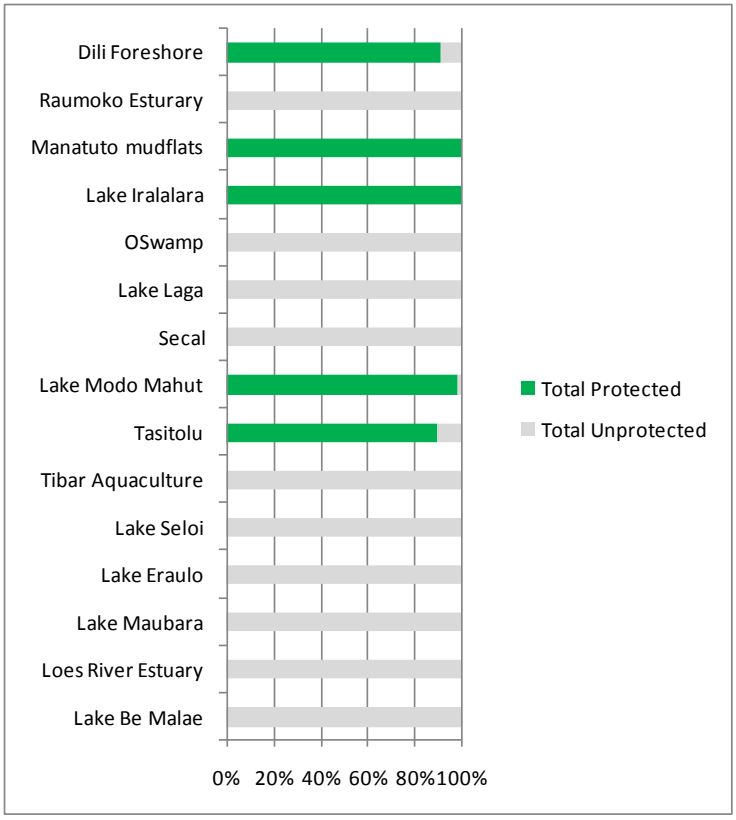

Figure 40. The proportion of important wetlands inside the protected area network.

Important sites for endemic frogs and reptiles

The important site for endemic frogs and reptiles has a 100% target. There is currently only one area within the protected area network while the four other areas are unprotected.

Important site for endemic orchids

The important areas for endemic frogs and reptiles have a 100% target. This is currently located within the protected area network.

Site of endemic species *Chelodina timorensis* (freshwater turtle)

The site of *Chlodina timorensis* has a 100% target. This is currently within the protected area network.

Site of endemic species *Craterocephalus laisapi* (freshwater hardyhead fish)

The site of *Craterocephalus laisapi* has a 100% target. This is currently within the protected area network.

Assessment of People

Household points

There were around 6% of households within the protected area network based on 2004 survey data. Households were found in every protected area (Fig. 28). This will be an important consideration when finalising the boundaries of the protected area network and when management plans are developed for each protected area.

Mining and Roads

Four out of 39 mines are located within the protected area network (Fig. 29). Roads also run through several protected areas (Fig. 29). These will be important considerations when finalising the boundaries of the protected area network and when management plans are developed for each protected area.

Priority areas for filling gaps in Timor-Leste's protected area network

As part of this gap assessment, we have identified Areas of Interest (AOI) that are not in the protected area network but should be considered when expanding the network in the future. We have used two different methodologies to do this, one based on expert opinion and the second based on an analysis using the spatial prioritisation software tool, *Marxan*.

Areas of Interest (AOI) based on expert opinion

Expert opinion is a good option for identifying AOI when there are serious data shortages. The disadvantage in using expert opinion is that it relies on an individual's knowledge which is often biased towards particular locations, ecosystems and species. The terrestrial AOI were identified by DPANP officials based on their extensive knowledge of Timor-Leste (Fig. 40). These AOI cover an area of ~ 500km^2 (3% of country). Rationale for the selection of these areas are listed in Table 7. For marine areas of interest, the AOI were identified previously during workshops organized by The Nature Conservancy (see Wilson et al. 2009) (Fig. 41) and cover an area of 5500 km^2. AOI 13 and 16 are proposed transboundary protected areas. More detailed images of each AOI are given in Appendix 3 using Google Earth to relate them to geographic and topographic locations.

Areas of Interest (AOI) based on the *Marxan* analysis

The following priority areas were identified in the *Marxan* analysis. The targets used to guide selection are listed in Table 8. These were related to the medium targets but for ecosystems more short-term targets (15%) were used. The rationale was that these areas will contribute towards interim priority areas and in the next few years better data will become and therefore enable refinement of these priorities in the medium term. The layer which preferences where the targets might be best achieved is given in Figure 42. When identifying areas to achieve targets, the analysis aimed to avoid areas that were close to households (Fig. 42). The analysis also tried to ensure connectivity between priorities based on goal 3. The results of the priorities are given in Figure 43, high priority areas are in the western part of the main land area of Timor-Leste and across the mountain chain that runs near Viqueque to Los Palos.

Table 7. Rationale for selection of Area of Interest (AOI)

AOI	Reasons
1	Important Wetland
2	Intact Forest / threatened species (e.g. Yellow Cockatoo)
3	Connectivity
4	Connectivity
5	Intact Forest
6	Important Mangroves
7	Important Mangroves
8	Important Coastal Forest / coral reefs
9	Important Estuary
10	Important Wetland
11	Important Wetland
12	Important Marine Area
13	Important Marine Area
14	Important Marine Area
15	Important Marine Area
16	Important Marine Area
17	Important Marine Area
18	Connectivity
19	Connectivity
20	Connectivity
21	Connectivity
22	Connectivity

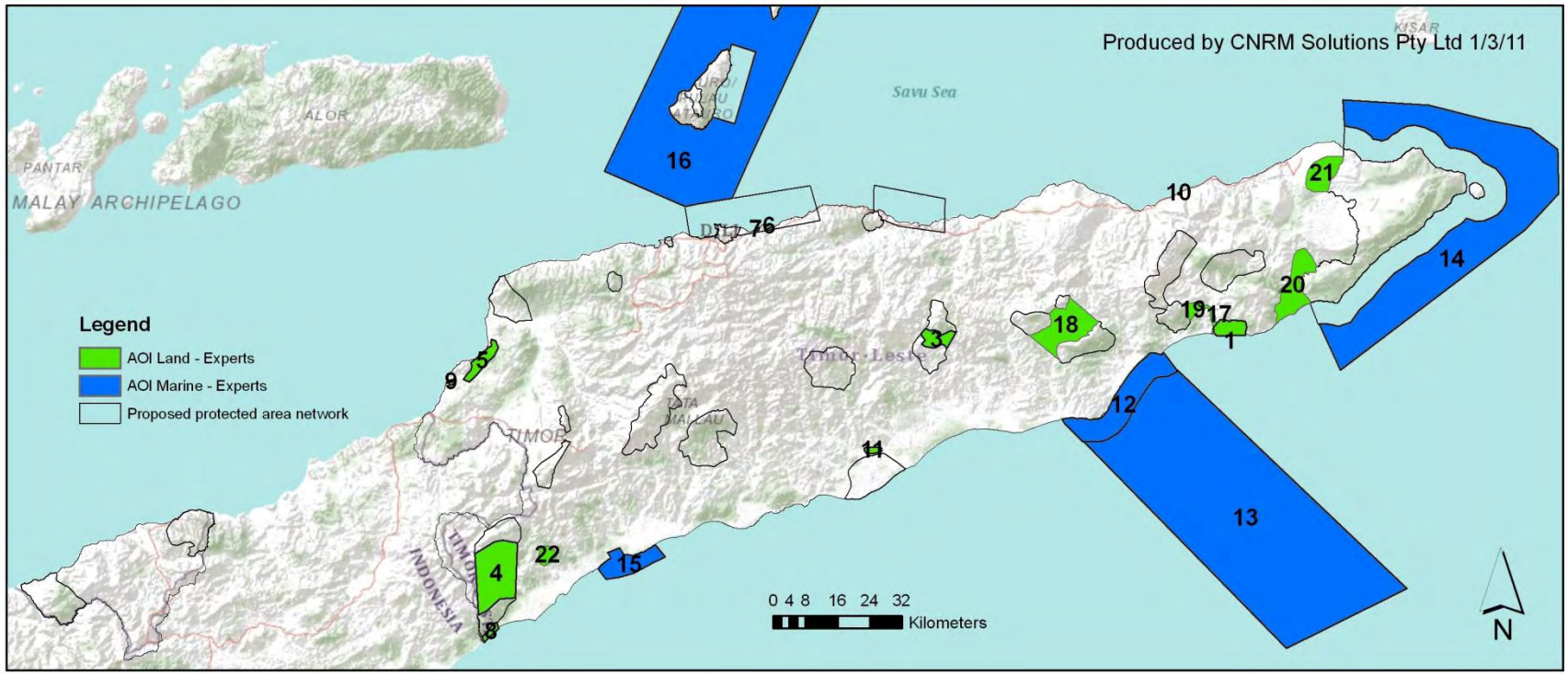

Figure 41. The spatial location of the AOI identified by expert opinion in Timor-Leste. More detailed images of each AOI are given in Appendix 3.

Table 8. Targets for each dataset in the *Marxan* analysis.

Dataset	Target (%)	Dataset	Target (%)
Aileu Formation forest	15%	IBA - Tilomaar	10%
Ainaro Formation forest	15%	IBA - Tata Mailau	10%
Aitutu Formation	15%	IBA - Fatumasin	10%
Aliambata Formatio forest	15%	IBA - Atauro Island	10%
Alluvial forest	15%	IBA - Sungai Clere	10%
Barique Formation forest	15%	IBA - Lore	10%
Baucau Limestone forest	15%	IBA - Mount Paitchau and Danau Iralalaro	10%
Bobonaro Complex forest	15%	IBA - Jaco Island	10%
Bobonaro Formation forest	15%	IBA - Mount Diatuto	10%
Borolalo Formation forest	15%	IBA - Be Malae-Atabae	10%
Cablaci Limestone forest	15%	IBA - Maubara	10%
Cribas Formation forest	15%	IBA - Mount Mak Fahik and Mount Sarim	10%
Dartollu Limestone forest	15%	IBA - Areia Branca beach and hinterland	10%
Dilor Formation forest	15%	IBA - Mount Curi	10%
Lariguti Formation forest	15%	IBA - Irabere Estuary and Iliomar forest	10%
Lolotoi Formation forest	15%	IBA - Tasitolu	10%
Maubisse Formation forest	15%	Lake be ma	100%
Suai Formation forest	15%	Loes river	100%
Surobeco Formation forest	15%	Lake mauba	100%
Viqueque Formation forest	15%	Lake eraul	100%
Walibuli Formation forest	15%	Lake seloi	100%
Waibua Formation forest	15%	Tibar aqua	100%
Unknown forest	15%	Tasitolu	100%
Estuary	25%	Lake modo	100%
Lake	15%	Secal	100%
Coral Reef4	15%	Lake laga	100%
Seagrasses	15%	Oswamp	100%
Mangroves	15%	Lake irala	100%
		Manatuto m	100%
		Raumoko es	100%

	Dili forefront	100%
	Important wetlands for birds	100%
	Important areas for reptiles and frogs	100%
	Important areas for orchids	100%
	Chelodina timorensis	100%
	Craterocephalus laisapi	100%
	Carbon	30%

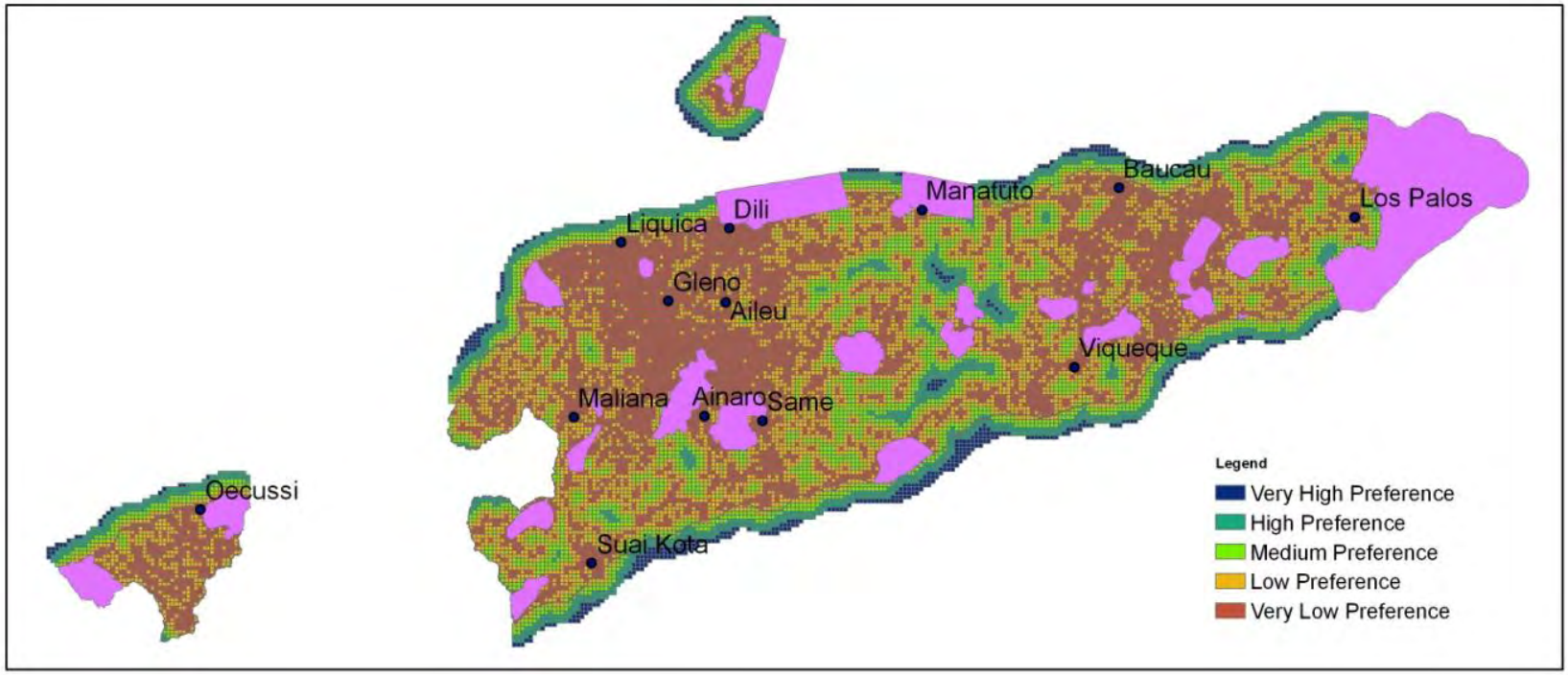

Figure 42. A new data layer was used to preference the selection of areas. Preferential areas were based on those located away from households. The layer is based on the distance of a cell to the nearest household.

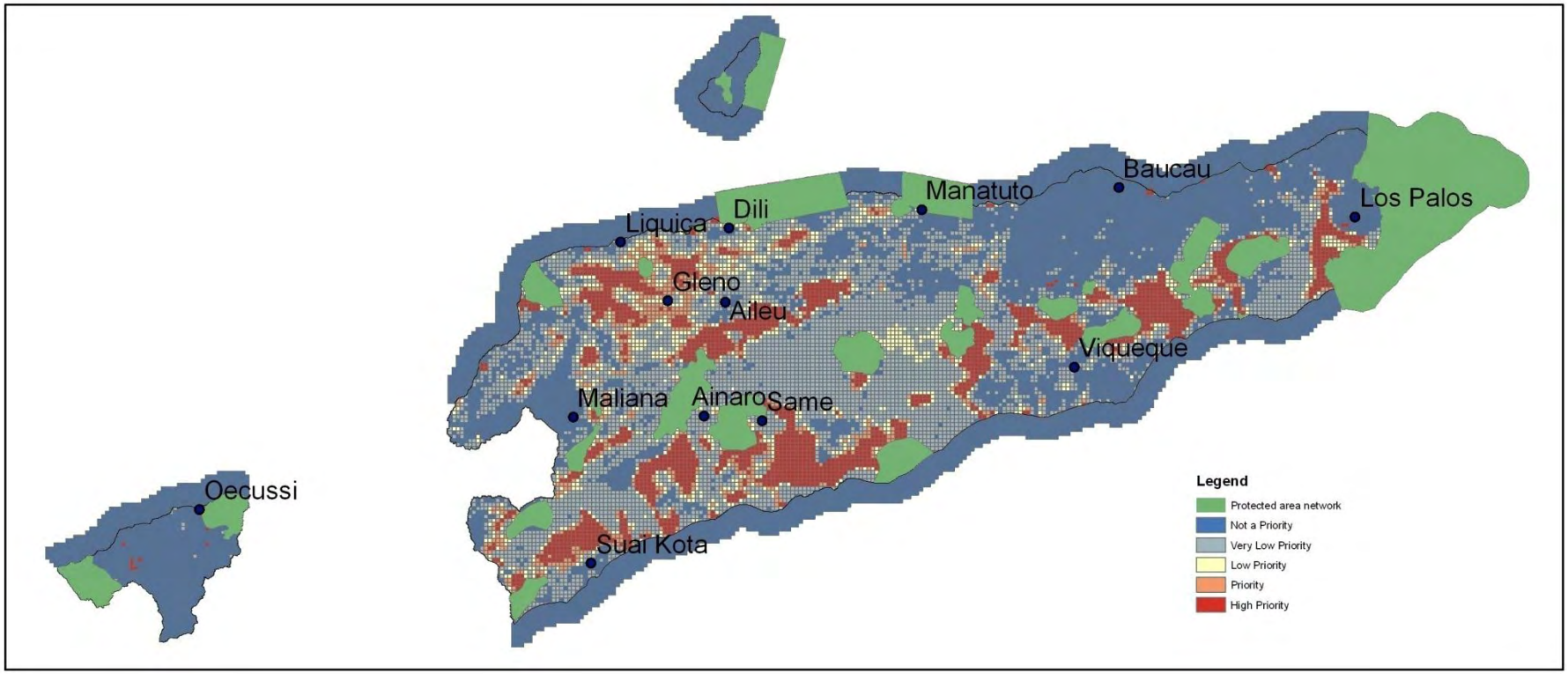

Figure 43. Priority areas map for *Marxan* analysis in relation to the protected area network and major towns.

The locations of all AOI

Figure 44 contains a summary of the protected area network and AOI based on both expert opinion and spatial prioritization software *Marxan*. Figure 44 contains a more general map of AOI based of Figure 43. These areas should ideally be assessed for their conservation value as either new protected areas or other types of areas for conservation management (e.g. community-based management schemes)

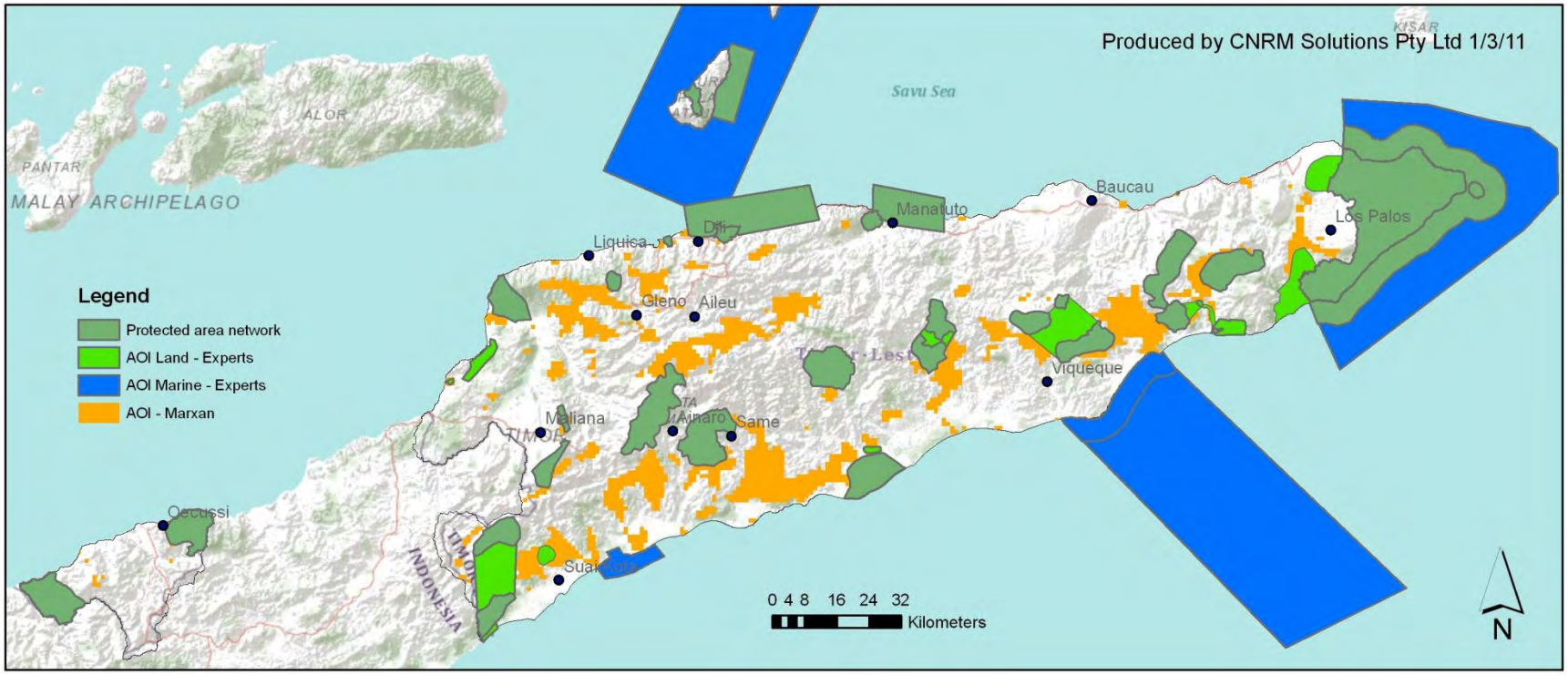

Figure 44. Summary of all areas of interest for new protected areas in Timor-Leste.

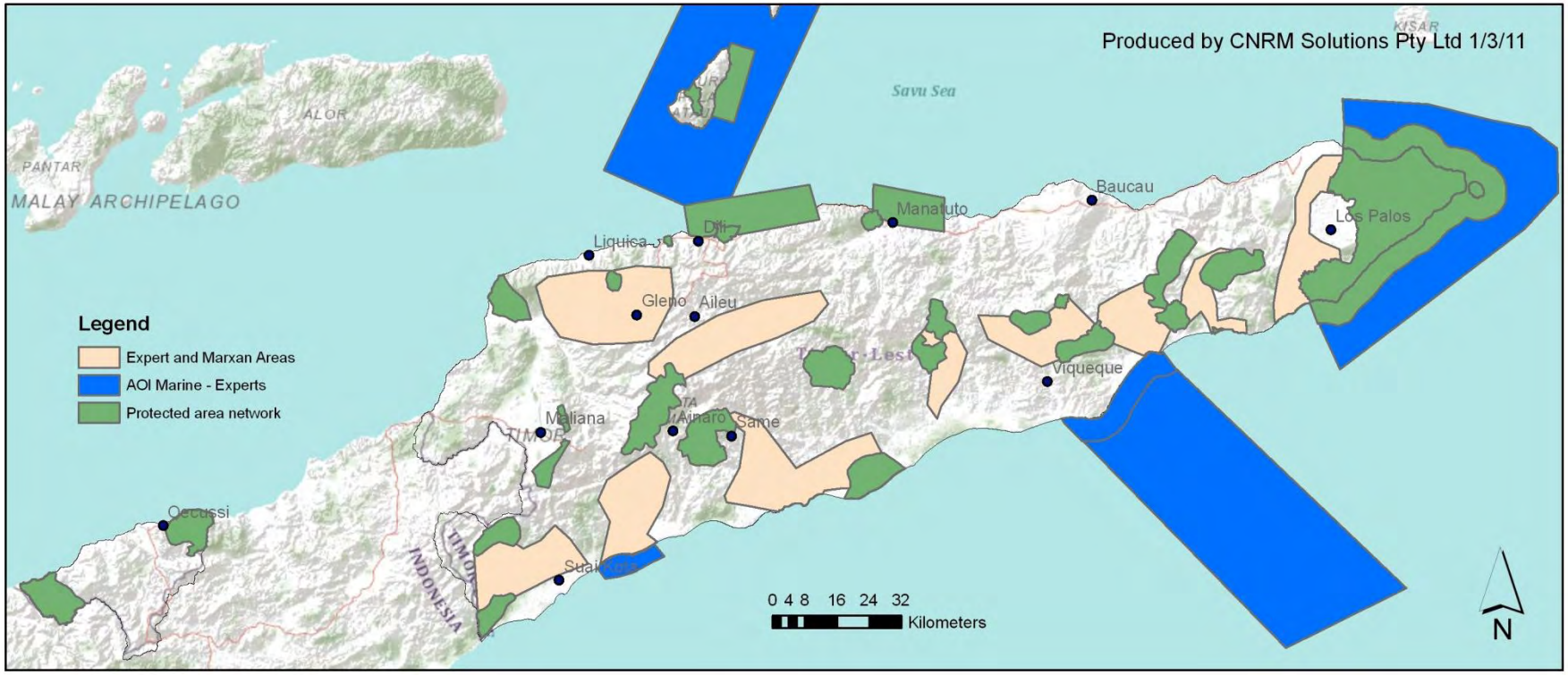

Figure 45. Summary of all areas of interest for new protected areas in Timor-Leste in relation to the protected area network and major towns.

Box 1. Locally Managed Marine Areas

During workshops and other discussions on protected areas in Timor-Leste, many people suggested that the Locally Managed Marine Areas (LMMA) model to marine conservation might be a more appropriate conservation strategy for inshore marine conservation in Timor-Leste than simply focusing on traditional Marine Protected Areas (MPA). It is outside the scope of this project to plan and assess the effectiveness of this strategy. Rather, we briefly discuss what a LMMA is and suggest it be considered as part of marine protected area planning. This might be in addition or within the framework of more traditional MPAs.

Pacific Island communities have long practiced traditional methods of protecting food sources by imposing seasonal bans and temporary no-take areas. These methods have been based on a system of community marine tenure, which regulates the right to own or control an inshore area and which is informally recognized by villagers and local chiefs. Traditionally, management of LMMAs included temporary closures of fishing zones, limitations on the number of fishers or the amount of fish that could be harvested, restrictions on using certain fishing practices, and the imposition of a *tabu*, or prohibition, on fishing for certain species. In addition, sacred fishing grounds were recognized by communities, and temporary moratoria on fishing were sometimes imposed as part of traditional ceremonies.

Communities set aside at least part of an LMMA as a restricted area, typically 10-15% of the villages fishing waters, in order to allow habitat and resources to recover from fishing pressure. The location and size of the *tabu* area is determined by members of the community, depending on how much they feel they can close and still meet their needs. The community may also choose a spot that is easy to police, and not necessarily a rich fishing area. Technical experts may offer their advice to the community on optimal placement of the *tabu* area, but ultimately the community itself has the final say about location and extent. Thus an LMMA is significantly different from a marine reserve or marine protected area. In a marine protected area, a central body, often a national government, makes all the decisions, often from afar and with little or no local input.

Most of this information comes from the LMMA Network (http://www.lmmanetwork.org/).

Prioritisation of new terrestrial protected area management plans

Priorities for new management plans for terrestrial protected areas were based on a spatial prioritisation analyses that was similar to the one used to identify the best places to fill the gaps. The difference between these approaches was this analysis identified the protected areas that ensured all threatened species are protected in (at least) three different protected areas, whilst minimizing the total number of management plans needed to be developed. This approach recognises that limited resources and capacity currently available in Timor-Leste to develop management plans and aims to highlight which areas should be of highest priority for development and implementation of management efforts.

We found that five protected areas were high priorities (Mount Manoleu/Area Mangal Citrana, Mount Cutete, Ribeira de Clere/Lake Modomahut, New Diatutuo) and several others were medium priorities (Mount of Taroman, Mount of Tapo/Suburai, Mount of Cablaque/Lake of Welenas, Mount of Builo, Mount of Ruilo and Mount of Burabo) (Fig. 46). The limitations of this approach is that it is solely based on threatened species and does not consider other factors like level of threat, social and institutional capital in the region or the cost/time of developing the management plan.

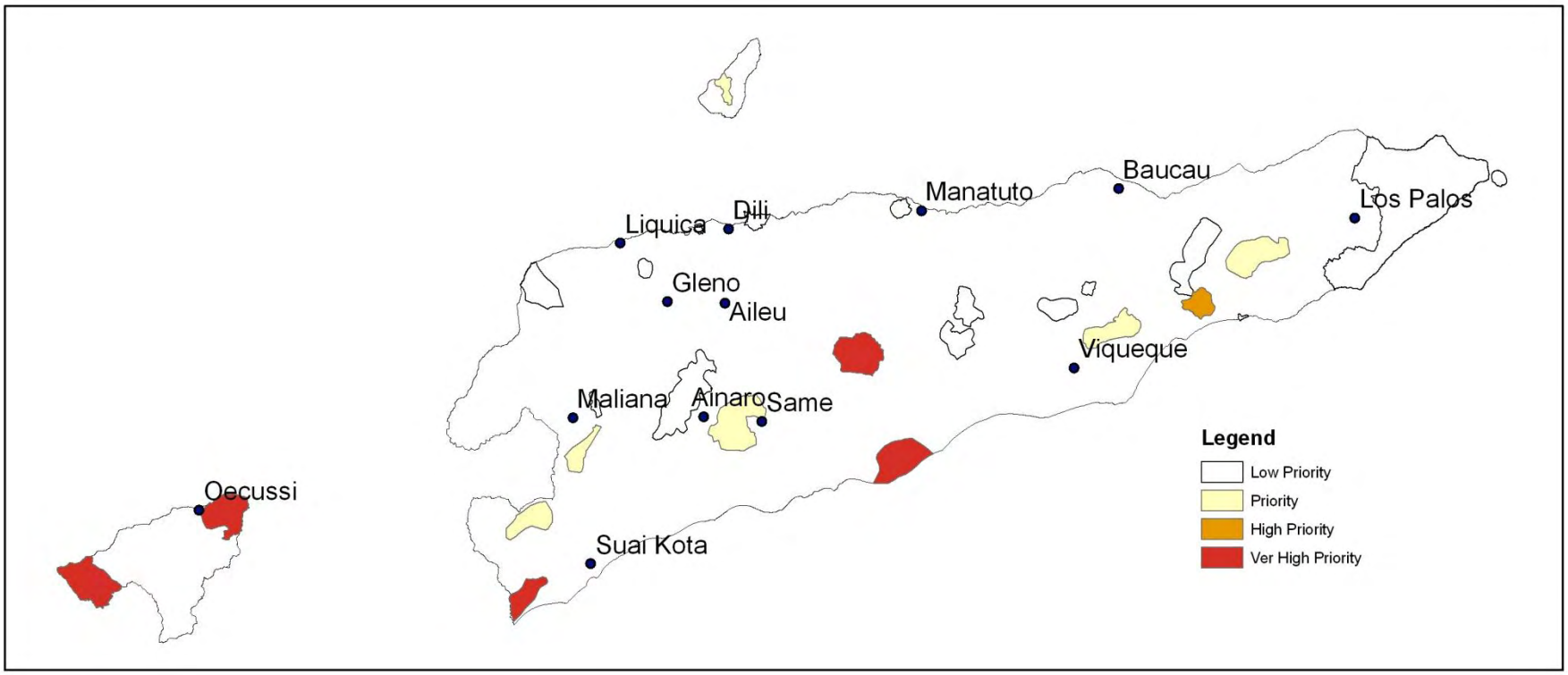

Figure 46. Priority protected areas in the protected area network for management plans. These ensure each species would be in at least three protected areas with management plans while minimizing the number of protected areas. Note that Nino Konis Santana NP management plan is already underway.

Conclusion: what was achieved in the NEGA and where to from here?

Summary

In this project, a number of key tasks were achieved:

- The development of a methodology that identified clear goals and targets for protected areas. The goals are:
    - Goal One. *Ensure full representation across biological scales and biological realms.*
    - Goal Two. *Protection of all critical habitats for endemic, migratory and threatened species*.
    - Goal Three. *Ensure that protected areas are the right size to ensure the persistence of biodiversity*.
    - Goal Four. *Ensure that protected areas play a role in mitigating climate change.*
    - Goal Five. *Design protected areas so that they are resilient and able to withstand stresses and changes such as human-forced climate change.*
  - There are a number of medium term objectivess for achievement of each of these goals by 2020.

- The spatial mapping of the protected area network for Timor-Leste for the first time
  - The size of the protected areas ranged from 2km^2 (Mount of Maurei) to 675 km^2 (Nino Konis Santana NP terrestrial section), with the average size of protected areas being ~100km^2 and the median being 65km^2 (Figure 5). The total area of protected areas is ~3200km^2. The total area of terrestrial protected area network is ~2000km2, which is around 15% of the nation's land area.
  - The boundaries are only estimates and in no way represent the final boundaries for any protected area.
  - The protected area network includes protected areas that mainly only exist in legislation (several not) and at various stages of implementation with most at early stages.

- The synthesis of all known ecological GIS data for Timor-Leste in this report and the related database as well as a library of all known scientific literature and reports.
    - A major effort was undertaken to collate all known reports from relevant government agencies, research institutions and environmental non-government organizations within and beyond Timor-Leste, as well as accompanying spatial data.
    - The formulation of a report and database is a key outcome because a serious limitation to all conservation initiatives undertaken in Timor-Leste (acknowledged by all stakeholders) is a lack of generic information about what research has been done, and also a lack of responsibility conducted by visiting scientists in passing their data and research back to the government. The reports and data we collated during the process of conducting this assessment is something the DPANP can build upon in the future.

- The first formal classification of Timor-Leste's unique biodiversity.
    - We identified 24 general forest types based on geological formations, which are the fundamental unit of lithostratigraphy. A formation consists of a certain number of rock strata that have a comparable lithology, facies or other similar properties. These were loosely confirmed to represent general forest patterns with a field trip that transected parts of the north coast and interior to the south coast. They are hypothesised to correlate well with species distribution patterns and evolutionary patterns.
    - The Sustainable Land Management project (UNDP) had developed a new landcover maps for Timor- Leste at $10m^2$ resolution. Using these data, we were able to show that Timor-Leste has lost between 70-50 % of it forest dependent on definition of forest type. The extent of clearing is distributed fairly evenly across forest types. The forests are heavily fragmented. We used these data for our protected area planning analysis.
    - Timor-Leste is within the Coral Triangle, the epicenter of coral reef diversity. Coral reefs cover over $100km^2$. A new classification of coral reefs was identified, dividing Timor-Lestes reefs into seven types.
    - Other habitats identified included, lakes, rivers, mangroves, estuaries and seagrass.
    - The condition of most habitats remains unknown.
    - Important sites were mapped for wetland birds, reptiles, amphibians and orchids. Also mapped was the distribution of several endemic species.

- The first gap analysis for the protected area network has been conducted for Timor-Leste.

- For the protected area network analysis we found a number of ecosystems are well represented while others are not.
    a. Forests
        i. For the optimistic scenario of forest cover, we found ~10% of the original cover of forests are protected in the proposed areas. This is around 20% of the distribution of current forest cover
            1. Four forest types were close to the 30% target (original cover), three were not represented.
        ii. For the pessimistic scenario of forest cover we found 6% of the original cover of forests would be protected. This is around 20% of the current forest cover. Three were not represented at all with one of the forest types having no forest cover left.
    b. Rivers, wetlands and estuaries
        i. 5% of braiding rivers, 55% of lakes and 6% of estuaries are in the protected area network.
    c. Coral Reefs
        i. The target for coral reefs is 30% of each type of reef. Coverage is 55% of coral reefs are in the proposed network overall which include, 100% of three types, three others with between 50% and 90% and one at 20%.
    d. Broad marine classes
        i. All classes had between ~20-30% coverage in the protected area network
    e. Mangroves and seagrasses
        i. The target for mangroves is 80% and seagrasses is 30% in protected areas. Currently targets are met for seagrasses with nearly 70% in the protected area. Mangroves did not achieve their targets with nearly 50% within the protected area network.
- For the protected area network, we found a number of species of conservation concern were well represented and others not so well represented
    a. A high proportion of records for birds of conservation concern were well represented.
    b. A total of 13 out of 16 Important Bird Areas were represented.
    c. A total of 5 out of 15 important wetlands for birds were represented.
    d. A total of 1 out of 5 important areas for reptiles and frogs were represented.
    e. The important site for orchids is completely represented.
    f. Two endemic species (freshwater fish and turtle) are only found at Lake Iralalara in Nino Konis Santana NP.

- The target for carbon is 30% within protected areas. Overall, around 22% of carbon is within the protected area network.

- A priority areas map was developed based on several types of data
    a. Areas of interest based on expert opinion have been mapped for terrestrial and marine areas
    b. The first prioritisation analysis to inform protected area planning
        i. Priority areas were identified in the *Marxan* analysis based on setting quantitative targets for coverage of ecosystems and species whilst maximizing connectivity and avoiding human settlements;
    c. This map can be used for identifying locations for future protected areas and for conservation management strategies beyond protected areas (e.g. community based management see box 1).

- Prioritisation of new protected area management plans
    a. Use of *Marxan* to identify which areas should be managed first to ensure that each threatened species would be managed in three protected areas.
    b. We found that five protected areas were high priorities (Mount Manoleu/Area Mangal Citrana, Mount Cutete, Ribeira de Clere/Lake Modomahut, New Diatutuo) and several others were medium priorities (Mount of Taroman, Mount of Tapo/Suburai, Mount of Cablaque/Lake of Welenas, Mount of Builo, Mount of Ruilo and Mount of Burabo).

- Capacity Building
    a. DPANP staff now have excellent understanding of the principles of systematic conservation planning and how to undertake a National Ecological Gap Assessment (NEGA).
    b. DPANP staff has understanding of spatial priorization software, particularly Marxan, that can help systematically plan protected areas.

Recommendations

1. The protected area network contains high conservation value areas of international importance. The network contains a relatively high representation of the full range of ecosystems and species of conservation concern in Timor-Leste. The network also contains valuable watersheds that protect water systems critical to people downstream and a

relatively high proportion of the countries carbon. Development of management plans for the protected areas should continue to be the first priority of the DPANP.

2. There are gaps in the protected area system and other areas need to be added to the system to account for the needs of particular species and habitats. These areas are important for endemic reptiles and frogs, wetlands for birds, and habitats for species living in estuarine ecosystems.

3. Once the protected areas are formally established, connectivity between protected areas should be considered to help species and ecosystem adapt to climate change.

4. Lake Iralalara is a particularly important site in Timor-Leste with at least two endemic freshwater fish species confined to its waters. Proposed development such as dams should be very carefully considered or stopped. Introduction of new fish species should not be permitted for this globally recognized site managed for its ecological values.

5. Further assessment outside of the protected area network should focus on the AOI identified in our spatial prioritisation analysis. If these areas are found to have high conservation value, new protected areas should be considered or complementary conservation management strategies (e.g. community led projects) implemented.

6. A moratorium on large development projects should be placed on these AOI before formal assessments take place as reducing the value of these areas might have significant impacts on national biodiversity.

7. We encourage the Locally Managed Marine Area model of marine conservation that is currently being considered as a management tool. Similar community-based approaches could be considered for terrestrial areas as complementary to protected areas.

8. Current boundary delineation is a key problem to implementing the protected area network, as at the current rate of progress, it will take decades to finish. This process needs to be accelerated and more appropriately funded.

9. The management planning processes still need to be developed for the protected area network. This is currently happening with component two of the POWPA.

10. Management plan needs to be developed for all protected areas. Without regulations and zoning, the conservation values of these protected areas cannot be ensured. The planning

process for Nino Konis Santana NP is currently being conducted and we propose the priorities (if based on threatened species) should be Mount Manoleu/Area Mangal Citrana, Mount Cutete, Ribeira de Clere/Lake Modomahut, and New Diatutuo. Others to be considered are Mount of Taroman, Mount of Tapo/Suburai, Mount of Cablaque/Lake of Welenas, Mount of Builo, Mount of Ruilo and Mount of Burabo. These collectively would ensure each threatened species are adequately protected in several protected areas.

11. The budget is woefully inadequate for protected area implementation. Current budget is US$60,000 per annum. It is estimated at least US$500,000 per annum would be required to finance the protected area network based on broad estimates from DPANP. Sources of potential funding include increasing the budget from the current government, Lifeweb, AusAID, GEF, UNDP, NGOs, international agencies, donors and the carbon market.

12. The protected area network contains over 20% of the country's terrestrial carbon. Protected areas will likely lead to avoided deforestation, and with reforestation in protected areas the amount of carbon is going to increase. The REDD+ program being developed at the UNFCCCC should be seriously considered to help finance protected areas.

13. The need for policies, laws and regulations, including enforcement of existing regulations, is urgent for the DPANP to work effectively and to achieve lasting impact. All policies and laws on protected areas, threatened species, wildlife trade and national parks should be reviewed and updated to meet standards set by the international community.

14. The information and database system generated by this report should be centralised. Regulations should be in place so that data that are collected by academics, NGOs and other researchers be made accessible to the government and other local institutions. There is a need for more capacity for this type of data collation (both in terms of skill sets and also the number of people doing it) and this should be developed as a high priority.

15. A national ecological classification of ecosystems should be formally developed, particularly for forest type mapping and benthic habitats in marine ecosystems.

16. Funding should be allocated to assist the government in updating the NEGA every five years to assess progress in protected area planning. Training should be continued on GIS and conservation planning capabilities.

18. For protected area planning, there should be increased coordination between government ministries and agencies, and between the government and non-governmental organisations.

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Appendix 1: Data on protected areas

The following are data on protected areas that would be difficult to determine from the figures.

Forest Types (pessimistic scenario)

Protected Area	Aileu Formation	Ainaro Formation	Aitutu Formation	Aliambata Formation	Alluvial	Barique Formation	Baucau Limestone	Bobonaro Complex	Bobonaro Formation	Borolalo Formation	Cablaci Limestone
Mount of Cablaque and Lake of Welenas*	0	8	0.17	0	0.02	0	0	0	0	0	5.54
Mount of Tapo/Saburai*	0	0	0	0	0	0	0	3.45	0	0	0
Mount of Loelako*	0	0	0	0	0	0	0	0	0	0	0.16
Mount of Taroman*	0	0	0.49	0	0	0	0	2.35	0	0	0
Mount of Kuri*	0.83	0	0	0	0	0	0	0	0	0	0
Mount of Laretame*	0	0	0	0	0	0	0	0	1.98	0	0.15
Mount of Builo*	0	0	0	0	0	0	0	0	7.19	0	14.31
Mount of Guguleur*	9.08	0	0	0	0.51	0	0	0	0	0	0
Lake of Maurei*	0	0	0	0	0.99	0	0	0	0	0	0
Mount of Mundo Perdido*	0	0	0	0	0	0	0	0	8.51	0.01	9.09
Area Protegida Reserva De Tilomar	0	0	0	0	0	0	0	1.65	0	0	0
Mount Tatamailau and Talobu/Laumeta	0	1.27	39.34	0	0	0	0	0.03	0	0	0
Manucoco Protected Area	0	0	0	0	0	0	0	0	0	0	0
Ribeira de Clere and Lake of Modomahut*	0	0	0	0	6.84	0	0	0	0	0	0
Mount of Matebian	0	0	0.04	0	0	0	0	0	0.64	6.62	12.56
Mount of Fatumasin	7	0	0	0	0	0	0	0	0	0	0
Mount Cutete*	0	0	0	0	0.11	0	0	0.15	0	0	0
Mount Manoleu* and Area Mangal Citrana	0	0	0	0	0.34	0	0	2.46	0	0	0
Mount of Burabo*	0	0	5.06	0	0	7.41	0	0	1.4	0	0
Cristo Rei Protected Area	2.69	0	0	0	0	0	0	0	0	0	0
Mount Legumau*	0	0	0.59	0	0	0	0	0	28.14	0	0
Mount of Aitana*	0	0	13.74	0	0	0	0	0	0	0	0
Mount of Bibileo*	0	0	4.78	0	0	0.21	0	0	6.41	0	0
Nino Konis Santana National Park	0.01	0	21.24	0	9.24	0	123.59	0	13.71	0	0.23
New Diatuto	0	0	1.49	0	0	0	0	1.45	0	0	0
Tasitolu	0.18	0	0	0	0.08	0	0	0	0	0	0

Protected Area	Cribas Formation	Dartollu Limestone	Dilor Formation	Lariguti Formation	Lolotoi Formation	Maubisse Formation	Suai Formation	Surobeco Formation	Viqueque Formation	Walibuli Formation	Unknown Forest
Mount of Cablaque and Lake of Welenas*	0	0	0	0	37.16	0	0	0	20.42	0.1	0
Mount of Tapo/Saburai*	0	0	0	0	12.04	0	0	0	0	0	0
Mount of Loelako*	0	0	0	0	0	0	0	0	3.04	0	0
Mount of Taroman*	0	0	0	0	4.27	0	0	0	0	0	24.32
Mount of Kuri*	0	0	0	0	0	0	0	0	0	1.29	0
Mount of Laretame*	0	0	0	0	0	0	0	0	1.28	0	0
Mount of Builo*	0	0	0	0	0	0	0	0	6.92	0	0
Mount of Guguleur*	0	0	0	0	0	0	0	0	0	0	0.01
Lake of Maurei*	0	0	0	0	0	0	0.13	0	0	0	0.09
Mount of Mundo Perdido*	0	0	0	0	0	0	0	0	0.36	0	0
Area Protegida Reserva De Tilomar	0	0	0	0	0	0	4.74	0	1.68	0	32.29
Mount Tatamailau and Talobu/Laumeta	0	0	0	0	0	3.99	0	0	0	5.9	0
Manucoco Protected Area	0	0	0	0	0	0	0	0	0	0	0
Ribeira de Clere and Lake of Modomahut*	0	0	0.09	0	0	0	51.75	0	0.79	0	0.14
Mount of Matebian	0	0	0	0	3.06	0	0	0	0	0	0
Mount of Fatumasin	0	0	0	0	0	0	0	0	0	0	0
Mount Cutete*	0	0	0	0	0	0	0	0	0	0	3.72
Mount Manoleu* and Area Mangal Citrana	0	1.31	0	0	0	0	0	0	0	0	0.09
Mount of Burabo*	2.13	0	0	0	6.06	0	0	0	0	0	0
Cristo Rei Protected Area	0	0	0	0	0	0	0	0	0	0	0.03
Mount Legumau*	8.26	0	0	0	0	8.76	2.08	0	0	0	0
Mount of Aitana*	0.01	0	0	0	6.85	0	0	0	0	1.11	0
Mount of Bibileo*	0	0	0	0	8.24	0	0	0	0	15.59	0
Nino Konis Santana National Park	47.93	0	0	0	0	0	11.46	128.21	0	0	28.74
New Diatuto	0	0	0	0	45.43	0	0	0	0	0.38	0
Tasitolu	0	0	0	0	0	0	0	0	0	0	0.01

Coral Reef Types

	Coral Reef Class 1	Coral Reef Class 2	Coral Reef Class 3	Coral Reef Class 4	Coral Reef Class 5	Coral Reef Class 6	Coral Reef Class 7
Ataura (marine)	0.63	0	0	0	1.66	4.76	2.43
Behau (marine)	0	0.15	0.17	0.16	3.23	12.61	3.83
Nino Konis Santana National Park (marine)	0	0	0	0	12.3	8.97	0.19
Lamsanak (marine)	0	0	0	0	0.31	2.76	0.06
Mount of Cablaque and Lake of Welenas*	0	0	0	0	0	0	0
Mount of Tapo/Saburai*	0	0	0	0	0	0	0
Mount of Loelako*	0	0	0	0	0	0	0
Mount of Taroman*	0	0	0	0	0	0	0
Mount of Kuri*	0	0	0	0	0	0	0
Mount of Laretame*	0	0	0	0	0	0	0
Mount of Builo*	0	0	0	0	0	0	0
Mount of Guguleur*	0	0	0	0	0	0	0
Lake of Maurei*	0	0	0	0	0	0	0
Mount of Mundo Perdido*	0	0	0	0	0	0	0
Area Protegida Reserva De Tilomar	0	0	0	0	0	0	0
Mount Tatamailau and Talobu/Laumeta	0	0	0	0	0	0	0
Manucoco Protected Area	0	0	0	0	0	0.17	0
Ribeira de Clere and Lake of Modomahut*	0	0	0	0	0	0	0
Mount of Matebian	0	0	0	0	0	0	0
Mount of Fatumasin	0	0	0	0	0	0	0
Mount Cutete*	0	0	0	0	0.18	0.01	0
Mount Manoleu* and Area Mangal Citrana	0	0	0	0	0	0	0
Mount of Burabo*	0	0	0	0	0	0	0
Cristo Rei Protected Area	0	0	0	0	0	0.21	0.17
Mount Legumau*	0	0	0	0	0	0	0
Mount of Aitana*	0	0	0	0	0	0	0
Mount of Bibileo*	0	0	0	0	0	0	0
Nino Konis Santana National Park	0	0	0	0	0.38	0.63	0.03
New Diatuto	0	0	0	0	0	0	0
Tasitolu	0	0	0	0	0.07	0.06	0

Endangered and endemic birds

	Macropygia magna	*Turacoena modesta*	*Gallicolumba hoedtii*	*Treron psittaceus*	*Ducula rosacea*	*Ducula cinerascea*	*Cacatua sulphurea*	*Trichoglossus euteles*
Mount of Cablaque and Lake of Welenas*	1	1			1		1	1
Mount of Tapo/Saburai*	1	1		1				1
Mount of Loelako*		1						
Mount of Taroman*	1	1				1	1	
Mount of Kuri*		1			1			1
Mount of Laretame*		1		1				
Mount of Builo*	1	1		1		1	1	1
Mount of Guguleur*		1			1			
Lake of Maurei*		1			1		1	
Mount of Matebian	1	1						1
Area Protegida Reserva De Tilomar	1	1	1		1		1	
Mount Tatamailau and Talobu/Laumeta		1			1	1		1
Manucoco Protected Area	1	1		1	1			1
Ribeira de Clere and Lake of Modomahut*	1	1		1	1		1	1
Mount of Mundo Perdido*	1	1		1	1	1	1	
Mount of Fatumasin	1				1		1	
Mount Cutete*	1	1			1	1		
Mount Manoleu* and Area Mangal Citrana	1	1	1	1	1		1	
Mount of Burabo*	1	1				1	1	1
Cristo Rei Protected Area					1			
Mount Legumau*	1	1		1	1	1		1
Mount of Aitana*								
Mount of Bibileo*								
Nino Konis Santana National Park	1	1			1			
New Diatuto		1		1		1	1	1
Tasitolu		1			1			1

	Todiramphus australasia	*Meliphaga reticulata*	*Philemon inornatus*	*Lichmera flavicans*	*Myzomela vulnerata*	*Gerygone inornata*	*Phachyrephala orphaus*	*Sphecotheres viridis*
Mount of Cablaque and Lake of Welenas*		1	1			1		1
Mount of Tapo/Saburai*		1	1					1
Mount of Loelako*		1	1	1	1	1		1
Mount of Taroman*		1	1		1	1	1	1
Mount of Kuri*		1	1	1	1	1	1	1
Mount of Laretame*			1	1	1			
Mount of Builo*		1				1		
Mount of Guguleur*		1	1			1	1	1
Lake of Maurei*		1	1			1	1	
Mount of Matebian		1	1			1	1	1
Area Protegida Reserva De Tilomar	1	1	1		1	1	1	1
Mount Tatamailau and Talobu/Laumeta		1	1	1	1	1	1	
Manucoco Protected Area						1	1	
Ribeira de Clere and Lake of Modomahut*		1	1		1	1	1	1
Mount of Mundo Perdido*		1	1	1	1		1	
Mount of Fatumasin		1	1		1	1	1	
Mount Cutete*	1	1	1	1		1	1	1
Mount Manoleu* and Area Mangal Citrana		1	1	1	1	1		1
Mount of Burabo*		1	1			1	1	1
Cristo Rei Protected Area		1	1			1	1	
Mount Legumau*						1	1	1
Mount of Aitana*								
Mount of Bibileo*								
Nino Konis Santana National Park		1					1	
New Diatuto			1	1		1		
Tasitolu		1	1	1	1	1	1	

	Phyllocopus presbytes	*Halcia rueller*	*Zoothera dohertyi*	*Zoothera peronii*	*Saxicola gutturalis*	*Ficedula timorensis*	*Cyornis hyacinthinus*	*Dicaeum maugei*
Mount of Cablaque and Lake of Welenas*	1			1	1		1	1
Mount of Tapo/Saburai*	1						1	1
Mount of Loelako*	1						1	1
Mount of Taroman*	1						1	1
Mount of Kuri*								1
Mount of Laretame*								1
Mount of Builo*			1	1	1			
Mount of Guguleur*					1			1
Lake of Maurei*								1
Mount of Matebian							1	
Area Protegida Reserva De Tilomar	1	1		1	1	1	1	1
Mount Tatamailau and Talobu/Laumeta	1				1	1	1	1
Manucoco Protected Area	1			1				1
Ribeira de Clere and Lake of Modomahut*	1			1	1	1	1	1
Mount of Mundo Perdido*	1	1					1	1
Mount of Fatumasin	1			1			1	1
Mount Cutete*				1	1			
Mount Manoleu* and Area Mangal Citrana	1	1	1			1		
Mount of Burabo*			1	1	1		1	
Cristo Rei Protected Area								1
Mount Legumau*	1	1						1
Mount of Aitana*								
Mount of Bibileo*								
Nino Konis Santana National Park								1
New Diatuto	1	1	1	1				
Tasitolu					1			1

Appendix 2: Images of individual protected areas

The following images, from Google Earth, of individual protected areas in the protected area network. It is hoped that these images will provide better context for the rough boundaries of the protected area network than more traditional mapping methods. Some are images in 3D providing elevation context too.

Image 1. Atauro Marine Protected Area.

Image 2. Behau Marine Protected Area.

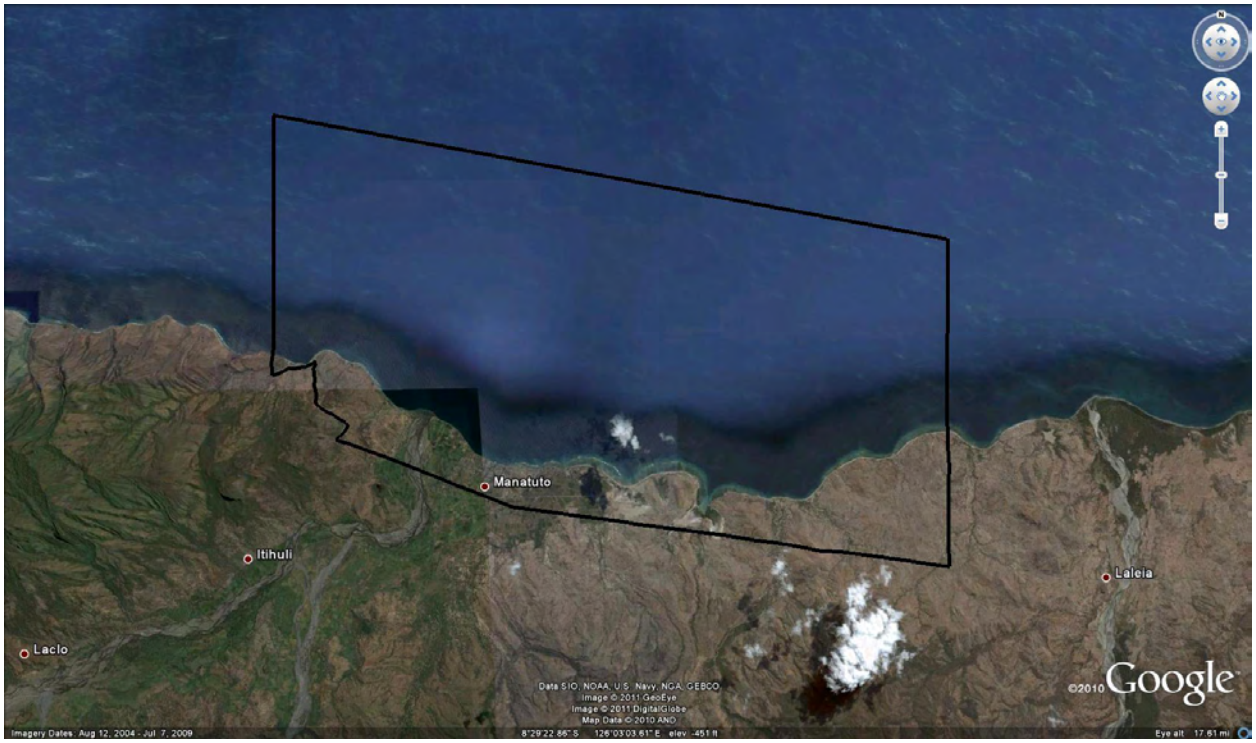

Image 3. Lamsanak Marine Protected Area.

Image 4. Nino Konis Santana National Park (including marine park)

Image 5. Mount of Cablaque and Lake Welenas

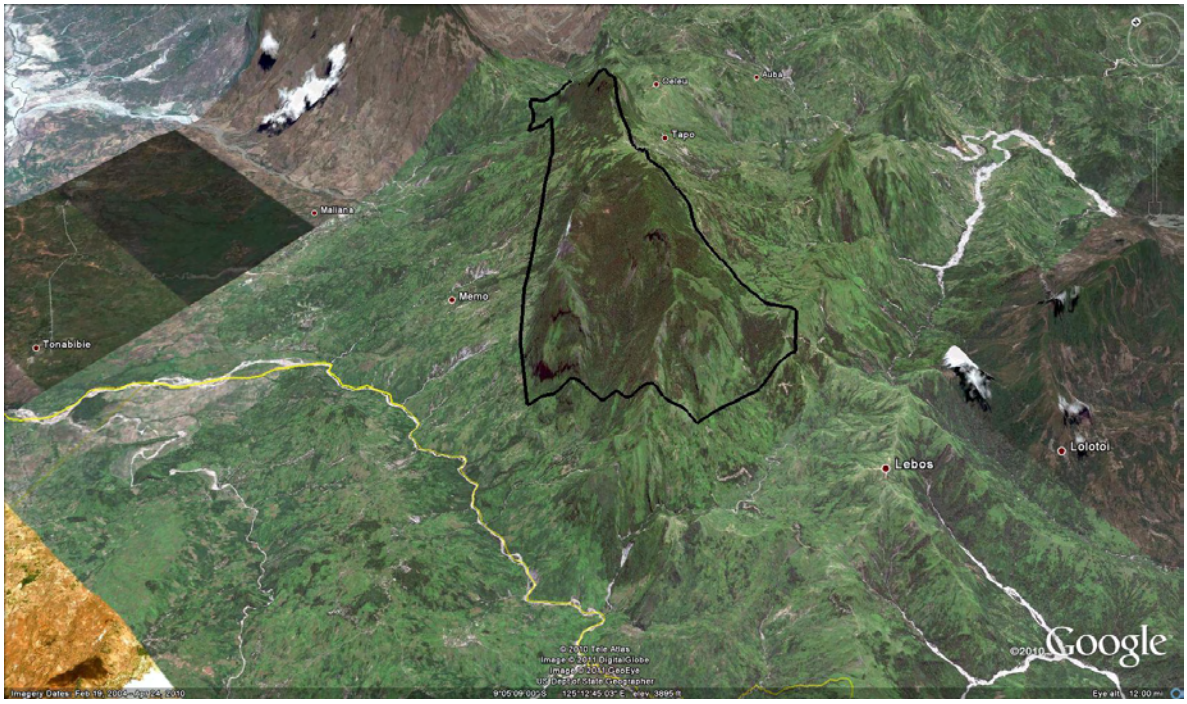

Image 6. Mount of Tapo/Saburai

Image 7. Mount of Loelako

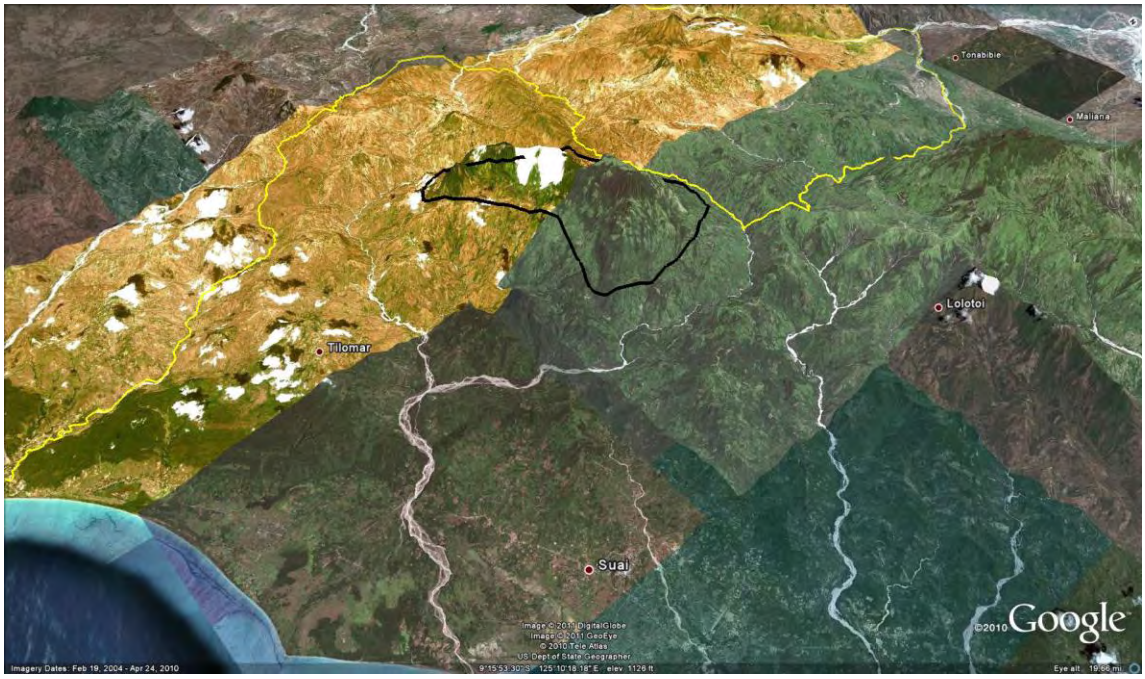

Image 8. Mount of Taroman

Image 9. Mount of Kuri

Image 10. Mount of Laretame

Image 11. Mount of Builo

Image 12. Mount of Guguleur

Image 13. Lake of Maurei

Image 14. Mount of Mundo Perdido

Image 15. Mount Tatamailau and Talobu/Laumeta

Image 16. Manucoco Protected Area

Image 17. Ribeira de Clere and Lake of Modomahut

Image 18. Mount of Matebian

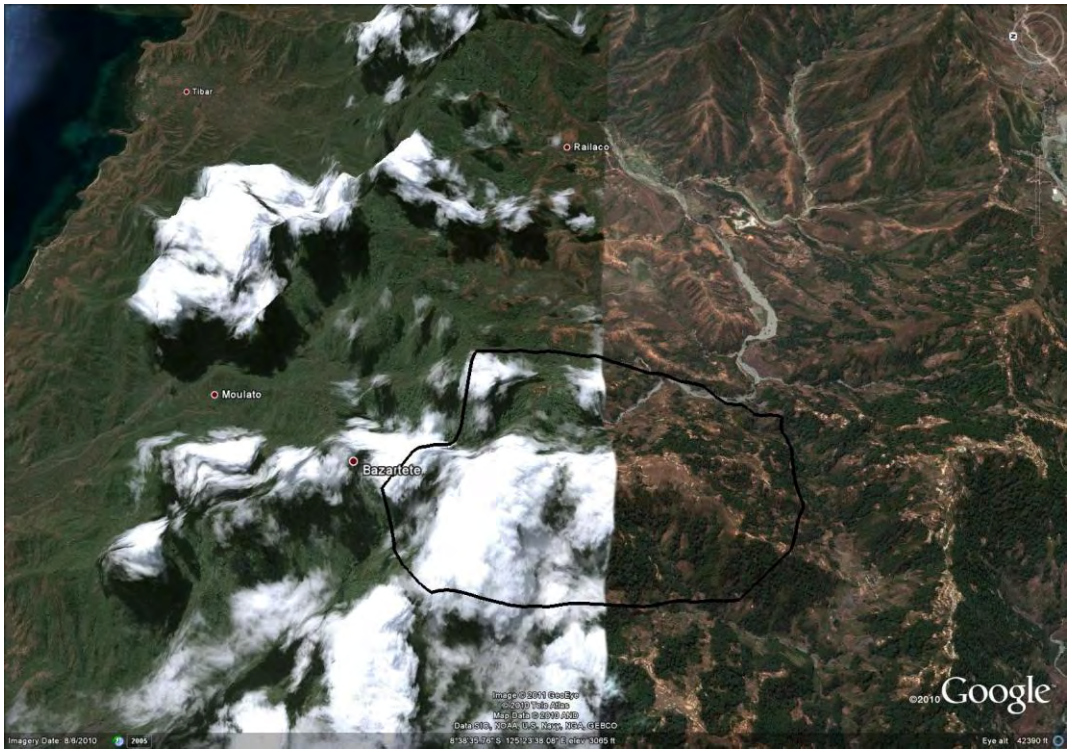

Image 19. Mount of Fatumasin

Image 20. Mount Cutete

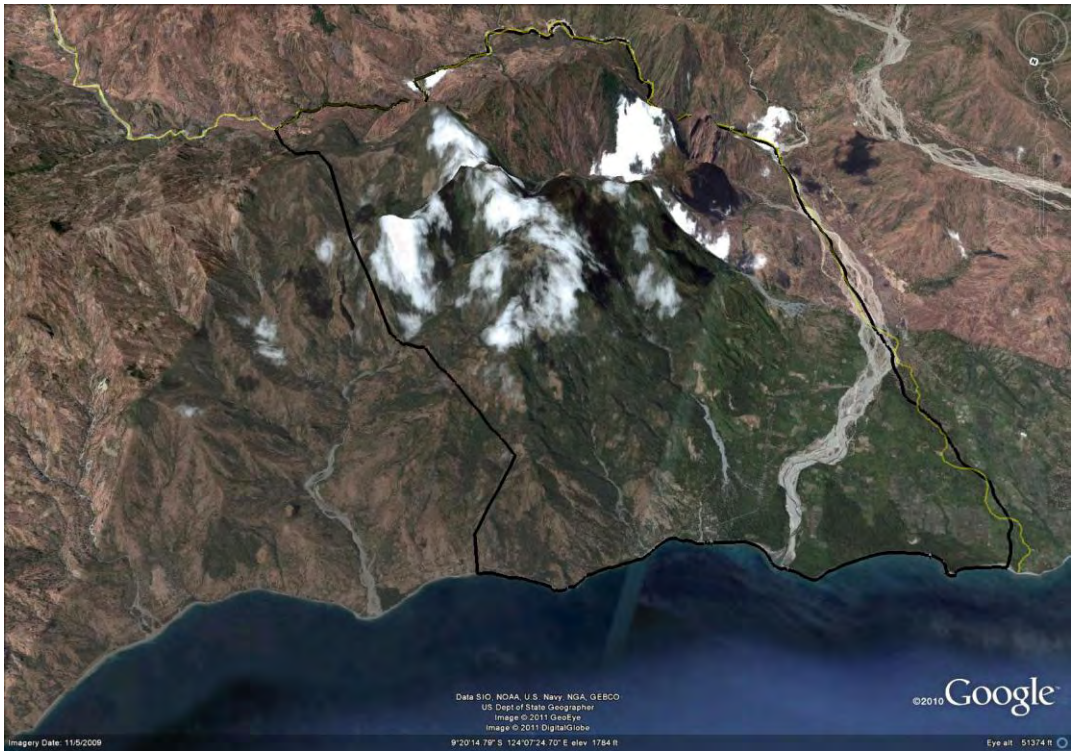

Image 21. Mount Manoleu and Area Mangal Citrana

Image 22. Mount of Burabo

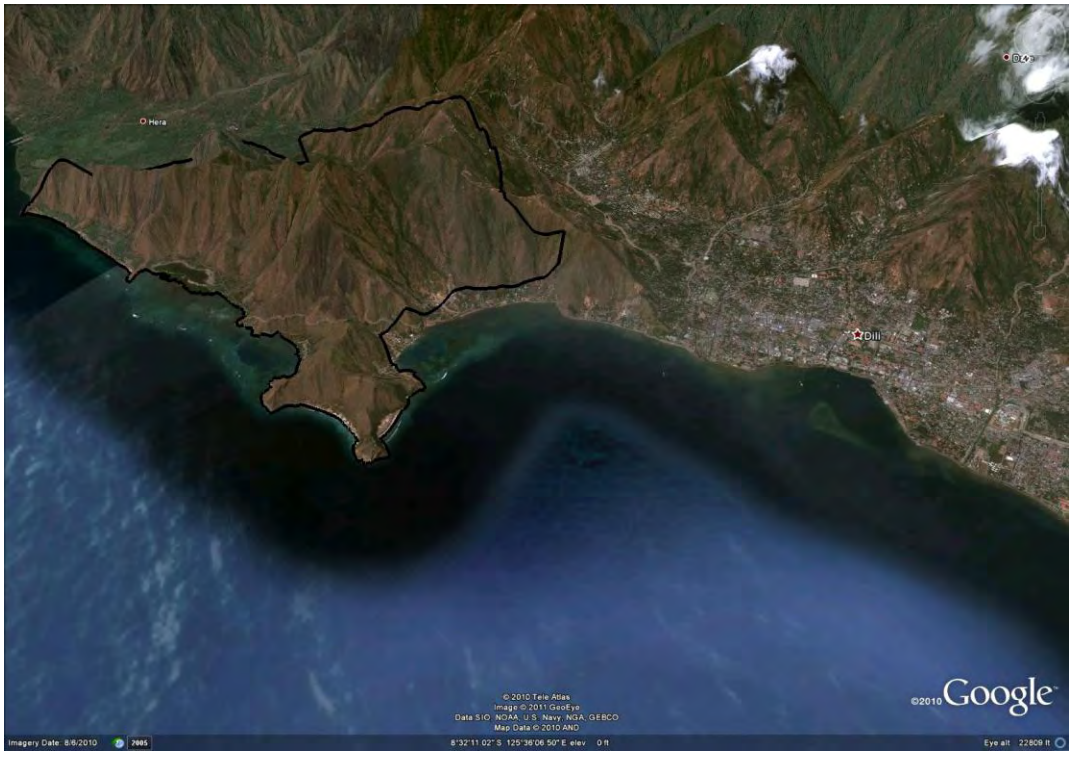

Image 23. Cristo Rei Protected Area

Image 24. Mount Legumau

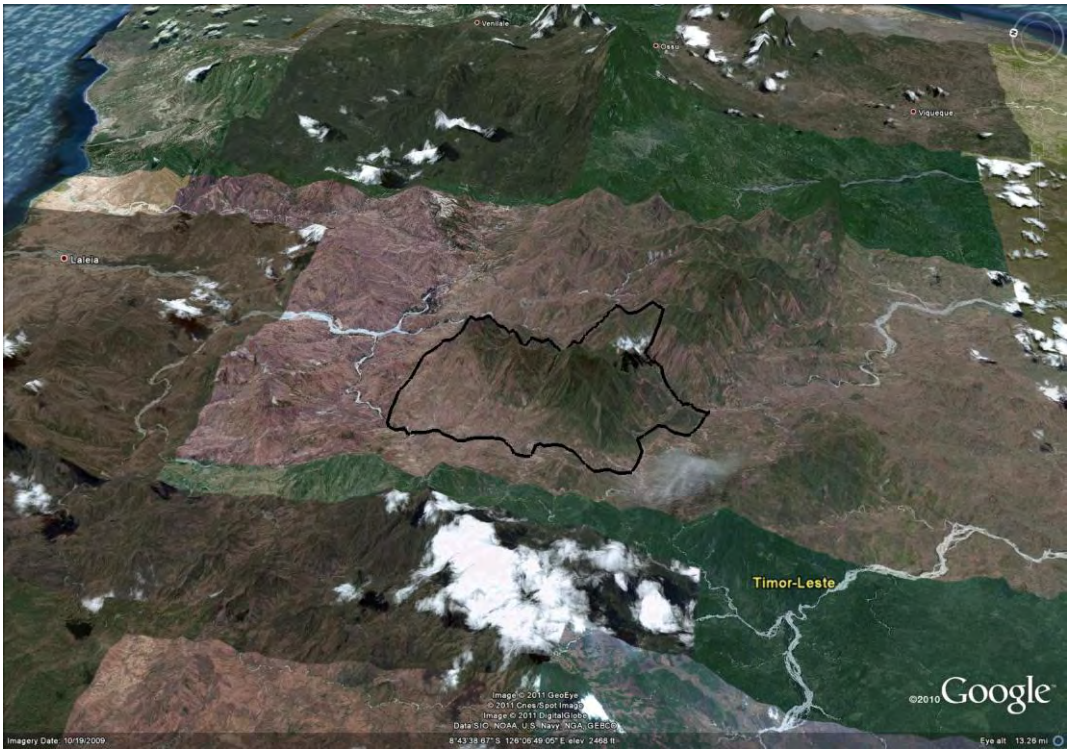

Image 25. Mount of Aitana

Image 26. Mount of Bibileo

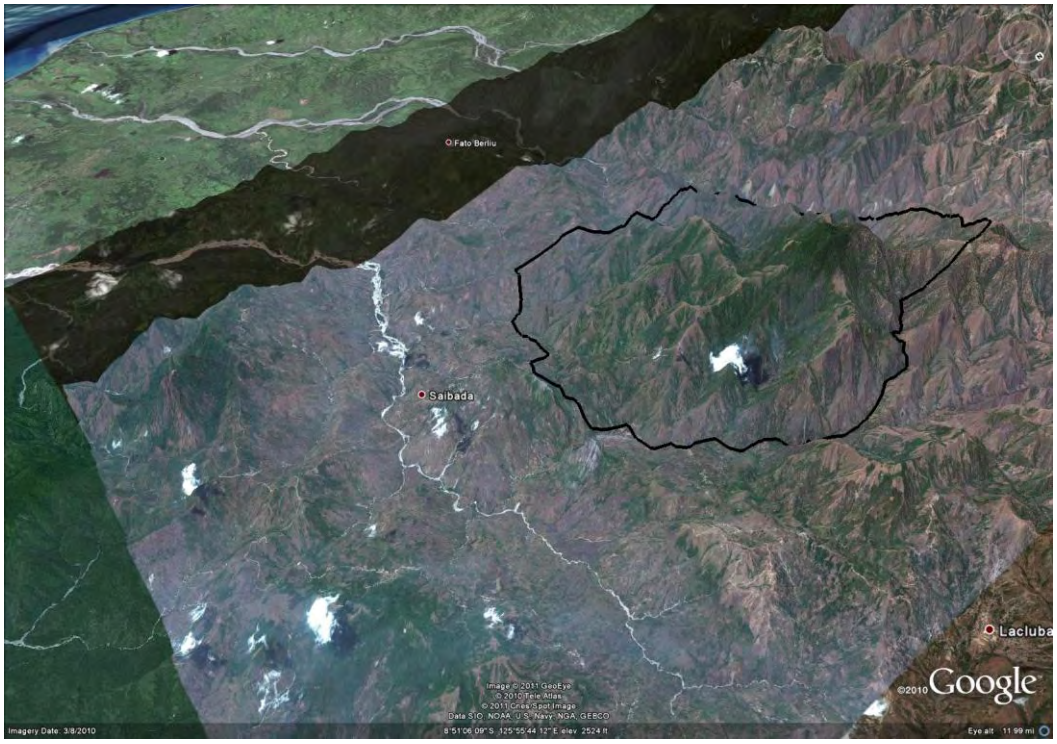

Image 27. New Diatuto

Image 28. Tasitolu

Appendix 3: Images of Areas of Interest based on expert data

The following terrestrial AOI were identified by DPANP officials based on their extensive knowledge of Timor-Leste. For marine areas of interest, the AOI were identified during prior workshops organised by The Nature Conservancy (see Wilson et al. 2009).

Image 29: AOI 1

Image 30: AOI 2

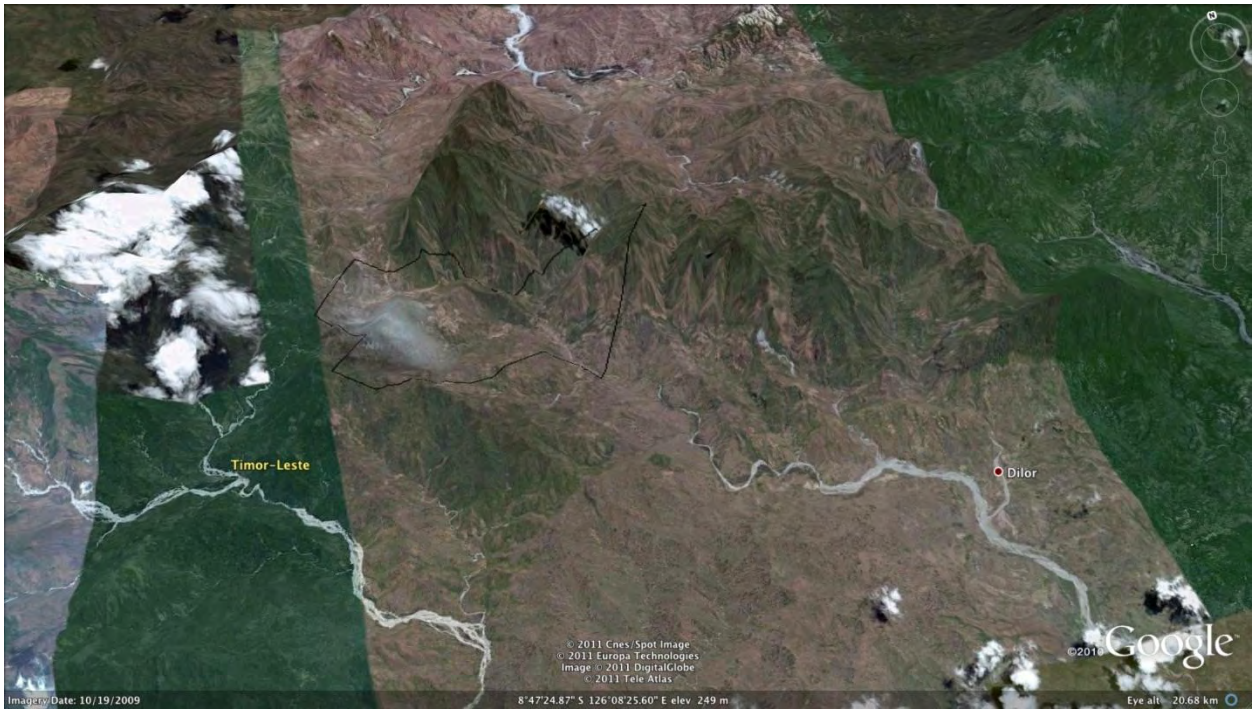

Image 31: AOI 3

Image 32: AOI 4

Image 33: AOI 5

Image 34: AOI 6

Image 35: AOI 7

Image 36: AOI 8

Image 37: AOI 9

Image 38: AOI 11

Image 39: AOI 12

Image 40: AOI 13

Image 41: AOI 14

Image 42: AOI 15

Image 43: AOI 16

Image 44: AOI 17

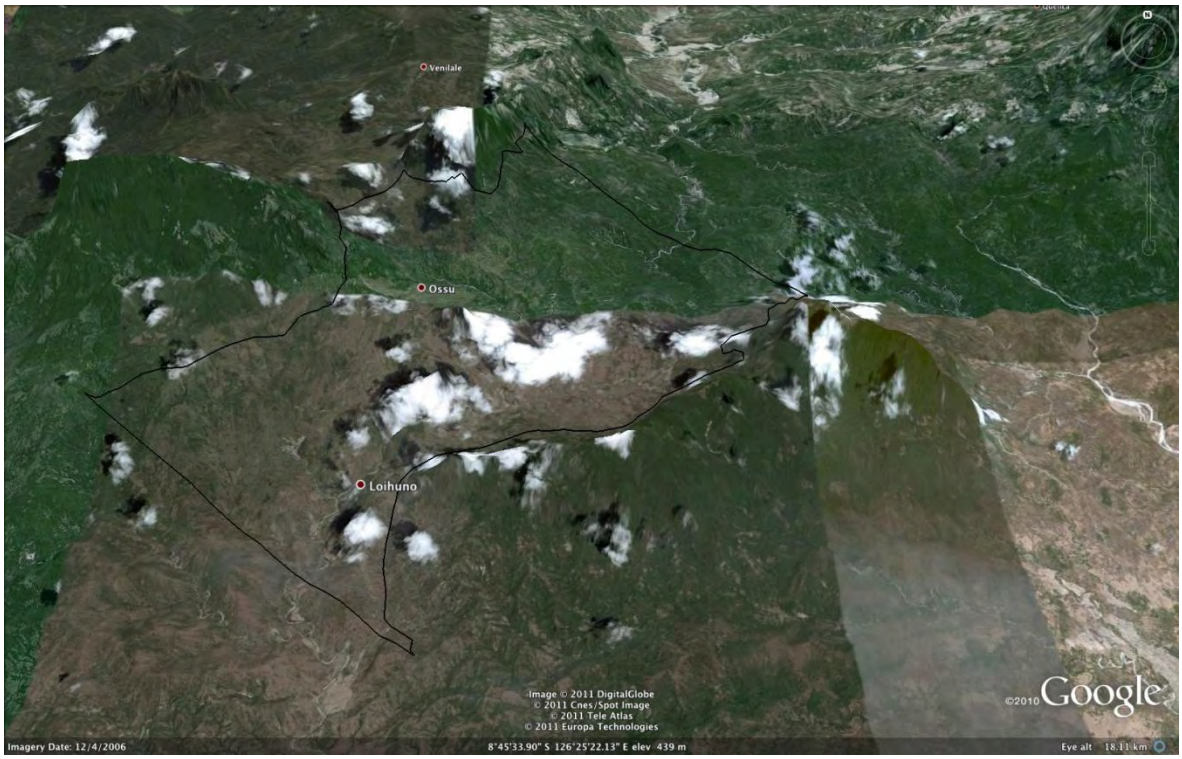

Image 45: AOI 18

Image 46: AOI 19

Image 47: AOI 20

Image 48: AOI 21

Image 49: AOI 22

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