Developing a New Model for Sustainable Financing for Conservation Areas Based on Payment for Ecosystem Services (PES) in Bolikhamxay

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1. Introduction

Payments for reduced emissions from deforestation and forest degradation (REDD) are increasingly being presented as a new opportunity for developing sustainable financing of natural resource management and biodiversity conservation, particularly within protected areas (Ebeling & Yasué, 2007; Dudley, 2008; Miles & Kapos, 2008). Protected areas contain significant stocks of carbon, estimated to be up to 15% of total global carbon stocks (Campbell et al., 2008), and yet it is not guaranteed that land conversion within their boundaries is always eliminated (Clark et al., 2008). As a consequence of this continued threat to carbon stocks, Scharlemann et al. (2010) estimate that payments from reducing emissions within protected areas in the humid tropics alone could be valued at USD 6,200–7,400 million, approximately 1.5 times the total protected area management expenditure in this region. These figures suggest that not only do protected areas have the potential to play a significant role in the efforts to limit the global emission of greenhouse gases but that there is also potential for the fulfilment of this role to generate funding to support protected areas in countries where resource extraction and competing land uses threaten their continued existence and integrity and where financing for effective management is largely reliant on external donor funding.

The purpose of this study is to investigate the feasibility for payments from REDD or other carbon finance mechanisms to contribute to the conservation management of protected areas in Bolikhamxay Province, Lao PDR.

Project Boundaries

The project boundaries for any potential carbon finance project were set in agreement with Bolikhamxay provincial authorities at a workshop held in the Provincial Agriculture and Forestry Office (PAFO) headquarters in Pakxan on 5th May, 2010. It was agreed that any project would not be implemented outside of 5 km within the boundary of Nam Kading (NK) National Protected Area (NPA) and a new protected area proposed as part of the Theun Hinboun Expansion Project (THXP). These areas are described in greater detail in Section 2.

The start date of the Bolikhamxay REDD project under consideration would follow the cessation of current donor funds for the conservation management of the area included inside the project spatial boundaries.

REDD in Lao PDR

The results of this study will be integrated into the ongoing methodology and framework development process for REDD activities implemented in Laos. The Government of Lao PDR (GoL) has recently established a national REDD taskforce, which will oversee this process. This committee is led by the Department of Forestry (DoF) within the Ministry of Agriculture and Forestry, with representatives from other agencies, including the National Land Management Authority and the Water Resources and Environment Authority. As part of this policy development framework, the Wildlife Conservation Society (WCS), in collaboration with government partners, is undertaking demonstration feasibility assessment of the landscapes associated with three protected areas in Lao PDR: Nam Kading, Nam Et-Phou Louey and Nam Phoui. This report presents the findings of the first component of this assessment.

2. Background

The Bolikhamxay conservation landscape in central Lao PDR is of critical importance for the conservation of biodiversity due to the presence of a large number of endemic species and species of regional or global priority, such as tiger and elephant. It is recognized as a biodiversity hotspot by many international conservation assessments, and contains the largest block of dry evergreen forest in Indochina. WCS began working in the Bolikhamxay landscape in 2004, focusing on NK NPA (169,000 ha). Initial activities concentrated on replicating the successful model of protected area management that WCS has developed for Nam Et-Phou Louey (NEPL) NPA in northern Laos. With the technical assistance of WCS, the provincial government is implementing a comprehensive project, the Integrated Ecosystem and Wildlife Management Project (IEWMP), with the aim of conserving the globally significant biodiversity found in Bolikhamxay Province. As a result, WCS has forged an excellent working relationship with the Bolikhamxay provincial government and has begun to extend work into the wider Bolikhamxay landscape, in partnership with the Government of Laos (GoL) and various private sector companies, most notably the Theun Hinboun Power Company (THPC), a private dam company. The Bolikhamxay provincial conservation vision seeks to link NK NPA with the heart of the Central Sai Phou Luang mountain range, specifically with the Phou Chomvoy Provincial Protected Area (PCV PPA; 25,040 ha).

2.1. Management Units

There are three principal conservation management units within the area considered by this study: NK NPA, the proposed THXP area[1] and PCV PPA (Figure 1). These management units form part of a network of NPAs and PPAs within the wider Bolikhamxay landscape.

The NK NPA was gazetted in 1993 by Prime Ministerial decree as part of a national network of 18 NPAs[2]. This network was created with the aim of protecting a significant and representative portion of the important habitats in Lao PDR (Berkmüller et al., 1995). It lies at the node between two ecoregions of global and regional importance: the Northern Annamite Tropical and Subtropical moist forests, and the Northern Khorat Plateau moist deciduous forest. The former is regarded as a Pleistocene refuge of very high endemism; and the latter boasts a very high degree of biological diversity (Wikramanayake et al., 2002). It characterizes the largest high quality block of dry evergreen forest, the dominant habitat type in Bolikhamxay Province, remaining in Indochina (Duckworth et al., 1999). Other habitat types in this protected area include mixed deciduous forests, grasslands, wetlands and riverine ecosystems, and limestone karst (Strindberg, et al. 2007). The NPA is home to a considerable amount of wildlife, including at least 43 species of mammals and 234 species of birds. Since 1990, five large and midsized mammals have been described in and around the landscape; a number of discoveries unmatched anywhere in the world (Hedemark, 2007).

[1] THXP is a hydropower expansion project planned by THPC on the Nam Gnouang River, a major watercourse which runs through the Bolikhamxay conservation landscape.
[2] Establishment of NPAs Decree No. 164/PM.

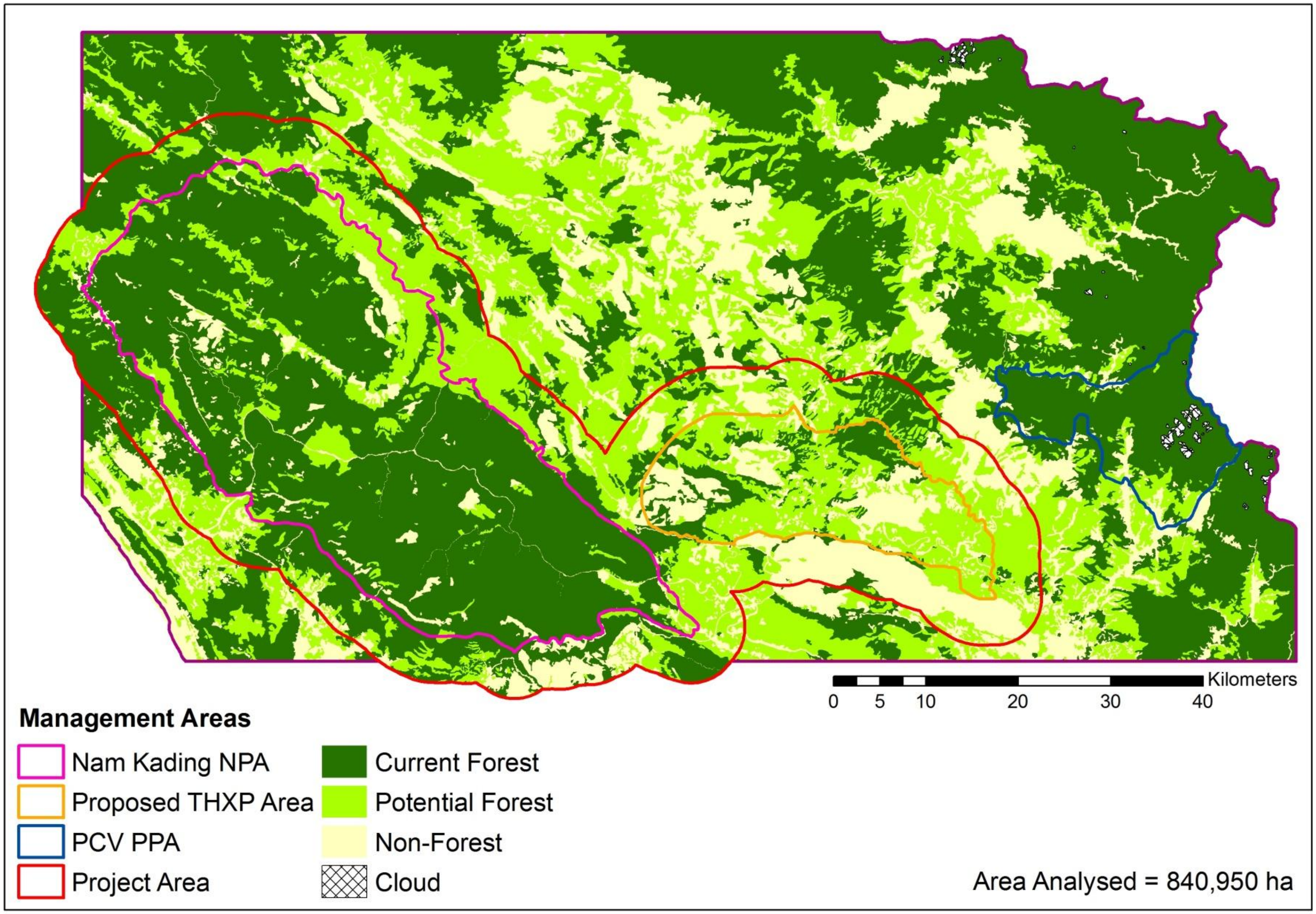

Figure 1: Principal management units under consideration for the feasibility study. Forest cover shown for the initial dry season considered for the feasibility study, 2000/1.

NK NPA is managed by the IEWMP, with technical assistance provided by WCS. The IEWMP commenced in 2005 and was initially supported until 2010 through a GEF grant. This has subsequently been extended with further funds raised by WCS. The NPA is zoned into the core protection zone, covering an area of 130,000 ha (approximately 78% of the protected area), and the controlled use zone in which restricted use of natural resources is permitted. There are 24 villages within 5km of the NPA boundary, comprising a population of 13,802 people (NSC, 2005). This includes a population of 1,150 people who live in 3 villages enclaved within the NPA.

In 2009, WCS formed a partnership with THPC to create a unique opportunity to develop a new model for sustainable financing of conservation areas in Laos. THPC is planning to build a new hydroelectric dam on the Nam Gnouang River in Bolikhamxay and has established a payment for watershed services agreement with WCS to protect and restore the forest of the Nam Gnouang watershed. This new conservation area has the potential to form a biodiversity corridor linking the Sai Phou Luang mountain chain with NK NPA. A rapid survey of the proposed new watershed protection area identified a high diversity of wildlife, including many species of regional or global conservation concern (McWilliam, 2007). At the time of writing the boundary of the new protected area is the subject of negotiation between THPC and the provincial government. For the purposes of this study a provisional boundary was agreed, encompassing an area of 43,159 ha.

PCV PPA, an important area of montane evergreen and semi-evergreen forest situated in the central Sai Phou Luang Mountains, was declared by the provincial government in December 2000. WCS is currently in the process of assisting the provincial government to develop a management plan that would cover the period until 2020. Such a plan would serve as firm basis for its long-term planning and implementation of conservation activities. PCV PPA is known to harbour a host of near-endemic mammals and birds including the saola (*Pseudoryx nghetinensis*), a highly threatened forest dwelling ox species endemic to the Sai Phou Luang mountain range. Managment of the PPA is the responsibility of the Bolikhamxay Province Agriculture & Forestry Office (PAFO) in coordination with the relevant district administrative authorities.

2.2. Bolikhamxay Province

The area considered is made up of 4 administrative districts: Bolikhan, Pak Kading, Viengthong and Khamkeut; with a population of greater than 120,000 people. There is a high degree of ethnic diversity with 33 distinct ethnic groups recorded in Bolikhamxay province. Poverty is widespread. The 2004 National Growth and Poverty Eradication Strategy identified both Viengthong and Khamkeut Districts as poor and therefore priorities for future development interventions (GoL, 2004a).

Agriculture is the most important livelihood activity with shifting upland rice cultivation predominating. Other important crops include corn, mung beans, ground nuts, sugar cane, long beans, sweat potato, soy beans, cassava, sesame, taro, ginger, and tobacco. Commercial production of tree crops is being started comprising eucalyptus and eaglewood plantations, as well as rubber. Fish, wildlife and other non-timber forest products account for a high proportion of incomes for the largely rural population. Wild meat makes up a significant proportion of dietary protein and is supplemented by livestock raised on forested lands. Consequently, local villagers are highly dependent on forests both for their livelihoods and for food.

3. Driver Analysis

An analysis of the principal drivers of deforestation and forest degradation within the project area was undertaken to aid understanding of the deforestation rate and the potential impacts of identified drivers in the future. This analysis comprised of three separate components: a literature review, a participatory threat assessment (PTA), and an analysis of proxy indicators such as the incidence of fires and population change.

3.1. Literature Review

A comprehensive review of the available scientific and grey literature regarding land use practices and deforestation in Lao PDR was conducted. This review focused on four main topics in order to examine the existing state of understanding of the drivers of deforestation and forest degradation at national and local scales. The topics considered were:

- Current land use practices and local livelihoods
- Impact of national natural resource policies
- Transition to commercial agriculture
- Historical land cover change in Lao PDR

Current Land Use Practices and Local Livelihoods

Livelihoods in Lao PDR are dominated by agriculture with more than 75% of Lao workers involved in agrarian livelihoods (UNDP, 2009). In many instances such agrarian focused livelihoods are correlated with household poverty. Nationally poverty severity has declined over the last ten years, although a regional disparity remains with the northern region experiencing the greatest level of poverty (WB, 2006). To date national policy efforts to eradicate poverty and develop rural communities have been focused on the 47 poorest districts (GoL, 2004a). The average annual household income for rural families is estimated to be 18.4 million kip (ADB, 2006a). As is the case elsewhere the causes of poverty are diverse. An assessment conducted by the Asian Development Bank (ADB) in 2000 and repeated in 2006, however, ranked limited access to land for cultivation as the main cause of poverty (ADB, 2001; ADB, 2006b), illustrating the close linkage between rural livelihood practices and household poverty in Lao PDR.

The dominant livelihood activity in the rural uplands is shifting agriculture, also referred to as swidden or ‘slash and burn’ agriculture, in which forested or fallow land is cut and subsequently burnt before cultivation of specific so-called ‘upland’ rice varieties. While other crops, such as maize, cassava, soy, chillies, sesame or Job’s tears, are also grown rice has traditionally been planted on the significant majority of available arable land (Van Gansberghe, 2005a). Paddy rice farming is also a significant livelihood activity in the upland region although land suitable for this form of cultivation is often limited. Livestock husbandry, handicraft production and the collection and sale of non timber forest products (NTFPs) also contribute to livelihoods, with all of these activities representing important sources of cash income (Roder et al., 1992). Off-farm employment opportunities are typically limited but those households with poor access to agricultural land may supplement their earnings through hiring out family labour to wealthier families (Van Gansberghe, 2005b).

Rice Production Systems

Shifting agriculture is practiced in either a rotational or pioneering manner in which the same land is either reused on a cyclical basis or virgin land is newly cleared respectively (Van Gansberghe, 2005a). Whether households practice rotational or pioneering forms of shifting agriculture is strongly linked to ethnicity, with certain ethnic groups such as the Hmong associated with pioneering practices in particular (Lee, 2005; Robichaud et al., 2009), and to land availability. Land is selected for cultivation on the basis of suitability and proximity to the village. Some soils may support more intense use than others and so fallow periods in these areas can afford to be shorter without permanently reducing yields, although in this case fallow periods may be determined by the presence of weeds (Roder, 2001). How land is divided amongst households within a village is largely dependent on village traditions, which again may vary with ethnicity and the availability and suitability of land (Schlemmer, 2002). In some cases households may seek permission from the headman of another village to use land within that village's traditional agricultural boundaries (Schlemmer, 2002). In many cases families will plant other crops such as vegetables and livestock feed and will collect NTFPs from the surrounding fallow areas. In this way shifting agriculture offers a diverse set of livelihood opportunities and thus provides a safety net to reduce vulnerability to environmental uncertainty (Decourtieux et al., 2005).

The alternative rice production system, widely used throughout the uplands, is paddy cultivation. In this system rice is grown in small plots surrounded by dykes to retain water. These plots are either rain-fed, river-fed or irrigated with yields increasing with an increasingly consistent water supply. A severe constraint on this form of cultivation, however, is the availability of suitable land, which requires low-gradient topography, suitable soil and a reliable water supply (Schlemmer, 2002). In the uplands, land with a shallow gradient is in particularly short supply and the significant majority of land suitable for paddy rice is already in cultivation, limiting the opportunities for further development of this form of cultivation.

Shifting cultivation and paddy rice are not exclusive livelihood activities with many households practicing both. There are however distinct advantages and disadvantages of each form of cultivation (Table 1).

Table 1: Comparison of rice production systems (from Schlemmer, 2002).

	Shifting Cultivation	**Paddy**
Advantages	low barriers to entry	lower labour input
	diverse livelihood system	higher yields (3-4 tonnes per hectare)
	possible to cultivate land unsuitable for other agriculture	sedentary
Disadvantages	vulnerable to weather conditions	limited suitable land
	extensive	high capital input for ploughing
	high labour inputs	technical knowledge required
	lower yields (2-2.5 tonnes per hectare)	dependent on water

The high labour inputs required for shifting agriculture are largely due to weeding which makes up approximately 50% of all labour associated with this form of cultivation (Roder, 2001). This bottleneck represents a serious constraint on the ability of a household to scale up production. This is particularly accentuated when land is limited as this often has the effect of decreasing the time given to fallow, giving the land less time to recover. As discussed above, the most serious constraint for paddy cultivation is the limit on suitable land. Thus both principal forms of cultivation are constrained by the availability of land.

Livestock Husbandry

Livestock husbandry is another important livelihood activity for people in the uplands and is well integrated into shifting cultivation agricultural systems. Livestock are typically grazed on upland fields once crops have been harvested, in the process returning nutrients to the soil in the form of manure (Van Gansberghe, 2005a). In 2000, livestock was found to commonly contribute over 50% of household earnings, with 89% of farm households keeping one or more livestock species (Stur et al., 2002). Phimphachanhvongsod et al. (2005) present the following advantages of livestock husbandry:

- livestock can be sold at any time and have a relatively constant market value
- larger livestock species can be walked long distances to market
- livestock provides a high return per unit of labour input
- livestock can be sold during times of environmental stress making them less vulnerable than arable crops to uncertainty
- livestock provide a means of capital accumulation

It should be noted, however, that livestock husbandry is not without risk. Epidemics are common; in a survey for the ADB, 70% of respondents identified livestock disease as contributing to rural poverty (ADB, 2001). This was reconfirmed in the second poverty assessment in 2006 when, for the northern region, livestock mortality was again ranked as the second biggest cause of poverty behind access to land (ADB, 2006b).

Husbandry practices vary from village to village. Schlemmer (2002) reports: “Grazing areas may be near or far from the village, with fenced pathways, fully enclosed, or without fences, near hilltops (cows) or in lowlands (buffaloes), in grasslands or in forests. The cattle may be tended by a person who receives a salary or in a rotating system by owners themselves. Where possible, the grazing areas may include paddy fields. Before planting rice, cattle graze the fields to improve soil fertility and decrease weeds and shrubs which aids land preparation, and again after harvesting they can eat rice straw.” The impact on forest resources remains unclear, particularly how grazing livestock in the forest affects regrowth of fallow and recruitment of saplings and the extent to which forest is cleared to create new *sanams* (areas for grazing). The national Forest Strategy identifies grazing practices, including fire-setting to clear forest understory and promote grass growth and trampling of seedlings by livestock, as one of the two main drivers of habitat degradation for biodiversity in Lao forests (GoL, 2005).

NTFP Collection

NTFPs form another important component of upland livelihoods although estimates of the importance vary. Bounthong et al. (2003) report that NTFPs account for 40-60% of household income although the primary data for this is not presented. It is unlikely though that this figure represents the full contribution of NTFPs to household livelihoods since many of the products which are collected have little commercial value and are consumed in the home. These include firewood, building materials, forest vegetables, mushrooms and medicinal products among others. Collection sites vary from village to village with some villages having areas of forest specifically set aside for NTFP harvesting; while in others collection will mainly be focused in and around upland fields. There is also a strong division of labour along gender lines with men and women often responsible for the harvest and use of different products (Schlemmer, 2002).

The commercialisation of NTFPs in general is a subject of considerable debate with concerns raised about the quantity and quality potential of products in particular (Sunderlin et al., 2004; Belcher & Schreckenberg, 2007). There have, however, been numerous efforts in Lao PDR to support the commercialisation of NTFPs and integration with formal markets, some of which have met with success (Foppes & Phommansane, 2006). Commercialisation can also be on a micro scale. Viau et al. (2009) report a single household in Houaphan Province can earn up to 1 million kip by gathering bamboo shoots after accounting for their own consumption. This is not an insignificant amount for a rural household. There are, however, serious concerns regarding the sustainability of such commercialisation with many products having declined significantly or disappeared completely. In a study of three key NTFPs in Champasak Province, Foppes & Keptanh (2000) report a decline of 90% or greater over the past 10 years in all the products considered. Such overharvesting of NTFPs could well contribute to forest degradation (Wunder, 2001).

One NTFP group of particular importance is wildlife. A recent study in Ban Houey Dtern, a village close to NEPL NPA, found that wild sources provided approximately two thirds of the total meat that villagers were receiving during the time of the study (Johnson et al., 2010). The study concludes that the linkages between the food security of people living in the protected area are complex. Wild meat was shown to be an important source of dietary protein and the yet availability of these sources is prone to overharvest. In the protected area the hunting of many species is controlled and while this restricts access to this important resource, it also serves to protect stocks and to conserve important biodiversity. In addition to the issue of food security, there is also a potentially complex linkage with land use. The illegal sale of wildlife species can be an extremely profitable activity which has the potential to sustain livelihoods, at least in the short-term. A study in the Nakai Nam Theun NPA has shown that forest people are abandoning previous agricultural practices in favour of greater involvement with the illegal wildlife trade (Robichaud et al., 2009). This has had the perverse effect of allowing the forest to regenerate while seriously damaging wildlife populations.

Food Security

Overall food security has been improving in Lao PDR in recent times, moving from a rice deficit in 1996 to producing a surplus in 2006 (WFP, 2007). Between 2000 and 2005, the average per capita rice production in Bolikhamxay was 4% greater than the requirements for the province (WFP, 2007). In Lao PDR household food security is often simplified in terms of rice consumption per capita. Whilst reducing food security to simple rice intake is an insufficient metric, as it neglects many nutritional requirements, it does provide an indicator of the success of rural livelihood strategies. Households involved in other food gathering activities, such as hunting and fishing, have a better chance of meeting food requirements than those following purely agrarian livelihood strategies (WFP, 2007).

Emerging Livelihood Strategies

Over the last 50 years in particular, livelihoods in Lao PDR have been subject to a diverse set of push and pull forces, including civil war, early socialist collectivisation and subsequent market liberalisation, and modern NGO supported institutional and infrastructural development (Fujita, 2006). Consequently, there have been periods of rapid and dramatic change which have shaped the natural resources on which much of Lao PDR's rural economy is still based. At present modern livelihood strategies must adapt to rapid population growth, estimated to be 1.84% annually (WB, 2008a), government intervention in which the development of rural livelihoods has been made a national policy priority (GoL, 2010a) and the increasing integration of rural communities into the market economy (Rigg, 2006). As a result of these forces the World Bank (2008b) has identified emerging six livelihood systems:

- Fixed rotational cropping (mainly of upland rice)
- Modern rice-based agriculture in valley bottoms
- Annual monoculture cash crops
- Annual and perennial cash crops in diverse agro-forestry systems
- Industrial plantations of perennial cash crops
- Intensified production of large livestock

Impact of National Natural Resource Policies

Over the past decade government policies have had a major impact on rural livelihoods and natural resource use with a suite of laws and Prime Ministerial decrees (Table 2). In the uplands, the policy goals which have had the most dramatic impacts have included: the stabilisation of shifting agriculture, the resettlement and consolidation of remote villages, the promotion of commercial crop cultivation, the eradication of poverty, the conservation of biodiversity, the regeneration of degraded forest areas and the eradication of opium (GoL, 2004a; Thomas, 2005; GoL, 2005; GoL, 2006; WFP, 2007; Fujita & Pengosopha, 2008; SWGUP, 2008; WB, 2008b; Lestrelin, 2009; WFP, 2009; GoL, 2010a). These policies have been set in the context of the decentralisation of natural resource management mandating the policy planning and implementation roles from the national level, through provinces and districts, down to the village level (GoL, 2000a). Given the wide-reaching nature of many of these policies, the potential for conflict has been considerable, not least because a lack of institutional capacity at the local level has often resulted in to poor coordination of policy implementation (Thomas, 2005, Fujita & Pengosopha, 2008; WB, 2008b; GoL, 2010a).

Table 2: Key national legislation affecting rural livelihoods, land practices and natural resource use. Updated versions are given.

Policy	Date
Establishment of NPAs Decree No. 164/PM	1993
Law on Agriculture No. 01-98/NA	1998
Law on Environmental Protection No. 02-99/NA	1999
Decentralisation Instruction No. 01/PM	2000
Land Law No. 04/NA	2003
Forestry Law No. 06/NA	2007
Wildlife and Aquatic Law No. 07/NA	2007
State Land Lease or Concession Decree No. 135/PM	2009

Stabilisation of Shifting Agriculture
The stabilisation of shifting agriculture has been a major policy goal of the Government of Lao PDR (GoL) over the last decade and has been encapsulated in many of the policy strategies issued during this period, including the 5^{th}, 6^{th} and 7^{th} National Socio-Economic Development Plan (NSEDP; GoL, 2000b; GoL, 2006; GoL, 2010a), the National Growth and Poverty Eradication Plan (NGPES; GoL, 2004a), the National Biodiversity Strategy to 2020 and Action Plan to 2010 (NBSAP; GoL, 2004b) and the Forest Strategy for the year 2020 (GoL, 2005).

The principal policy intervention which has been used towards this goal has been the implementation of the Land Use Planning and Land Allocation (LUPLA) programme. The aim of this programme has been to implement land use planning in all villages to designate specific areas within the village boundary to varying degrees of use or protection, with responsibility for implementation mandated to District Agriculture and Forestry Offices (DAFOs). The main purpose of the designation of agricultural land in this way, particularly limiting the land available for upland cultivation, is to reduce shifting cultivation fallow periods thus making such practices no longer viable (Lestrelin, 2009). Government statistics show that implementation of this programme had been undertaken in 7,130 villages by 2005, with approximately 60% of households allocated land (GoL, 2005).

This programme has, however, had numerous criticisms aimed at it, regarding both the process and the impact of implementation, which are summarised below (ADB, 2001; Ducoutieux et al., 2005; GoL, 2005; ADB, 2006b; Barney, 2007; Fujita & Pengosopha, 2008; SWGUP, 2008; WB, 2008b; GoL, 2009; Lestrelin, 2009):

- Insufficient training or support given to implementing district staff
- Not completed in all villages due to lack of funds
- Inadequate participatory approaches utilised
- Poor monitoring or extension of agricultural services to villagers
- Lack of systematic record keeping
- Insufficient agricultural land designated resulting in land shortages
- Poor consideration given to population growth trends resulting in land shortages
- Poor coordination with resettlement and village consolidation programme resulting in land shortages and increased conflict between villages
- Allocation of family land undertaken in a small proportion of villages
- Villagers did not receive permanent land title in rural areas
- Flexibility removed from traditional land practices
- Direct cause of environmental degradation due to reduced fallow periods following land shortages
- Direct cause of rural poverty
- Land used previously used for fallow appropriated by commercial plantations with no compensation given to villagers
- Promoted single technical agricultural solutions leading to less sustainable land use
- Increased rural inequality and discrimination against particular ethnic groups

Many of these concerns have been recognised and addressed in a new Participatory Land Use Planning (PLUP) manual (GoL, 2009), although it remains unclear how this will be implemented. Despite the criticisms, however, it is likely that the implementation of the LUPLA programme has reduced the impact of household land practices and may lead to the regeneration of previously degraded land. Department of Forestry (DoF) figures give a decrease from 249,000 ha used for shifting cultivation in 1990 to 93,900 ha and 29,400 ha in 2001 and 2005 respectively (GoL, 2005). Consequently, even though degradation of the land in cultivation has been increased by this programme, a positive overall impact on forest cover is a credible outcome, although this neglects other negative impacts on rural livelihoods and the sustainability of land use practices.

Resettlement and Village Consolidation

The resettlement of villages or consolidation, the combination of households from different villages, is a component of the Focal Site Strategy, first implemented through the Rural Development Programme in 1994, which began in 1998 (Thomas, 2005). The main justifications given for resettlement, or consolidation, are the eradication of opium, increased service delivery, cultural integration, security concerns and the eradication of shifting cultivation (Baird & Shoemaker, 2007), and as such it links into many policy instruments affecting livelihoods and land practices in the uplands. The principal aim of the Focal Site Strategy is to create development centres to provide rural communities better access to health, education and agricultural extension services, as well as increased access to markets. In practice, due mainly to insufficient support or capacity at the implementing level, upland villages from remote areas have simply been relocated to roads, river valleys and other accessible areas (Lestrelin, 2009).

As with the LUPLA programme, resettlements have been the subject of severe criticism, again with respect to both the implementation and impact that it can have on rural people's livelihoods. These have largely focussed on the involuntary nature of many resettlements (Vandergeest, 2003; Baird & Shoemaker, 2007) and increased inequities in land distribution between different ethnic groups (SWGUP, 2008; Lestrelin, 2009), as well as the socio-economic and environmental impacts of artificially increasing population densities (Schlemmer, 2002; ADB, 2001; ADB, 2006b; WFP, 2007; SWGUP, 2008). Despite these criticisms, resettlements have often improved standards of living, particularly in areas with abundant land resources (Lestrelin, 2009). Similarly to the LUPLA programme many areas of upland forest will have benefited from the removal of anthropogenic degradation, whilst other specific areas have suffered from increased degradation as a result of increased population densities, poor understanding of lowland land practices and overexploitation of NTFPs (SWGUP, 2008).

Eradication of Opium

The eradication of opium became a government policy priority in the 1990s (Thomas, 2005), with the 5^{th} 5 year NSEDP targeting the complete elimination of production by 2005 (GoL, 2000b). This policy has been highly successful with opium poppy cultivation falling dramatically since its inception. Since monitoring began in 1992 the area estimated to be under opium poppy cultivation has fallen from a peak of 26,837 ha in 1998 to a stable level of approximately 2000 ha from 2005 to the present (UNODC, 2009). Current production levels are estimated to be 1.1 ha per 25 km^2 (UNODC, 2009). Consequently, it is highly unlikely that opium production in itself is a cause of significant forest degradation or deforestation.

Reduction in production has, however, removed a profitable livelihood option for upland households and a number of former opium producing villages now require emergency food assistance (WFP, 2007). Similarly, resettlement efforts as a means of eliminating production have in some cases resulted in high levels of drug addiction (ADB, 2006b). As with other policies, opium eradication is likely to have affected different ethnic groups to varying degrees. It is also conceivable that the adoption of less productive upland crops could have increased pressure on upland forests. One example of this comes from the northern province of Luang Namtha where Cohen (2009) suggests that households seeking an alternative cash crop are helping to fuel the rubber boom which is devastating natural forests.

Forest and Biodiversity Policies

The forest policy for Lao PDR is spelt out in the Forest Strategy for the Year 2020 (GoL, 2005). This policy strategy sets out the government goals for all sectors relating to forests, including production forests, NTFPs, plantation forests, logging plans, wood processing, protection forests, biodiversity conservation and rural poverty eradication. Much of the legal basis for the strategy comes from the Forest law (GoL, 2007).

One of the most significant policy goals included in the Forest Strategy is the target for the restoration of forest cover in Lao PDR to 70% by the year 2020, identifying the need for natural regeneration of 6 million ha and 500,000 ha of assisted regeneration of temporarily unstocked forests[3]. This has been reiterated in many policies subsequently, most recently in the 7th 5 year NSEDP which targets 65% forest cover by the year 2015 (GoL, 2010a). In making the restoration of degraded forests a priority this ambitious policy goal, coupled with the land management policies discussed above and the aggressive promotion of foreign direct investment (FDI), has, however, opened the door for foreign companies to be granted land concessions on land which, although previously used for shifting agriculture by local villagers, has been designated as regeneration forest[4] through the LUPLA programme (Barney, 2007). Given that much of this land would previously have had a long fallow period, this often represents an overall loss of forest cover. This issue stems from the contradictory nature of national policies which seek to base rapid economic growth on the country's natural resources whilst protecting those same resources for future generations (Hanssen, 2007).

Forest designations are one of the primary instruments for the management of forest resources at all levels of administration from the Ministry of Agriculture and Forestry (MAF) through the Provincial Agriculture and Forestry Office (PAFO) and DAFO to village management committees. These are summarised in Table 3.

Currently, NPAs cover 3.4 million ha, or 14.3% of the country's total land area, with additional areas designated by provinces and districts to bring the overall total to 5.3 million ha, or 22.6% of the country's total land area (GoL, 2005). These conservation areas are zoned into areas of total protection and controlled use, in which harvesting of resources is restricted (GoL, 2007). In addition to the restriction imposed on the livelihood activities of households living in and around conservation areas resettlement of villages is used to reduce pressure on the resources protected within (Baird & Shoemaker, 2005).

[3] Unstocked forests are defined as previously forested areas in which the crown density has been reduced to less than 20% because of logging, shifting cultivation or other heavy disturbance. If the area is left to grow undisturbed it becomes forest again (Fidlóczky, 2003).

[4] Regeneration forests are defined as forest areas in a degraded condition that have been designated for regeneration such as young secondary forest regenerating from old fallow forest to become natural forest again (GoL, 2007).

Table 3: Forest designations in Lao PDR (GoL, 2007).

Designation	Purpose
Conservation Forest	conserving nature, preserving plant and animal species, forest ecosystems and other valuable sites of natural, historical, cultural, tourism, environmental, educational [importance]
Protection Forest	protecting water resources, river banks, road sides, soil quality, preventing soil erosion, strategic areas for national defence
Production Forest	areas for production, and wood and forest product businesses to satisfy the requirements of national socio-economic development and people's living

Decentralisation

All of the government policies and programmes presented above have been implemented in the context of decentralisation of power to the provincial, district and village levels. Many of these policies emphasise the role that the districts in particular are mandated to play in the implementation planning of central government policy by the Decentralisation Instruction 01/PM (GoL, 2000b). Thomas (2005) highlights a lack of institutional capacity as a major factor at the local level in policy implementation failure, identifying a lack of skills, lack of institutional support and lack of motivation as key weaknesses. As discussed above, many of the criticisms that have been levelled at government policies have been related to the process used rather than finding fault with specific policy goals. This is particularly true for the LUPLA programme where a lack of understanding of the complexity of the issues surrounding upland livelihoods on the part of district staff has been identified as a major cause of the negative impacts observed for this programme (GoL, 2009).

In general, the impact of GoL policies relating to natural resource management and land use are likely to be mixed, with some areas benefiting at the expense of others. As the guiding motivation for much of these policies has been increased control of state natural resources and greater integration of the diverse ethnic peoples in the uplands the primary focus has largely been on upland areas.

Transition to Commercial Agriculture

Economic growth is one of the primary objectives for the national government, with an annual growth rate in GDP of at least 8% targeted in the latest NSEDP (GoL, 2010a). With respect to the agriculture and forestry, the 5 year NSEDP identifies the promotion of commodity production for domestic use and export as one of the chief measures to support economic development. This is consistent with government policies which have sought the increasing commercialisation of agricultural production as a measure to eradicate rural poverty. In addition, increasing investment in infrastructural development had led to strong pull forces towards commercialisation as a result of increasing access to markets (WB, 2008b).

The vast majority of commercial crop production is done on the basis of contract farming agreements between companies and household farmers or villages, with some investment in industrial concessions (SWGUP, 2008). Contract farming is conducted largely on the basis of '2+3' arrangements in which farmers provide land and labour and companies provide agricultural inputs, technical expertise and marketing (WB, 2008b). These contracts are often brokered by technical staff from local DAFOs. Most contracts specify a minimum price at which companies will purchase commercial crops from farmers, regardless of the market value, and, as a means of protecting the traders' investments, will also specify a system of fines if farmers break the terms of the contract and sell their produce to other traders at a higher price. Two of the most significant contractual issues arising from these arrangements are farmers reneging on the contract and selling their produce at a better price to another buyer or traders refusing to buy at the agreed price, often when the market price drops due to over-supply (Johnson, 2005).

Of the six emerging livelihood systems identified by the World Bank (2008b), the two which most relate to the livelihood strategies followed by rural upland households have been strongly influenced by the increasing commercialisation of agricultural production: fixed rotational cropping and annual cash crop production in monocultures. In the first of these, annual cash crops, such as maize, have been added into rotations fixed through implementation of the LUPLA programme. In this instance they have replaced a proportion of the area in cultivation which would previously have been used for upland rice (Fitriana, 2008; Viau et al., 2009). The second system of annual cultivation of cash crop monocultures has emerged as a direct result of commercialisation and the creation of new market opportunities. In this case rotations have been abandoned for increased short-term gain with largely negative environmental impacts (WB, 2008b; Viau et al., 2009).

The rapid commercialisation of agriculture seen over the last decade has had a mixed impact on livelihoods and the environment. Social concerns include increased vulnerability to shocks such as market volatility and environmental fluctuations, higher vulnerability of farmers to exploitation due to lack of familiarity with contractual obligations and poor awareness of market mechanisms, increased conflicts over land, greater inequality between higher and lower earning families with asset poor households restricted to wage labour, higher levels of household debt, increased opportunities for corruption and greater long-term economic risk due to environmental degradation (Fullbrook, 2007; SWGUP, 2008; WB, 2008b; Viau et al., 2009; WFP, 2009). Environmental concerns include increasing surface water runoff, soil erosion, and soil nutrient loss, increased use of chemical pesticides and fertilisers, reduced fallow periods, encroachment of agricultural areas into protected forests thereby reducing forest cover and increasing forest fragmentation (SWGUP, 2008; WB, 2008b). The growth in commercial crops has, however, been accompanied by an increase in rural income and has contributed to the reduction in area of land used for shifting cultivation (WB, 2008b).

National Deforestation Studies

There is scant data available on the change in forest cover at a national scale. Table 4 summarises the rates of forest cover change given in the available studies. The most comprehensive dataset available comes from the Forest Inventory and Planning Division (FIPD) national land cover classifications from 1982, 1992 and 2002. Following the recent interest in REDD, there has been an increase in the number of quantified forest cover change studies, with three studies from different regions of Lao PDR published in 2010. Whilst other studies exist, a lack of consistent methods or application of forest definitions make comparison difficult (GoL, 2010a).

Although it is difficult to build up a complete picture of forest cover change, given the paucity of data, it is possible to make some general conclusions. In general there was an increase in the rate of forest loss comparing the change seen in the 1980s and the 1990s; an effect that was particularly felt in the Northern Region of the country. In more recent times, the SUFORD study shows a decline in the rate of deforestation over the second half of the last decade, although this could be interpreted as a result of specific management interventions conducted within the Production Forest Area (PFA). SUFORD have also found similar results in Bolikhamxay Province although the results are currently unpublished (Clarke, pers. comm.). This temporal variation, in which deforestation rates have been shown to increase and subsequently decline over the past thirty years, may well serve to confound the predictions of future land cover change necessary under the business as usual (BAU) scenario.

Table 4: Deforestation rates from existing forest cover (>20% canopy cover) change studies.

Location	**Time Period**	**Rate [%/yr]**	**Scale**	**Source**
Lao PDR	1982 - 1992	-0.20 %	national	Fidlóczky (2003)
Lao PDR	1992 - 2002	-0.57 %	national	Fidlóczky (2003)
Northern Region	1982 - 1992	-0.20 %	regional	Fidlóczky (2003)
Northern Region	1992 - 2002	-0.84 %	regional	Fidlóczky (2003)
Central Region	1982 - 1992	-0.26 %	regional	Fidlóczky (2003)
Central Region	1992 - 2002	-0.57 %	regional	Fidlóczky (2003)
Southern Region	1982 - 1992	-0.12 %	regional	Fidlóczky (2003)
Southern Region	1992 - 2002	-0.19 %	regional	Fidlóczky (2003)
Santhong District (Central Region)	2000 - 2006	-0.85 %	district	Mekong Maps (2010)
Bachiangchaleunsouk District (South Region)	2000 - 2006	-1.98 %	district	Mekong Maps (2010)
Dongsithouan PFA	1989 - 2006	-0.53 %	PFA	SUFORD (2010)
Dongsithouan PFA	2006 - 2009	-0.20 %[5]	PFA	SUFORD (2010)

It is also possible to discern spatial variation in the deforestation rates found by the various studies. The strongest evidence for this comes from the FIPD data which shows a clear difference in the rate for the different regions considered, particularly for the latter time period 1992-2002. This is supported by the findings of the Mekong Maps and SUFORD studies which show varying rates for the specific areas considered, although caution should be applied when interpreting these results as each study utilised different classification methods and analysed different time periods. This conclusion is unsurprising given the regional variation in physical factors, such as soil type and elevation, and socio-economic factors, particularly market forces from neighbouring states and ethno-demographic distribution. It does, however, have implications for the development of sub-national REDD projects as it indicates the importance of considering the specific context and land use history in which individual projects are due to operate.

[5] Following support for management of the PFA by the SUFORD project.

3.2. Participatory Threat Assessment

The second component of the driver analysis which was undertaken for the project area was a participatory threat assessment conducted at a provincial level meeting in Bolikhamxay. Participants, from various sectors under the Provincial Government, were asked to draw up a list of the principal drivers of deforestation and forest degradation within the designated project area. Once they had identified the principal drivers they were asked to predict for which of these drivers the impact on forest cover would change over the next five years. Finally, they were asked to rank the drivers in terms of expected impact to forest cover over the next five years. Table 5 gives the results of this discussion.

This shows that the three drivers expected to have the most significant impact on forest cover in the next five years are all government driven: hydroelectric power development, new mines and further infrastructure development. The two drivers ranked fourth and fifth in impact both relate to the expansion of agriculture either at the household scale through encroachment of areas outside of designated village agriculture zones or through government sponsored schemes to promote expansion of lowland rice production. All of these drivers are expected to increase in impact over the next five years.

These results indicate that, unlike in some more remote areas of the rural uplands where household activities are the major driver of forest declines, the drivers with the greatest impact are government supported. One driver that wasn't included in the ranking was commercial plantations. This is slightly surprising given the number of plantations that have been planted along Route 13, the main highway between Vientiane and the south of the country.

Table 5: The results of the participatory threat assessment conducted as part of a Provincial level workshop to discuss the feasibility of carbon financing in Bolikhamxay.

Driver	Scale	Change	Rank	Reason
Swidden agriculture	household	-	7	
Overharvesting of NTFPs	household	-		
Bush fire (anthropogenic)	household	-		
Government supported agricultural expansion	household	increasing	5	irrigation scheme planned for the Nam Soun
Encroachment	household	increasing	4	Population growth
Labour opportunities	household	-		
Illegal logging	household	-		
Infrastructure development	landscape	increasing	3	
Road construction	landscape	increasing	6	
Hydropower development	landscape	increasing	1	Nam Theun 1 hydro development to proceed
Mines	landscape	increasing	2	new mining contracts signed in Paksoun area
Plantations	landscape	increasing		
Bush fire	landscape	-		
Natural disaster (eg storm)	landscape	-		
Urban expansion	landscape	-		

The participants of the meeting were also asked to discuss potential reasons for changing rates of deforestation between 2000 and 2010. The overwhelming suggestion for a change over this period was the initiation of the IEWMP in 2005. In addition to this, as many outreach activities are conducted in villages located up to 55 km from the Nam Kading NPA boundary it is possible that the initiation of the IEWMP has had an impact in the wider landscape. Further discussion also highlighted a number of policy changes which were felt to have contributed to a reduction in forest loss, not just within Nam Kading NPA but also within the wider landscape (Table 6).

Table 6: National policies identified as contributing to the reduction in deforestation rate observed within the project area between 2000/1-2005/6 and 2005/6-2009/10.

Law/Decree	**Date**
Land Law	2003
Land Decree	2005
Environment Fund Decree	2005
Forest Fund Decree	2005
Forestry Law	2005

3.3. Driver Proxy Analysis

The PTA identified uncontrolled fires, either natural or as a result of fire setting for hunting or clearance for agriculture, as one of the major causes of forest loss prior to the commencement of the IEWMP in late 2005. Identifying potential trends in fire usage can therefore be a useful tool in understanding how land use practices have changed over time and in interpreting the results of land cover change analyses. This is made possible by analysing MODIS Data Processing System (MODAPS) collection 5 hotspot data which is a geo-referenced database of thermal anomalies detected by the Moderate Resolution Imaging Spectroradiometer (MODIS) sensor onboard NASA's Aqua and Terra satellites (Justice et al., 2002). This data was supplied through the Fire Information for Resource management Systems (FIRMS; Davies et al., 2009) website. Table 7 gives the number of fires per month recorded in the MODAPS dataset between November 2000 and December 2009 for the wider landscape (excluding NK NPA) and for Nam Kading.

Table 7: Monthly fire incidence between Nov 2000 and Dec 2009 for the wider landscape and NK NPA (Davies et al., 2009).

	Landscape	**NK NPA**	**NK Core Zone**
Nov 2000 – Jan 2006	34.78	3.00	1.24
Feb 2006 – Dec 2009	45.79	3.23	1.00
Ratio	**1 : 1.32**	**1 : 1.08**	**1 : 0.81**

Although the incidence of fires increases for both analysis areas after 2005, the rate of increase is significantly lower for NK NPA, and in the core zone (110,455 ha), the area in which enforcement is at its highest, the trend is reversed and there is a reduction in fire incidence. This suggests that the IEWMP has been successful in reducing one of the principal drivers of forest loss, particularly in the core zone which contained 74% of the total intact forest in NK NPA in 2005/6.

As human populations in the study area grow it can be expected that the impacts of household activities will also increase. Indeed, population growth was identified in the PTA as one of the main underlying forces affecting household land clearance. As such, population statistics are a useful proxy for household deforestation drivers. Table 8 shows the aggregate population statistics of the 2000 and 2005 censuses for all villages within the 5 km project area buffer (NSC, 2005).

Table 8: Population statistics for villages within the study area for 2000 and 2005 (NSC, 2005).

Statistic	2000	per / km^2	2005	per / km^2	% Change
Total Population	18,825	5.24	25,148	7.00	33.6 %
No. of Households	3,343	0.93	4,072	1.13	21.8 %

The population density for the project area is low at just 7.0 individuals per square kilometre. This is comparable with Viengthong District (5.1 km^{-2} in 2005) but significantly lower than the remaining districts in Bolikhamxay (Table 9). The percentage population increase for the project area over the five year period considered is, however, significant, both in terms of absolute population and number of households. Comparison with the districts in which the project area is located show that the rate is population growth within the project area was higher during this period than in other parts of the districts. If this trend continues then pressure on forest resources due to population growth may be expected to increase more within the project area than the wider landscape. It is not clear, however, the extent to which this trend is due to natural growth or migration.

Table 9: District populations for 2000 and 2005 (NSC, 2005).

District	2000	per / km^2	2005	per / km^2	% Change
Bolikhan	28,316	9.7	34,152	11.7	20.6
Khamkeut	50,093	11.5	64,555	14.9	28.9
Pakkading	34,784	14.4	40,625	16.9	16.8
Viengthong	18,968	4.3	22,455	5.1	18.4

4. Land Cover Change Analysis

4.1. Land Cover Classification

A land cover mapping exercise was conducted for an area encompassing 840,950 ha over a nine year period and three dry seasons over the last ten years: 2000/2001, 2005/2006, 2009/2010. Classification was done through manual interpretation[6] of Landsat 7 ETM+ (pre 2003) and Landsat 5 TM satellite imagery (refer to Table 10 for list of imagery used). For the purposes of this feasibility study three different land cover classes have been adopted: Non-Forest (canopy cover < 10%), Potential Forest (canopy cover 10-20%) and Current Forest (canopy cover > 20%). These classes are compatible with the basic forest categories used by FIPD in the land cover classifications undertaken for the whole of Lao PDR in 1982, 1992 and 2002. As such, the

[6] Onscreen visual scene to scene interpretation of land cover classes, recognised by the GOFC-GOLD REDD Source-Book 2.0 as being a time-consuming but simple and robust method for classification of forest types (GOFC-GOLD, 2009).

FIPD classifications are the most up-to-date and have the widest temporal coverage of all land cover datasets for Lao PDR[7]. A single operator was responsible for all interpretation of imagery. This involved visually differentiating between the different classes and creating digital polygons to define areas belonging to each class.

Table 10: Details of the satellite imagery used for the land cover mapping.

Dry Season	Sensor	Date	Bands	Scene	Resolution	Use
2000/1	Landsat 7 ETM+	Nov 2000	RGB: 5,4,3	127/47	30m pixels	Classification
2005/6	Landsat 5 TM	Feb 2006	RGB: 5,4,3	127/47	30m pixels	Classification
2009/10	Landsat 5 TM	Oct 2009	RGB: 5,4,3	127/47	30m pixels	Classification
	Landsat 5 TM	Dec 2009	RGB: 5,4,3	127/47	30m pixels	Classification
	ALOS PRISM	Apr 2009	-	125/3230	2.5m pixels	Accuracy Ass.
	ALOS PRISM	Apr 2009	-	125/3235	2.5m pixels	Accuracy Ass.

The accuracy of the classification for 2009/10 was assessed with the use of very high resolution (VHR) satellite imagery (Table 10). A random sample of 200 points was generated with at least 50 points of the least common land cover class. Each point was independently interpreted visually and this interpretation was compared with the classification to form a confusion matrix (Table 11). Unfortunately, none of the VHR imagery available for 2005/6 was within the project budget which meant that it was not possible to conduct an accuracy assessment for this time period. As the imagery used for 2005/6 was taken in February, later in the dry season than the imagery for the other two years analysed, some doubts were raised with regard to the consistency of the interpretation. Consequently, areas that were interpreted to have changed within the project area were compared to the interpretation of Landsat 5 TM images from Nov/Dec 2006. These images were taken during the early part of the dry season and thus corresponded to the imagery used for the 2000/1 and 2009/10 interpretations. As such it was possible to check for seasonal effects owing to the imagery being taken during different times of the dry season. This was especially useful to check the accuracy of the interpretation of areas considered to have been deforested during the time period 2000/1 – 2005/6. It was found that less than 5% (by area) of the classification for 2005/6 was affected by seasonal changes in spectral signature which is considered to be within acceptable limits.

Overall, producer and user accuracies, in addition to the kappa statistic ($\hat{\kappa}$), were calculated following Equations (1-4) (Congalton & Green, 2009). The results of this assessment are shown in Table 12. The resulting accuracies show that the classification for 2009/10 reached a level of accuracy for the forest class which was considered acceptable for the feasibility assessment but performed poorly with respect to potential and non-forest areas. Closer examination of the errors reveals that it is difficult to differentiate between these two classes. This is not surprising since there will always be an error range when applying distinct canopy cover boundaries to medium resolution remote sensed imagery. This is an issue which has been particularly highlighted for Lao PDR where the forest is often highly heterogeneous (Mekong Maps, 2010). In an effort to improve the overall accuracy, the Potential and Non-Forest classes were lumped together into a single Non-Forest class and new accuracy statistics derived (Table 13).

[7] FIPD are currently in the process of updating the land cover classification and are expecting to publish this towards the end of 2010.

Table 11: Mathematical example of confusion matrix for the two land cover classes included in the accuracy assessment.

Ground Truth Data

		Forest	Non-Forest	n_{i+}
Interpretation Data	Forest	n_{11}	n_{12}	$n_{1+} = \sum_{j=1}^{2} n_{1j}$
	Non-Forest	n_{21}	n_{22}	$n_{2+} = \sum_{j=1}^{2} n_{2j}$
	n_{+j}	$n_{+1} = \sum_{i=1}^{2} n_{i1}$	$n_{+2} = \sum_{i=1}^{2} n_{i2}$	n

Equations 1-4: Accuracy statistics.

$$\text{overall accuracy} = \frac{\sum_{i=1}^{k} n_{ii}}{n} \quad (1)$$

$$\text{producer accuracy} = \frac{n_{jj}}{n_{+j}} \quad (2)$$

$$\text{user accuracy} = \frac{n_{ii}}{n_{i+}} \quad (3)$$

$$\widehat{\kappa} = \frac{n\sum_{i=1}^{k} n_{ii} - \sum_{i=1}^{k} n_{i+}n_{+i}}{n^2 \sum_{i=1}^{k} n_{i+}n_{+i}} \quad (4)$$

Table 12: Accuracy statistics for the land cover mapping of the 2009/10 dry season.

Accuracy	2009/10
Overall accuracy	0.65
Producer accuracy (F)	0.70
Producer accuracy (PF)	0.52
Producer accuracy (NF)	0.72
User accuracy (F)	0.85
User accuracy (PF)	0.54
User accuracy (NF)	0.50
Kappa statistic	0.46

Table 13: Accuracy statistics for the land cover mapping of the 2009/10 dry season with Non-Forest and Potential Forest consolidated into a single class.

Accuracy	2009/10
Overall accuracy	0.81
Producer accuracy (F)	0.70
Producer accuracy (PF+ NF)	0.90
User accuracy (F)	0.85
User accuracy (PF+NF)	0.78
Kappa statistic	0.60

This vastly improved the overall accuracy, attaining a level acceptable under the provisional Modular REDD Methodology under development by the Avoided Deforestation Partnership (ADP; ADP, 2010), as well as improving the producer and user accuracies of the lumped class. The minimum accuracy achieved of 70% is lower than the level accepted under the ADP methodology but was considered to be acceptable at this stage of project development.

4.2. Land Cover Change

The land cover change was calculated for the whole landscape and four overlapping subsets of the area, including the potential REDD project area agreed with provincial officials (defined as a 5km buffer around the NK NPA and THXP management units), NK NPA, THXP PA and PCV PPA.

Comparison of the land cover classifications for 2000/1, 2005/6 and 2009/10 showed that for the wider AoI considered in the analysis the total area of Current Forest decreased by 1,489 ha (0.2% of the total area) between 2000/1 and 2005/6 and decreased by a further 271 ha (0.1% of the total area) between 2005/6 and 2009/10. Table 14 gives the area of the different land cover classes for the five management units considered, whilst Figures 2, 3 and 4 show the results for the land cover comparison for the time periods 2000/1 – 2005/6, 2005/6 – 2009/10 and 2000/1 – 2009/10 respectively. The area analysed may differ from the stated areas in Section 1 due to clouds obscuring portions of the satellite images used.

These results appear to show very little net change in forest cover for any of the areas analysed. On closer inspection, however, it is clear that the true picture is of relatively rapid change due to almost equal rates of deforestation and forest regeneration at different locations. As such it becomes necessary to decide how to approach areas in which some form of regeneration has occurred. These can be broken into two types: degraded areas which have been allowed, or potentially encouraged, to regenerate or areas which are only temporarily cleared.

The first type can be defined as areas classified as non-forest in one time period that are then classified as forest in a subsequent time period. These represent areas that have been allowed to naturally regenerate following clearance at some unknown point time prior to 2000/1. It becomes much more difficult to understand the carbon flux in these areas since, although they are classified as Current Forest, the carbon that they store will be significantly less than areas of old growth forest until such at time as the forest attains maturity once again. Under the Voluntary carbon standard (VCS), areas must have been classified as forest for a minimum of 10 years prior to the commencement of a project in order to qualify as forest. Consequently, any area that was classified as non-forest for the 2000/1, 2005/6 or 2009/10 dry seasons is unlikely to qualify as forest for any future REDD project for which this feasibility study is applicable.

Table 14: Land cover for 2000/1, 2005/6 and 2009/10 for the five areas of analysis.

	2000/1		**2005/6**		**2009/10**	
	Area [ha]	% of total	Area [ha]	% of total	Area [ha]	% of total
Landscape						
Current Forest	426,868	51.1 %	425,379	50.9 %	425,108	50.8 %
Non-Forest	409,177	48.9 %	410,666	49.1 %	410,938	49.2 %
Project Area						
Current Forest	197,631	55.0 %	194,050	54.0 %	195,414	54.4 %
Non-Forest	161,815	45.0 %	165,396	46.0 %	164,032	45.6 %
NK NPA						
Current Forest	130,464	80.2 %	129,622	79.7 %	132,087	81.2 %
Non-Forest	32,135	19.8 %	32,977	20.3 %	30,512	18.8 %
THXP						
Current Forest	9,353	21.7 %	9,616	22.3 %	9,910	23.0 %
Non-Forest	33,806	78.3 %	33,543	77.7 %	33,249	77.0 %
PCV PPA						
Current Forest	19,948	82.6 %	18,950	78.5 %	18,888	78.2 %
Non-Forest	4,199	17.4 %	5,197	21.5 %	5,259	21.8 %

A further complication applies to those areas which are temporarily clearcut and then allowed to regenerate. Currently the national definition of forest is under discussion and it is not clear at this stage how these areas will be approached. In this case, areas that are classed as non-forest for a single time period only should, for the purposes of the land cover, be considered as forest during this time period. This is particularly relevant to the Lao context due to both the rapid regeneration potential which is observed for cleared forest and to the extensive land use systems employed in highland areas. It is conceivable for an area of forest to be cleared, used for swidden agriculture, abandoned and then allowed to regenerate in a very short space of time. Whether such areas should be considered as temporarily unstocked, and therefore as forest, can have a potentially significant impact on forest cover estimates, although carbon stock estimates will be affected in the same manner as for other areas of regeneration.

The total area for each historical land cover history (ie. each unique combination of land cover classes over the three time periods analysed) can therefore be used to investigate the importance of the two regeneration types within the different areas of analysis. This is given in Table 15. For this purpose, Temporary Regeneration is defined as areas classified as Non-Forest in 2000/1, Current Forest in 2005/6 and Non-Forest in 2009/10 and Temporarily Unstocked is defined as areas classified as Current Forest in 2000/1, Non-Forest in 2005/6 and Current Forest in 2009/10. Figure 5 shows the results of the comparison of the three classifications and highlights the different areas for each land use history.

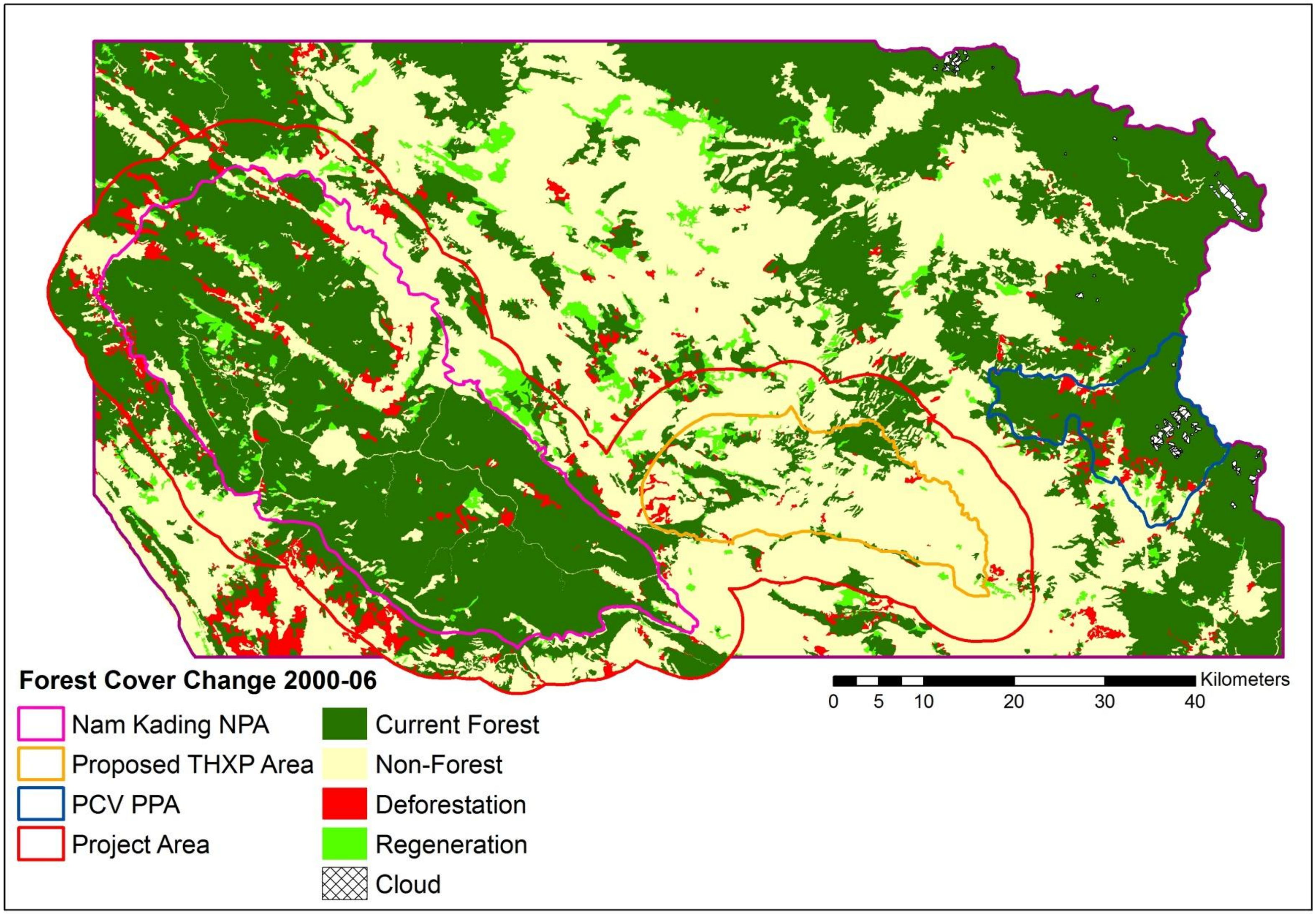

Figure 2: Comparison of land cover classes between the 2000/1 and 2005/6 dry seasons.

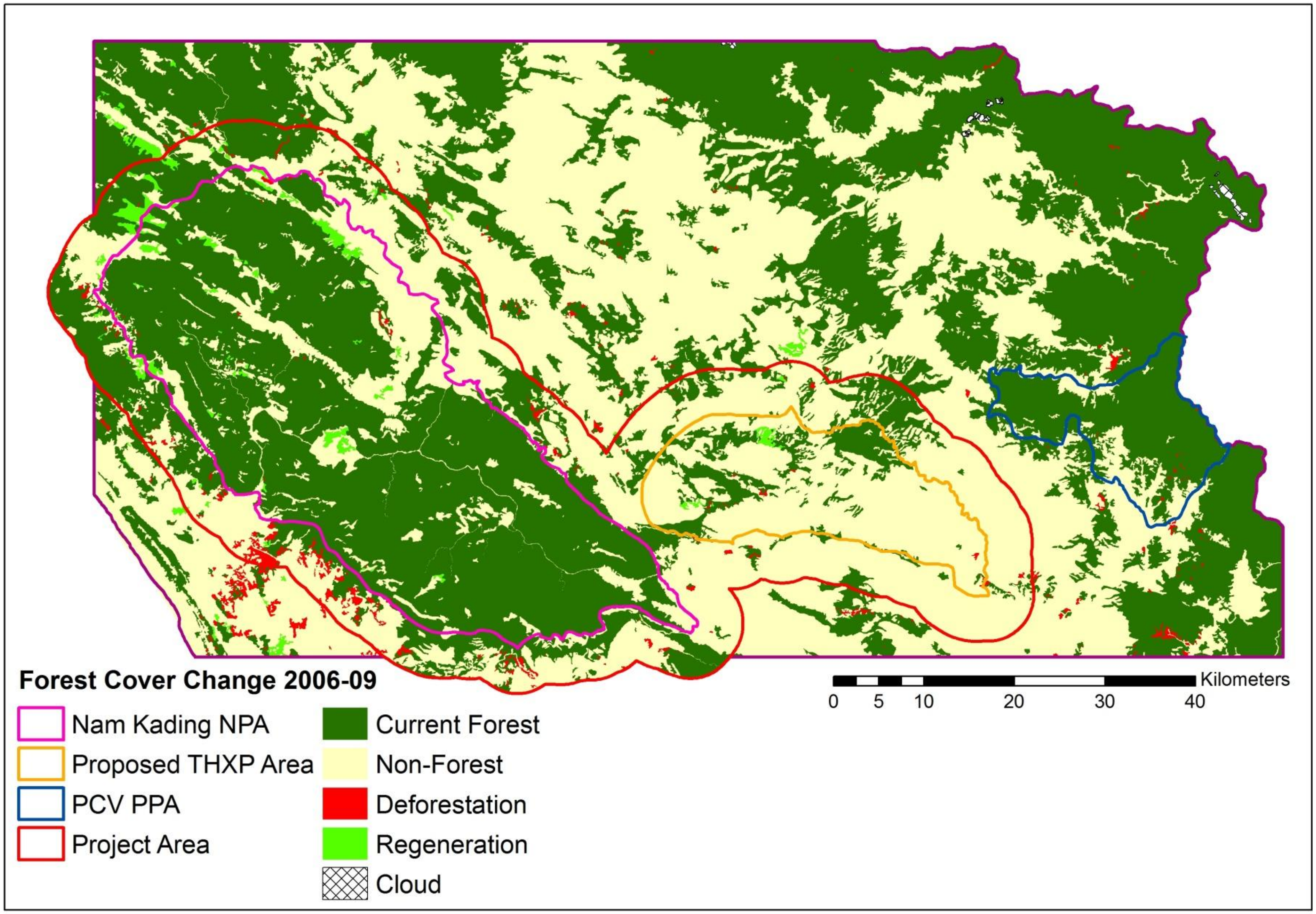

Figure 3: Comparison of land cover classes between the 2005/6 and 2009/10 dry seasons.

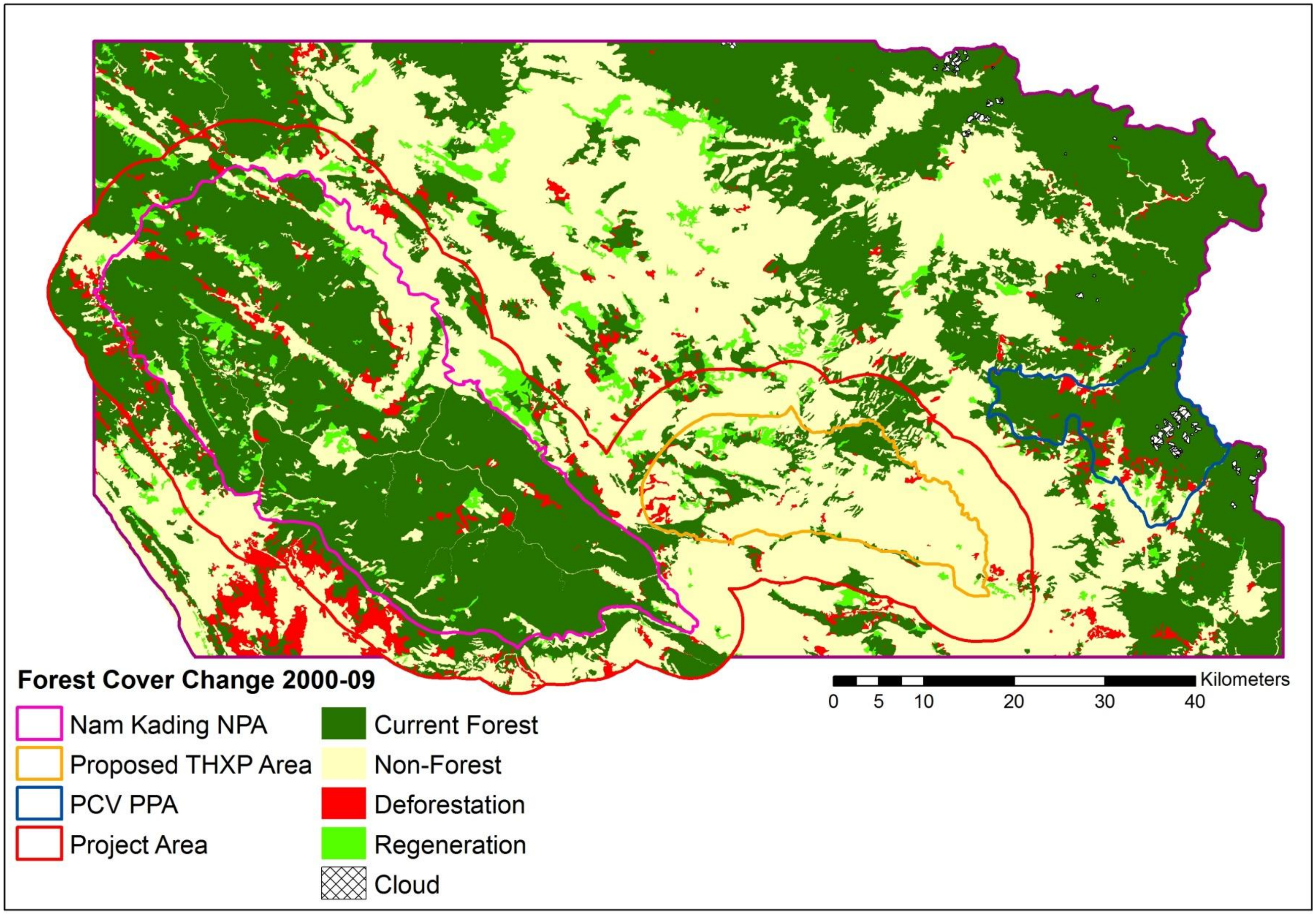

Figure 4: Comparison of land cover classes between the 2000/1 and 2009/10 dry seasons.

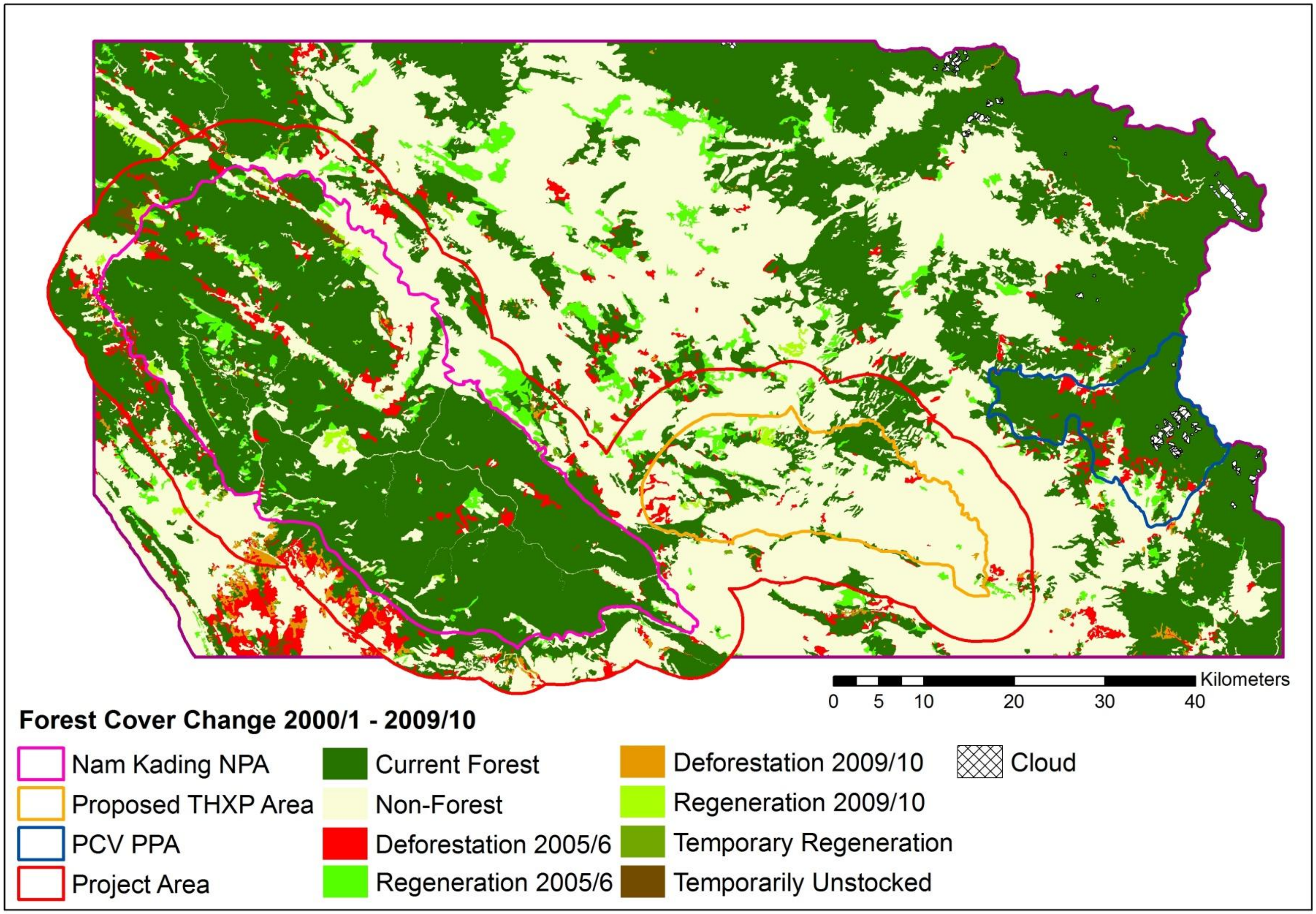

Figure 5: Comparison of land cover classes between the 2000/1 and 2009/10 dry seasons detailing the individual land use histories shown in Table 7.

Table 15: Total area for each land use history for the principal areas of analysis.

History	AoI		NK NPA		THXP		PCV PPA	
	Area [ha]	% of total	Area [ha]	% of total	Area [ha]	% of total	Area [ha]	% of total
Current Forest	392083	47.1 %	124599	77.2 %	8225	19.1%	18185	75.4%
Non-Forest	377314	45.4 %	25707	15.9 %	32074	74.3%	3486	14.4%
Deforestation 2005/6	26425	3.2 %	4550	2.8 %	1034	2.4%	1710	7.1%
Regeneration 2005/6	26324	3.2 %	4769	3.0 %	1250	2.9%	701	2.9%
Deforestation 2009/10	5474	0.7 %	193	0.1 %	93	0.2%	51	0.2%
Regeneration 2009/10	3949	0.5 %	1598	1.0 %	435	1.0%	0	0.0%
Temporary Regeneration	2752	0.3 %	1122	0.7 %	0	0.0%	2	0.0%
Temporarily Unstocked	1403	0.2 %	62	0.0 %	42	0.1%	12	0.1%

Tables 12 and 15 show that, although 8.1% of the landscape changed class at least once during the two time periods considered, deforestation and regeneration largely balanced to result in an overall change in total forest cover of only 0.3% between 2000/1 and 2009/10. This picture is mirrored for NK NPA and the THXP area for the time period 2000/1 – 2005/6, although regeneration was higher than deforestation for both areas during 2005/6 – 2009/10.

For the purposes of generating a baseline rate of carbon emissions, annual forest loss was calculated as a percentage of the total forest cover at the start of the time period in question (Table 16). These figures refer solely to areas which were classified as Current Forest in 2000/1 and exclude areas defined above as Temporarily Unstocked. This shows a significantly higher rate of deforestation during 2000/1 – 2005/6 than during 2005/6 – 2009/10 for all areas considered. The rate of deforestation calculated for the AoI between 2000/1 and 2005/6 is comparable to the values found by Thomas et al. (2010) for the two districts analysed during the same time period. As discussed in Section 3.1, the SUFORD project feasibility study in the Dong Sithouane PFA in Savannakhet also found a decrease in deforestation rates for the period 2006 - 2009, which is comparable to the period 2005/6-2009/10 used in this study. Unfortunately this also corresponds to a change in management of the PFA and may not be representative of a more general regional or national change which would be of relevance to this study.

Table 16: Annual rate of forest loss for the principal areas of analysis. Rates are calculated as a percentage of the total forest cover at the start of the time period in question.

Time Period	AoI		NK NPA		THXP		PCV PPA	
	Area [ha]	% of forest	Area [ha]	% of forest	Area [ha]	% of forest	Area [ha]	% of forest
2000/1 – 2005/6	26425	1.24 %	4550	0.70 %	1034	2.21 %	1710	1.71 %
2005/6 – 2009/10	5281	0.26 %	193	0.04 %	93	0.28 %	51	0.07 %

To calculate the rate of deforestation in the absence of any management, the result for 2005/6 - 2009/10 for the wider AoI was calculated excluding the respective result for NK NPA which reflects the situation following the commencement of the IEWMP in 2005. This resulted in a much higher annual rate of deforestation of 0.48% of the area classified as Current Forest in 2005/6, as opposed to 0.26% if the result for NK NPA was included.

The problem with these rates is that it is not known how long forest had been present for the areas which were interpreted as being deforested or regenerated. This makes it difficult to understand the effect of forest cover loss on carbon stocks given that it is clear that much of the landscape is allowed to regenerate following clearance. One solution to investigate this issue further would be to use the 1992 FIPD land cover classification to assess the status of land cover 10 years prior to the analysis. This would enable a check on whether areas which had been interpreted as being deforested, during either 2000/1 – 2005/6 or 2005/6 – 2009/10, had been classified as forest for a minimum of 10 years[8], allowing greater confidence in the eventual estimates of changes in carbon stocks. Unfortunately, the 1992 FIPD land cover map was considered to contain multiple inaccuracies for the areas of analysis, including showing large areas of NK NPA as under paddy rice cultivation. As an alternative the 1997 land cover classification carried out by the Mekong River Commission (MRC) and Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ) was used (MRC/GTZ, 1997). While this classification does not cover the entire 10 year period prior to the land cover change analysis, it was deemed to give a more reliable picture of past land use than the 1992 FIPD classification. For the purposes of comparison with the land cover mapping undertaken as part of this study, areas classified as forest or forest regrowth by the MRC were taken to be equivalent to the land cover class Current Forest[9]. Figure 6 shows the comparison of land cover classes between 1997 and 2000/1.

Table 17 shows the amended results of the land cover change analysis taking into account the status of land cover in 1997. These results should be treated with a degree of caution since they are derived using different methodologies and scale of analyses. They can, however, be considered as indicative of the scale of change during this period. The picture revealed is markedly different from the change analysis shown in Table 15. Between 1997 and 2000/1, an area of 174,965 ha (20.9% of the total area) was cleared in the AoI, of which 155,098 ha remained as Non-Forest for all other years analysed. This is a significantly higher rate than during the subsequent time periods covered by the land use change analysis. It is possible that this higher rate may be due to a difference in the accuracy with which the two classifications identify areas of forest with low density canopy. Table 18 shows the breakdown of forest loss for the different forest classes used in the MRC/GTZ classification for the period 1997-2000/1. This shows that the significant majority of areas that were cleared came from classes with lower canopy densities. Unfortunately, since the accuracy achieved for the MRC/GTZ classification is unknown it is not possible to be fully confident in the results.

In general, however, the results show a decline in the rate of deforestation for each of the time periods considered for all the areas analysed. This goes some way to explaining the decline in the rate of regeneration as this too declines for successive time periods, suggesting that the area of regeneration in any time period is correlated with the area of deforestation from previous time periods. As clearance rates drop so too does the area which is allowed to regenerate. Regeneration following the significant clearance between 1997 and 2000/1 and any clearance prior to this was, however, enough to cancel out losses to forest cover during subsequent time periods, resulting in little net change for 2000/1-2009/10.

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[8] In the absence of forest regrowth data, the length of period required is arbitrary. Further study is required to understand the rate at which different forest types achieve a state which can be considered as maturity..

[9] The definition of forest used for the MRC classification is any area with a canopy cover of greater or equal to 20%, with a minimum height of 10m. Areas of greater or equal to 20% canopy cover with a height less than 10m were classified as forest regrowth.

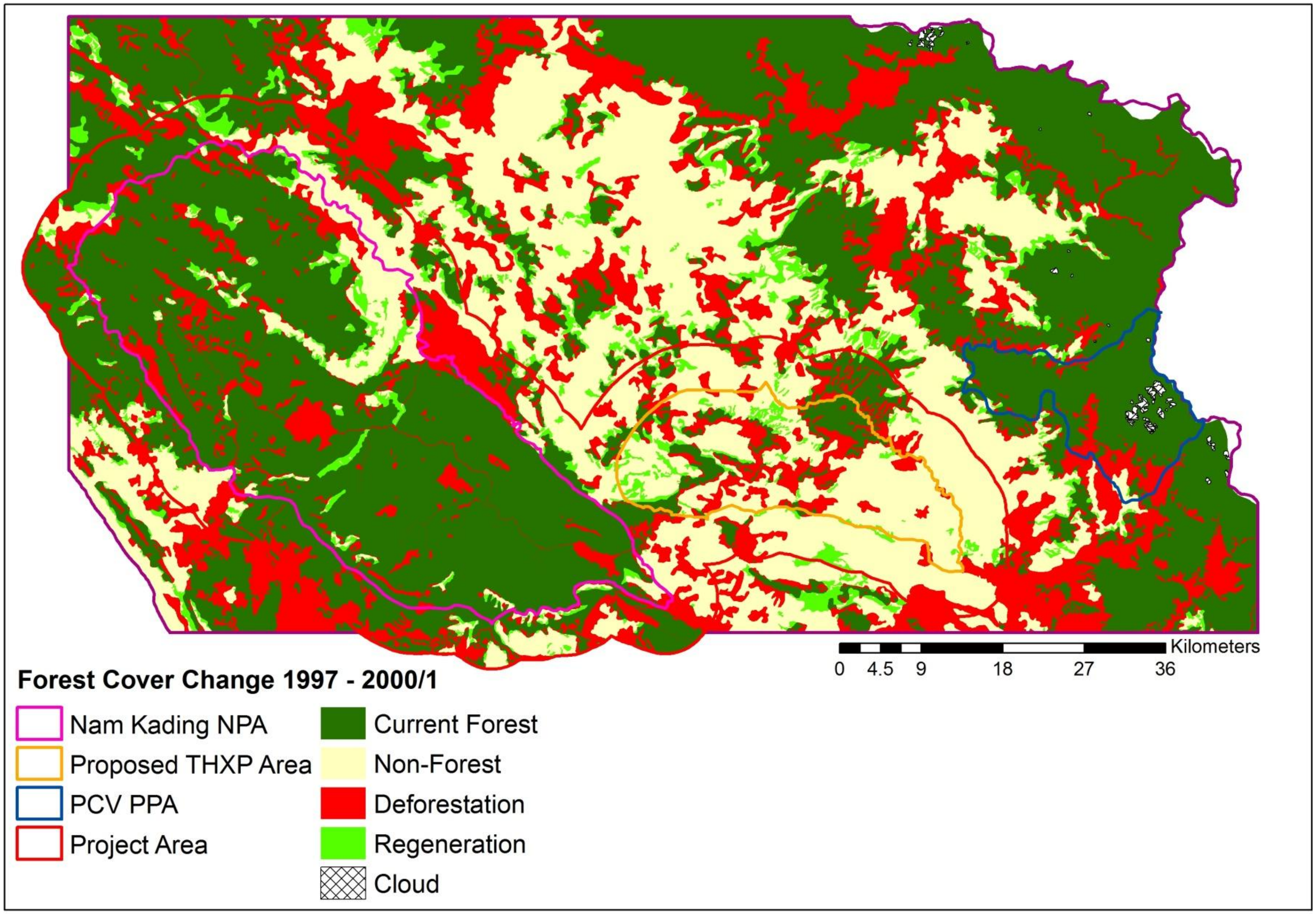

Figure 6: Comparison of land cover classes between 1997 and the 2009/10 dry season. Area analysed = 836,046 ha due to a slight difference in the Vietnamese border for the MRC dataset.

Table 17: Total area for each land use history for the principal areas of analysis between 1997 and 2009/10.

History	**AoI**		**NK NPA**		**THXP**		**PCV PPA**	
	Area [ha]	% of total	Area [ha]	% of total	Area [ha]	% of total	Area [ha]	% of total
Current Forest (F)	359711	43.0%	120287	74.0 %	5858	13.6 %	18108	74.9%
Non-Forest (N)	222352	26.6%	9377	5.8 %	23479	54.4 %	538	2.2%
Deforestation 2000/1	155098	18.6%	16329	10.0 %	8594	19.9 %	2948	12.2%
Regeneration 2000/1	32373	3.9%	4311	2.7 %	2367	5.5 %	77	0.3%
Deforestation 2005/6	20784	2.5%	3639	2.2 %	199	0.5 %	1647	6.8%
Regeneration 2005/6	10194	1.2%	871	0.5 %	687	1.6 %	52	0.2%
Deforestation 2009/10	4836	0.6%	91	0.1 %	45	0.1 %	51	0.2%
Regeneration 2009/10	1012	0.1%	113	0.1 %	368	0.9 %	22	0.1%
Temporary Regeneration 2000/1	5732	0.7%	911	0.6 %	836	1.9 %	63	0.3%
Temporarily Unstocked 2000/1	16130	1.9%	3898	2.4 %	563	1.3 %	650	2.7%
Temporary Regeneration 2005/6	654	0.1%	34	0.0 %	24	0.1 %	0	0.0%
Temporarily Unstocked 2005/6	2438	0.3%	966	0.6 %	0	0.0 %	2	0.0%
Temporary Regeneration 2000/1 – 2005/6	682	0.1%	102	0.1 %	47	0.1 %	0	0.0%
Temporarily Unstocked 2000/1 – 2005/6	2937	0.4%	1484	0.9 %	66	0.2 %	0	0.0%
FNFN	800	0.1%	28	0.0 %	24	0.1 %	12	0.1%
NFNF	314	0.0%	157	0.1 %	0	0.0 %	0	0.0%

Table 18: Forest cover loss between 1997 and 2000/1 for the classes used in the MRC/GTZ forest classification (MRC/GTZ, 1997).

Class	**Area (1997) [ha]**	**Area deforested (1997-2000/1) [ha]**	**% loss**
Evergreen, high cover density	257714	19721	7.7 %
Evergreen, medium - low cover density	151765	47106	31.0 %
Cropping mosaic, cropping area <30%	70628	58949	83.5 %
Evergreen mosaic	43992	22957	52.2 %
Mixed (evergreen & deciduous), mid-low density	18036	8162	45.3 %
Regrowth	10299	8031	78.0 %
Cropping mosaic, cropping area >30%	6055	5517	91.1 %
Mixed mosaic	4471	2982	66.7 %
Mixed (evergreen & deciduous), high cover density	1787	0	0.0 %

Table 19 shows the history of areas cleared within the AoI during the time periods 1997-2000/1 and 2000/1-2005/6. This shows that for each area cleared approximately 10% can be expected to regenerate during subsequent time periods. This suggests that if deforestation rates were to stabilise, the regeneration from previous time periods would reduce, resulting in a net loss of forest cover.

Table 19: History of areas cleared within the AoI during the time periods 1997-2000/1 and 2000/1-2005/6.

Year Cleared	Area of NF 2000/1 [ha]	Area of NF 2005/6 [ha]	Area of NF 2009/10 [ha]
2000/1	174,965	158,035	155,898
2005/6	-	23,222	20,784

Vulnerability Modelling

Following the land cover change analysis, the vulnerability of forest under different spatial conditions was modelled to identify areas at risk of deforestation. A random sample of single hectare plots was generated for areas classified as Current Forest in 2000/1 across the entire AoI. For each plot a number of different variables were considered (Table 20). A generalised linear mixed model (GLMM) was then created to estimate the effect size of each fixed effect variable on whether or not a plot would be deforested. Separate models were used for each time period.

Table 20: Variables considered for the vulnerability modelling of the driver analysis.

Variable	Data Type	Variable Type	Description
deforestation	binary	response	whether plot is deforested
npa	binary	explanatory	whether plot is located in an NPA
ppa	binary	explanatory	whether plot is located in a PPA
fire	continuous	explanatory	number of MODAPS hotspots within 5 km
elevation	categorical	explanatory	elevation in 500m categories
village_1km	continuous	explanatory	number of villages within 1 km
village_3km	continuous	explanatory	number of villages within 3 km
village_5km	continuous	explanatory	number of villages within 5 km
road_1km	binary	explanatory	whether plot is within 1 km of a major road
road_3km	binary	explanatory	whether plot is within 3 km of a major road
road_5km	binary	explanatory	whether plot is within 5 km of a major road
river_1km	binary	explanatory	whether plot is within 1 km of a major river
river_3km	binary	explanatory	whether plot is within 3 km of a major river
river_5km	binary	explanatory	whether plot is within 5 km of a major river
WS_class	categorical	explanatory	MRC watershed class (MRC, 2001)
district	categorical	random	administrative district plot is located in

The two GLMMs were fitted using backwards stepwise selection of fixed effect variables. Main effects only were considered due to data limitations. The fixed effects structures were simplified using the Akaike information criterion (AIC; Akaike, 1974). If AIC values differed by >2 models with the lowest AIC were selected. For models with a difference in AIC of <2, models with fewer degrees of freedom were selected (Burnham & Anderson, 2002). Following selection of the fixed effects, random effects were selected using likelihood ratio (LR) tests (Bolker et al., 2009). Table 21 gives the effect size estimates for the two final simplified models.

Table 21a: Effect size estimates for the 2000/1-2005/6 model. Significant results are in **bold**.

Variable	$\boldsymbol{\beta}$	**p value**
intercept	0.03908	<< **0.001**
npa	-0.01985	**0.003**
fire	0.00096	<< **0.001**
river_3km	0.06284	**0.001**
elevation 500-1000	-0.02117	**0.001**
elevation 1000-1500	-0.02621	**0.001**
elevation 1500-2000	-0.01162	0.733

Table 21b: Effect size estimates for the 2005/6-2009/10 model. Significant results are in **bold**.

Variable	$\boldsymbol{\beta}$	**p value**
intercept	0.01456	<< **0.001**
fire	0.00041	<< **0.001**
elevation 500-1000	-0.01178	**0.010**
elevation 1000-1500	-0.01342	**0.027**
elevation 1500-2000	-0.01456	0.991

The two models for the 2000/1-2005/6 and 2005/6-2009/10 time periods both identify elevation and the number of fires recorded within a 5 km radius as being significant predictors of an area's vulnerability to deforestation. The result for elevation shows that forest at an elevation higher than 500 m has a lower probability of being deforested during any given time period. This is unsurprising given the generally higher suitability of low lying land for agricultural land use. The result for the number of fires suggests that forest loss is strongly correlated with the use of fires. This has implications for the development of suitable driver monitoring suggesting that MODIS hotspots have the potential to act as an indicator of driver threat. The effect of being within the boundaries of Nam Kading NPA had a significant effect for the first time period but no effect for the second time period. It is possible that this is due to a relative reduction in the number of fires for 2005/6-2009/10 within Nam Kading which would confound the result for the 'npa' variable.

For GLMMs, the effect size estimates for the fixed effect variables take the form shown in Equation 5. Since the response variable for deforestation is a binary variable, summing the effect sizes for each fixed effect will give an estimate for the probability that a sample plot will be deforested within the given time period. As such, it is possible to use these estimates to produce a vulnerability map for forested areas over the entire landscape. For the time period 2000/1-2005/6 this was done using a fixed grid with a cell size of 1 km x 1 km which was overlaid on areas classified as Current Forest in 2000/1 (Figure 7). Since the only significant variables identified for the time period 2005/6-2009/10 were the number of MODAPS hotspots recorded within 5km of the cell centre and elevation, a vulnerability map was not produced for this time period.

$$\eta = \beta_0 + \beta_1 X_1 + \cdots + \beta_n X_n \quad (5)$$

where η is the response variable estimate, β is the effect size estimate for fixed effect variables, X is the fixed effect variable and n is the number of variables in the simplified model.

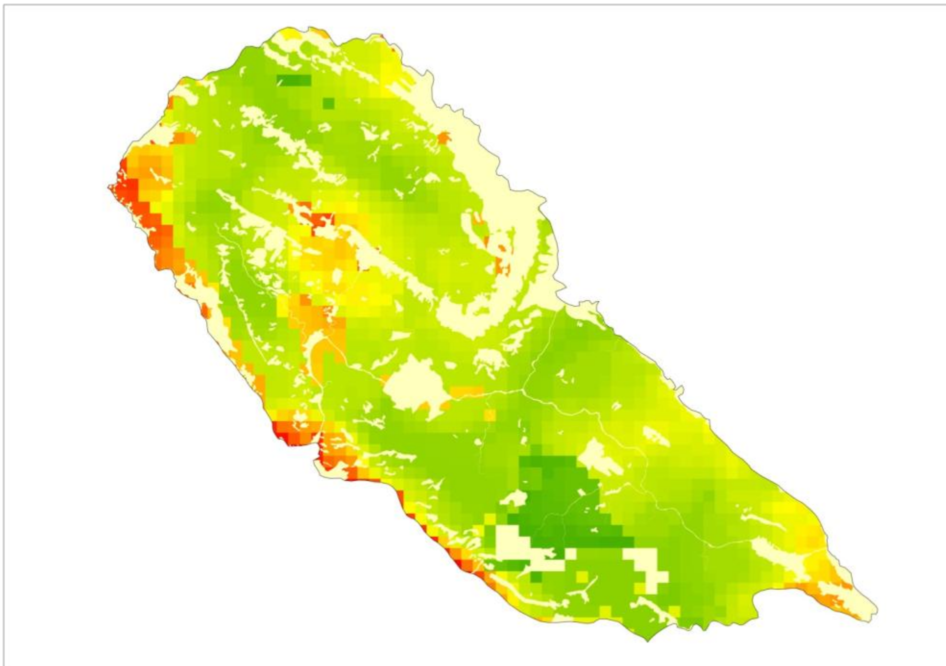

Figure 7: Forest loss vulnerability map for Nam Kading NPA during the time period 2000/1-2005/6.

The most significant result of the vulnerability modelling is to show the importance of the effect of elevation on the risk of clearance. This is supported to some extent by the fact that 3048 ha (58%) of the deforestation recorded in the AoI between 2005/6 and 2009/10 was found below 200m elevation (the boundary of NK NPA). It is likely that this effect of elevation is due to greater accessibility of the areas cleared and suitability for alternative land uses, suggesting that any baseline prediction for Nam Kading would be more conservatively based on rates of clearance in the wider AoI above 200m.

5. Current Carbon Storage

Carbon stock data for Lao PDR is sparse. A recent study commissioned by DoF and the Sustainable Forest Management and Rural Development (SUFORD) Project used data from the National Forest Inventory (NFI) to calculate average biomass and carbon density values for five of the Current Forest land cover classes used by FIPD (Vesa, 2010). Parameters for the calculation of these values were taken from a single study in the Nam Leuk reservoir site (Sogreah, 1997). Although concerns have been raised about the accuracy of using a single study to derive the biomass and carbon parameters (Watt, 2010), this is the only study to investigate such variables that currently exists for Lao PDR. Sensitivity analyses in which the values are substituted for those commonly quoted from studies outside of Lao PDR show that the Nam Leuk parameters produce a conservative estimate of carbon stocks. As such, the average carbon density values derived using the Nam Leuk parameters were used for areas classified as Current

Forest (Table 22). The total area of each type found within the area classified as Current Forest for the 2000/1 dry season was found by overlaying the latest FIPD land cover classification (FIPD, 2002), giving a weighted average of 373 tCO_2e/ha. Figure 8 shows the carbon density for the landscape following the classification for 2000/1. Areas that were found to have regenerated were conservatively considered to have same carbon density as Current Forest despite the fact that it would take a number of years to reach the equivalent stocking. Over time this would be expected to increase. In order to be conservative only areas classified as Current Forest from the initial time period were included in the calculations of carbon loss.

Table 22: Summary statistics for carbon stocks by forest type. Adapted from Watt (2010).

Forest Class	**Mean**	**Weighted Mean**	**Min**	**Max**	**SD**
			[tCO_2e/ha]		
Evergreen	568	572	341	891	169
Mixed broadleaf & coniferous	363	378	172	554	161
Mixed deciduous	246	275	92	418	92
Total	**392**	**373**			

For areas of our Non-Forest class, the carbon density was calculated using a weighted average of carbon values for the two classes that were lumped together: Potential and Non-Forest. For Potential Forest, the carbon density was found using the average of biomass values found for Stratum 1 and 2 of the Nam Leuk biomass study (Sogreah, 1997). These strata represented areas of young forest regeneration following recent cultivation and are the most representative values of carbon density in regenerating/degraded forest available for Lao PDR. This gave a carbon density of 200 tCO_2e/ha. This value was applied regardless of the land cover class given in the FIPD 2002 classification. For non-forest, it was assumed that the carbon storage was negligible. The weighted average for the lumped non-forest class was recalculated for each dry season to reflect changes in the area ratio of the two sub-classes.

6. Carbon Project Overview

Trade in greenhouse gas reductions is a large and rapidly growing market, and participating in this market can potentially provide new resources and revenue for conservation management. As presented in Section 5.0 above, forests in the Bolikhamxay landscape store significant amounts of carbon.

However, the current carbon market in the land use and forestry sector deals with emissions or removals of atmospheric CO2, i.e., changes in carbon stocks rather than the standing stocks that are currently present on a landscape.

We are interested in investigating options for carbon sequestration and/or emissions reductions as a strategy for generating revenue to support interventions leading to avoided deforestation, including site management by the Government of Laos and payments to local communities. We outline here the guiding principles of carbon projects that must be taken into consideration.

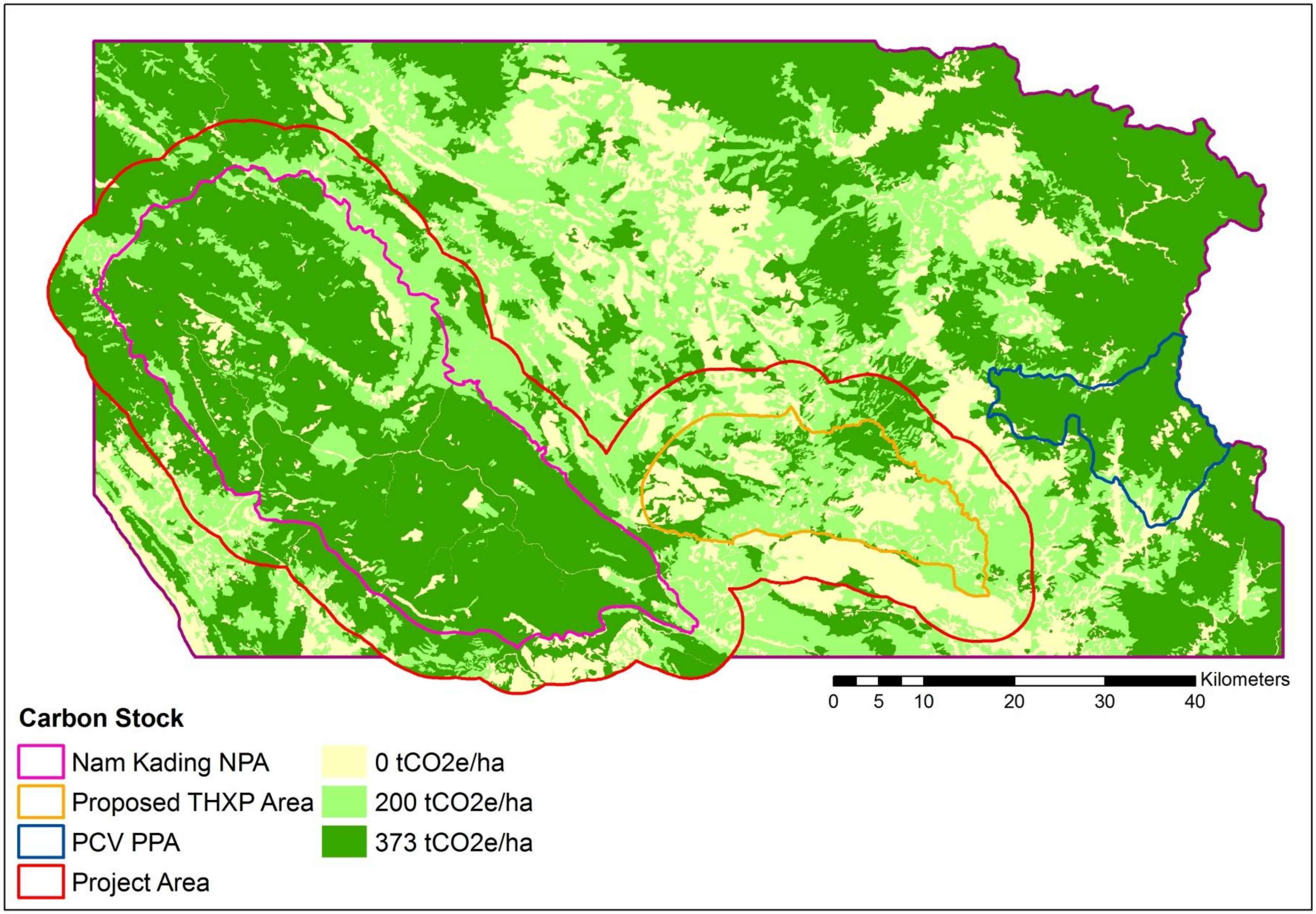

Figure 8: Landscape carbon stocks for 2000/1.

6.1. The Carbon Markets

The carbon project market is split between regulatory markets, where trading occurs to achieve mandatory caps in emissions, and voluntary markets, where participants may have more social, moral and public relation motivations.

The Regulatory Market

In the mandatory market, businesses, states and even whole countries are legislatively required to reduce their greenhouse gas emissions. This target may be met in part through the purchase of offsets from carbon projects. The mandatory market is dominated by the Clean Development Mechanism (CDM) of the Kyoto Protocol.

Under the CDM, the only land-use projects that are allowed are afforestation (planting trees on lands that were never forested in the past) and reforestation (planting trees on lands that were previously forested but have been without forest since at least 31st December 1989).

Projects wishing to qualify for carbon credits under the CDM must apply existing approved methodologies. These methodologies define how to create the baseline and how to monitor project benefits, project emissions and project leakage. Third party organizations known as Designated

Operating Entities (DOEs) verify that methodologies have been applied appropriately and that offsets are genuine.

It had been hoped that REDD would be incorporated into the CDM during the Copenhagen negotiations in late 2009, however, as no formal agreement was reached at this time, there is no change to its statutory status. Over the coming years, it is possible that REDD may be incorporated into the CDM. This could create greater opportunities for financing for carbon credits derived from a full REDD project as part of the statutory market.

The Voluntary Market

The voluntary market is still developing, but criteria for projects wishing to obtain finance on the voluntary market are now becoming more stringent and thus standards and markets have been created in response to these demands.

The Voluntary Carbon Standard (VCS) is the dominant worldwide standard for voluntary projects in the future with over 40% of market share. Like the CDM, it has a governing body that approves methodologies, third party verifiers that assure that offsets are genuine, and a buffer system to ensure flexibility of the credits. Offsets generated under the VCS will be recorded and traded with a unique serial numbers for each credit. Under the VCS, several activities are allowed in the Agriculture,

Forestry and Other Land Use (AFOLU) sector that result in carbon sequestration or avoided carbon emissions:

1. Afforestation, Reforestation and Revegetation (tree planting activities);

2. Agricultural Land Management;

3. Improved Forest Management;

4. Reduced Emissions from Deforestation and Forest Degradation (REDD).

This project would qualify as a REDD project.

6.2. Main Requirements Under The Carbon Market

There are different standards in the voluntary market to which the credits generated by projects are held accountable. However, all carbon projects have the same general underlying principles that must be followed. These are outlined below.

The Baseline

Carbon projects are formulated based on the difference in carbon emissions or sequestration between a **baseline**, or business-as-usual, and **project** case. To calculate carbon project benefits, the baseline case is compared against the measured land use and carbon stocks on the project lands. Under both the CDM and the VCS, the baseline is the most likely land use and associated carbon stocks in the absence of the project.

After the start of a carbon sequestration project, project participants monitor the project's land use and carbon stocks through time by measuring the carbon that accumulates in the growing trees. A proxy area may be selected also to monitor the carbon accumulation through time of the baseline land use.

The difference in carbon accumulation between the baseline land use (degraded or logged land) and the project land use (forest) essentially equals the carbon benefits (Figure 9).

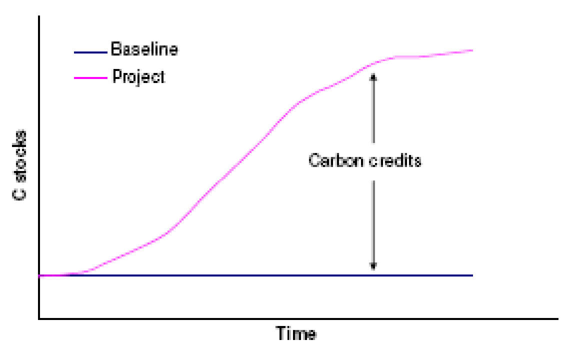

Figure 9: Baseline vs. project case for a carbon sequestration project.

For avoided emissions projects, carbon credits are calculated as difference in carbon *emissions* (rather than sequestration) between a baseline case, such as deforestation or logging, and the project case (Figure 10).

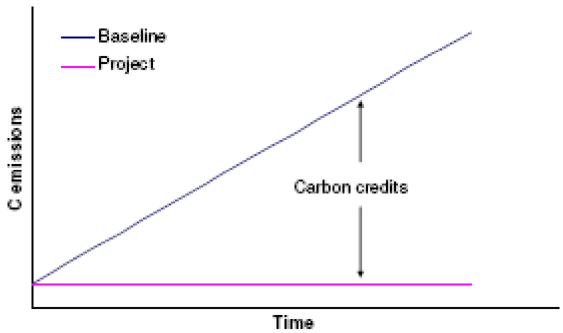

Figure 10: Baseline (cumulative emissions) vs. project case for an avoided emissions project.

Under the CDM, there is a process to go through (often tied to proof of additionality) to illustrate both the most likely land use and the carbon stock to be associated with the expected land use.

Under the VCS, criteria similar to those of the CDM are followed. However, the VCS permits avoided emission projects as well as sequestration projects. For avoided emission projects, formulating a baseline case can be more difficult because as soon as the project starts, what would have happened on the land (deforestation, degradation, logging, etc.) no longer occurs and a proxy area where this activity does occur may not be relevant to the project area or may not be measured easily.

Under the VCS, baselines must be reassessed and validated at least every 10 years. The reason behind this is that deforestation is so uncertain when predicted into the future. Any prediction beyond 10 years would be meaningless.

For a VCS Avoided Deforestation project, establishing a project baseline requires project developers to develop baselines for three geographical areas: a Reference Region, a Project Area and a Leakage Belt. The Reference Region, which includes the Project Area and the Leakage Belt, is the analytic domain from which information about deforestation agents, drivers and rates is obtained, projected into the future and monitored. The Project Area is the geographical area delineated by the project's boundaries where the project participants will implement activities to reduce deforestation. The Leakage Belt is the land surrounding the project area where project activities influence deforestation and where leakage is most likely to occur. There must be a demonstrable deforestation threat within the project area over the time period of the expected emission reductions.

Carbon Project Requirements

Basic requirements of emissions reductions or removals are to create real, measurable and long-term benefits related to the mitigation of climate change. The credits should be additional to any that would occur in the absence of the project activity and usually must be verified and certified by an independent, third-party verifier. The estimation of carbon benefits must be conservative to prevent over-crediting that would result in a negative effect on the atmosphere. The credits generated by a carbon project must be able to be measured, monitored and tracked through time.

Real and Measurable

To be real and measurable, a project needs a detailed baseline that can be compared, using on-the ground measurements, with the reality after a project is implemented. For land use carbon project baselines, two main components need to be assessed: the change in area and the change in carbon stocks. For avoided deforestation a detailed model predicting both the extent and location of deforestation in the absence of project activities would be required. This deforestation model would be paired with on-the-ground measurements of carbon stocks in both pre- and post-deforestation conditions. The non-CO2 gases resulting from the process of deforestation could also be included.

Long-term

Credits generated from land use carbon projects have the potential to be reversed through time if a human or natural disturbance occurs.

Under the CDM, emission offsets are termed Certified Emission Reductions (CERs). The CDM's solution to permanence is the issuance of temporary, expiring credits (tCERs and lCERs). Temporary CERs (tCERs) are issued at each verification/certification period and expire at the next verification/certification period. Long-term CERs (lCERs) are issued at each verification/certification period but do not expire until the end of the crediting period. All CDM land use credits must ultimately be replaced with permanent credits from other (non-CDM forestry) sectors.

In the voluntary carbon market, companies and individuals buy Verified Emissions Reductions (VERs) to reduce their carbon footprint. The market for VERs is not regulated currently in the way that the CER market is. However, VERs from land use projects are interchangeable with VERs from a project in any other carbon sector (such as the energy sector). The Voluntary Carbon Standard (VCS) provides deductions and buffers for land use projects to account for the risk of non-permanence.

Additional

Additionality, which is a key requirement of CDM and VCS projects, is the concept that all project activities that occur must be additional to the activities that would have occurred in the absence of carbon financing.

Proving additionality for CDM standards requires the use of the additionality tool developed by the United Nations Framework Convention on Climate Change (UNFCCC). The tool includes a barriers analysis, an investment analysis, or both. These tests must demonstrate conclusively that income from carbon crediting was essential for the project to go forward.

The Voluntary Carbon Standard has a similar step-wise approach towards proving additionality. The project proponent must demonstrate that the project is additional using one of three tests: the Project Test, the Performance Test or the Technology Test:

6.3. The VCS Additionality Test

Test 1: The Project Test

Step 1. Regulatory surplus. The project shall not be mandated by any enforced law, statute or other regulatory framework.

Step 2. Implementation barriers. The project shall face one (or more) distinct barrier(s) compared with barriers faced by alternative projects. These can include investment barriers, technological barriers or institutional barriers.

Step 3. Common Practice. The project type shall not be common practice in sector/region, compared with projects that have received no carbon finance. If it is common practice, the project proponents shall identify barriers faced compared with existing projects.

Test 2: Performance Test

Step 1: Regulatory surplus. The project shall not be mandated by any enforced law, statute or other regulatory framework.

Step 2: Performance standard. The emissions generated per unit output by the project shall be below the level that has been approved by the VCS Program for the product, service, sector or industry, as the level defined to ensure that the project is not business-as-usual.

Test 3: Technology test

Step 1: Regulatory surplus. The project shall not be mandated by any enforced law, statute or other regulatory framework.

Step 2: Technology additionality. The project and its location are contained in the list of project types and applicable areas approved as being additional by the VCS Program. These project types are defined as those in which all projects would also be deemed additional using Additionality Test 1 and will be determined on a case by case basis.

Conservative

Estimating the difference between baseline and project emissions should be conservative to prevent over-crediting. For avoided emissions projects, it is conservative to underestimate baseline and overestimate project emissions. For sequestration projects, it is conservative to overestimate baseline carbon accumulation and underestimate project carbon accumulation.

7. Carbon Strategies for Nam Kading NPA

7.1. Baseline Scenarios

The baseline scenario is taken to be a prediction of deforestation and carbon loss within the defined project area in the absence of any carbon project activities. Following discussion with PAFO, IEWMP and WCS representatives, the project area has been defined as NK NPA only for the purposes of calculation of carbon emissions under the baseline and project scenarios. This decision was taken due to the existing infrastructure and institutional capacity in place for the management of NK NPA through the IEWMP. In addition, the GoL is keen to use demonstration projects to test the potential scope of carbon finance within existing institutional arrangements, such as the NPA network, before expanding into other areas.

There is significant uncertainty associated with any projection of deforestation or regeneration rates given the noticeable change in forest cover between the 2000/1-2005/6 and 2005/6-2009/10 time periods. Further uncertainty is introduced by the significant reduction in forest cover loss between 1997 and 2000/1 suggested by the MRC/GTZ data, and the extent to which this is true loss or a product of methodological differences. Due to the extent of variation between the rates for the different time periods, it is not possible to fit a significant linear regression of the area deforested or regenerating over time. As such, it is very difficult to predict the future trend in forest cover.

Under the '*Unplanned Baseline'* module of the ADP Modular Methodology (ADP, 2010), if it is not possible to fit a linear regression to the historical baseline rate then the baseline is found by taking the mean deforestation rate over the time periods considered. As the deforestation rate declined significantly after 2005, it is probable that following this methodology would provide an unconservative overestimate of future deforestation. Given this, a more conservative approach would be to project forward using the lower deforestation rate recorded between 2005/6 and 2009/10 for the AoI, excluding Nam Kading NPA itself since the IEWMP had already commenced at this time.

In addition, the vulnerability modelling highlighted the effect that elevation has on risk of clearance. Using the rate of deforestation recorded for the entire AoI is therefore likely to produce an overestimate due to the higher proportion of land below 200m, the contour which forms the boundary to NK NPA. Table 23 gives the area for each unique land use history for area within the AoI above 200m. This gives a decrease of 32% in the deforestation rate between 2005/6 and 2009/10 compared to the whole AoI and an increase in long-term regeneration associated with cleared areas of 50%. Table 24 gives the deforestation rate as a percentage of the area of forest remaining at the start of each time period for the AoI above 200m and for the AoI above 200m but excluding NK NPA.

Comparing the rates of forest clearance between NK NPA and the AoI above 200m shows that even once elevation has been corrected for deforestation was lower in NK NPA prior to the commencement of the IEMWP. Using a weighted average to correct for the difference in clearance rates for the time periods 1997-2000/1 and 2000/1-2005/6 shows that on average deforestation in NK NPA was 50% lower in NK NPA than for the rest of the AoI above 200m.

As discussed in the driver analysis, it is anticipated that certain drivers within the project area will increase within the next 5 years. Due to the scarcity of data, however, it is difficult to predict the scale of the impact that these drivers will have on forest cover. Several of the drivers identified through the PTA relate to planned development activities, such as hydropower and irrigation development, and it is doubtful whether it would be possible to reduce these. In addition to this, at this stage in the development of REDD methodologies it is not yet clear how changes to driver impacts, such as through in-migration, will be considered in baseline calculations. Consequently, although increases in driver impacts are anticipated, these have been conservatively neglected.

Table 23: Total area for each land use history for areas of the AoI above 200m between 1997 and 2009/10.

History	**AoI above 200m**	
	Area [ha]	% of total
Current Forest (F)	358,912	44.8 %
Non-Forest (N)	210,389	26.2 %
Deforestation 2000/1	141,528	17.7 %
Regeneration 2000/1	32,260	4.0 %
Deforestation 2005/6	16,506	2.1 %
Regeneration 2005/6	9,924	1.2 %
Deforestation 2009/10	3,282	0.4 %
Regeneration 2009/10	919	0.1 %
Temporary Regeneration 2000/1	5,559	0.7 %
Temporarily Unstocked 2000/1	15,909	2.0 %
Temporary Regeneration 2005/6	505	0.1 %
Temporarily Unstocked 2005/6	2,089	0.3 %
Temporary Regeneration 2000/1 – 2005/6	505	0.1 %
Temporarily Unstocked 2000/1 – 2005/6	2,727	0.3 %
FNFN	510	0.1 %
NFNF	310	0.0 %

Table 24: Annual rate of forest loss for the AoI above 200m, including and excluding NK NPA and NK NPA. Rates are calculated as a percentage of the total forest cover at the start of the time period in question.

Time Period	**AoI above 200m incl. NK NPA**		**AoI above 200m excl. NK NPA**		**NK NPA**	
	Area [ha]	% of forest	Area [ha]	% of forest	Area [ha]	% of forest
1997 – 2000/1	141,528	6.80 %	125,199	8.24 %	16,329	2.9 %
2000/1 – 2005/6	16,506	0.87 %	12,867	1.01 %	3,639	0.59 %
2005/6 – 2009/10	3,282	0.23 %	3,190	0.33 %	9,1	0.01%

A further factor that needs to be taken into consideration is the extent to which the drivers of deforestation, which in NK NPA has been reduced to negligible amounts following the commencement of the IEWMP, will be displaced outside of the area considered in the analysis. There is again significant uncertainty surrounding this issue of leakage, in part due to the lack of quality data surrounding household livelihood activities, population movements and development paths. Consequently, it is very difficult to predict how much of the clearance seen prior to the creation of the IEWMP has been displaced and how much has simply been reduced. This is one of the principal areas that will require additional investigation as part of the development of any future carbon project.

Table 25 shows the projected rate of forest cover loss and associated carbon emissions within NK NPA for the next five years based on the assumptions that deforestation in NK NPA was 50% of the deforestation in the rest of the AoI above 200m prior to the commencement of the IEWMP, that the deforestation rate recorded for the AoI above 200m between 2005/6 and 2009/10 is maintained and that regeneration is 15% of the area cleared during that period. As discussed above there is considerable uncertainty regarding these assumptions due to the variability in the rates recorded over the time periods analysed but they represent the most credible scenario given the current level of understanding of the system dynamics.

Table 25: Projected forest cover loss and associated carbon emissions under the baseline scenario for the next five years. A baseline rate of 0.165 % annual forest clearance was used, of which 15% was assumed to regenerate.

Year	Area Forest [ha]	Area Deforested [ha]	Area Regenerated [ha]	Carbon Loss [tCO_2e]
2011	120,089	198	30	62,664
2012	119,890	198	30	62,664
2013	119,693	197	30	62,291
2014	119,495	197	30	62,291
2015	119,298	197	30	62,291

7.2. Project Scenario

For Nam Kading NPA, the land cover change mapping showed a net increase in forest cover, including a negligible annual deforestation rate of 0.01% of forest cover, following commencement of the IEWMP in 2005. This suggests that the activities conducted as part of the IEWMP are successfully tackling the principal drivers of forest loss in Nam Kading. The project scenario for Nam Kading therefore assumes that the same level of performance can be achieved over the next five years. Table 24 gives the estimated carbon emissions predicted under this project scenario. Table 25 gives the expected emission reductions resulting from the project scenario.

Table 24: Projected forest cover loss and associated carbon emissions under the project scenario for the next five years. A rate of 0.01% annual forest clearance was used, of which 25% was assumed to regenerate.

Year	Area Forest [ha]	Area Deforested [ha]	Area Regenerated [ha]	Carbon Loss [tCO_2e]
2011	120,275	12	3	3,357
2012	120,263	12	3	3,357
2013	120,251	12	3	3,357
2014	120,239	12	3	3,357
2015	120,227	12	3	3,357

Table 25: Projected reductions in carbon emissions comparing the baseline and project scenarios.

Year	Emission Reductions [tCO_2e]
2011	59,307
2012	59,307
2013	58,934
2014	58,934
2015	58,934
Total	**295,416**

8. Next Steps

The results of the comparison between the baseline and project scenario are contingent on the accuracy of the many assumptions made throughout the analysis. These assumptions were made necessary by the scarcity of useable data available at this stage of project development. It is therefore recommended that, should the decision be taken to proceed with project development, further rigorous investigation be undertaken. The key areas in which the current understanding of system dynamics is lacking are listed in Box 1.

Box 1: Key areas requiring further investigation

- Land cover prior to the 2000/1 dry season.
- The extent of historical degradation of carbon stocks within the Current Forest class.
- The extent of forest regeneration, that is associated with forest clearance, in subsequent time periods.
- The rate of regeneration of forest, including the time taken for a regenerated area to reach the median carbon density for Current Forest.
- The drivers of historical forest cover loss, including household livelihood activities and population movements and how these interact with rural development.

9. Conclusion

Forest clearance within NK NPA has been negligible since the commencement of the IEWMP and there has also been a concurrent increase in the relative rate of regeneration of forest cover in comparison with the wider Bolikhamxay landscape during this period. This suggests that the provision of international funding streams to the management of NK NPA through the IEWMP has reduced deforestation beyond the decline in clearance rate observed for the wider AoI. Whilst taking account of the many caveats raised above and the need for further investigation of the assumptions made in this report, comparison of the baseline and project scenarios predicts that management of NK NPA under the IEWMP will result in the avoided loss of forest cover of approximately 800 ha, with associated carbon emission reductions of approximately 300,000 tCO_2e, over the next five years.

All of the activities under the IEWMP which have reduced deforestation within NK NPA are currently supported without payment from any carbon finance mechanism and, therefore, whilst external funding can be secured, it is doubtful whether additionality could be argued for the IEWMP. The provision of international funding is, however, precarious. The lesson from other protected areas in Lao PDR where international funding has ceased is clear: once funding ceases, management can no longer be supported to the same level and resource extraction increases dramatically. To date the IEWMP has been funded by international donor funds raised by WCS. The two grants which have contributed the most to this project, from the GEF and MacArthur Foundation respectively, are one time only awards and consequently WCS is no longer confident that it can continue to secure the level of support that the project currently receives. As such, carbon financing offers a potential sustainable funding stream for the management of NK NPA, which has successfully controlled forest clearance since 2005, should WCS no longer be able to secure sufficient donor funds to be able to support management of NK NPA.

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