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FOR SOUTH AND SOUTHEAST ASIA (RFLP)

Reality check on the potential to generate income from mangroves through carbon credit sales and payments for environmental services

For the Regional Fisheries Livelihoods Programme for South and Southeast Asia

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Contents

Summary

Forests have been cited as an essential component of efforts to limit global temperature rise due to anthropogenic emissions of greenhouse gases to within 2^oC. Mangrove ecosystems commonly contain much larger amounts of carbon than most terrestrial forests and also have higher rates of primary productivity than many other tropical forests types. Although there is great variability, in many mangrove ecosystems, a large proportion of the carbon is contained within the anaerobic soils which can continue to accrete carbon even after vegetation has reached its maximum potential biomass/carbon content.

Mangroves provide a range of additional benefits including wood production, production of non-wood forest products (e.g. crabs, honey, bark for tannin production, etc.) and production of a range of environmental services including: protection from coastal hazards, erosion control, water filtration, maintenance of coastal fisheries productivity, bio-diversity conservation.

Due to the difficulty in marketing many of the services produced by mangroves and the lack of clarity over ownership of natural ecosystems, the value of the goods and services produced by mangroves has in almost all cases, not been fully realized. In Asia, mangrove forests have been cleared at higher rates than other forest types. Several factors are involved including the high value and easy accessibility of coastal land and the high value of mangrove wood, especially for wood fuel. In particular, large areas have been cleared for the establishment of aquaculture and rice production and also urban developments. Significant degradation of mangroves has also taken place as a result of excessive fuel wood collection.

In addition to these pressures the difficulty of realizing the non-market benefits of mangroves are compounded by the fact that the benefits accrue to many people, the majority of whom are often in poverty or of limited means. Conversion of mangroves is generally associated with a change in ownership towards an individual or an established entity while common access rights and the benefits that go with them are lost.

With the exception of carbon emissions reduction, markets for most environmental services have yet to develop to any great extent. In the case of carbon, rising concern over the possible impacts of climate change has stimulated demand and markets have been established both through voluntary and internationally agreed measures. Technical considerations have, however, generally prevented the widespread inclusion of forest related activities in these markets. In particular issues associated with monitoring and quantifying carbon flows with precision, setting baselines and with leakage and permanence have meant that costs associated with including forestry activities in markets have exceeded associated benefits.

Some progress is, however, being made and a range of forestry activities are eligible for inclusion in internationally agreed (compliance) carbon markets and under standards widely accepted by voluntary carbon markets.

Broadly, two classes of forestry activity may secure carbon emissions reductions: (i) afforestation and reforestation (A/R) or (ii) reduced emissions from deforestation and degradation (REDD). A/R activities are technically simpler to include in carbon accounting frameworks because the baseline level of carbon is more or less fixed at zero. REDD activities are more complex as a background rate of deforestation and degradation has to be estimated before emissions reductions resulting from project interventions can be assessed. REDD activities are now generally accepted to additionally include conservation and sustainable management of forests, and enhancement of carbon stocks (REDD+).

Under the Clean Development Mechanism (CDM) of the Kyoto protocol, only A/R activities are eligible. To date 19 forestry projects worldwide have been registered under the scheme, none of them in mangrove areas. Another four have requested registration. The average rate of CO_2 emissions reduction of existing projects is 14 tonnes per year and the range 4-34 tonnes. One CDM project in a mangrove area, in Indonesia, is currently under validation. The estimated sequestration rate is 33.2 tonnes $CO_2e\ ha^{-1}\ yr^{-1}$.

A/R activities under the CDM have not proliferated to a greater extent because of the high validation, registration and verification costs[1] of projects in relation to the low value (<$5) of the temporary certified emissions reductions (tCERs) available for forestry projects. Thus, even with carbon emissions reductions of 34 tonnes per year, a project would have to cover over 1 000 ha to break even within 5 years given a sale price of $5 per carbon credit.

Given the high transaction costs associated with compliance markets, voluntary markets have become a focus for forestry related activities. Project validation is simpler than under the CDM and costs are therefore lower. Carbon credits for forestry activities under voluntary standards also generally fetch higher prices than the tCERs available under the CDM. This is largely because, despite the potentially temporary nature of forestry emissions reductions, permanent credits have been made available through voluntary standards by employing a buffering system. The buffer refers to a cache of credits that are withheld from sale until permanence risks are proved to be low. This does mean, however, that, depending on the level of assessed risk, up to 60% of credits may not be sold; 10% of the buffer is released every 5 years if risk is proved to be low.

The Voluntary Carbon Standard (VCS) is the best recognised of the voluntary standards and covers a range of forestry activities under different endorsed methodologies. Currently there is no methodology that relates specifically to mangrove areas but CDM A/R methodologies are eligible. Activities associated with reduced emissions from deforestation and degradation although not accepted under compliance mechanisms are accepted under voluntary standards. Other methodologies exist for improved forest management and soil carbon can also be included in small projects under the VCS scheme.

The inclusion of soil carbon, in addition to carbon in biomass, is particularly important in the case of mangroves as soil carbon stocks may account for well over half of the total carbon present in the ecosystem. This is potentially of particular importance in relation to REDD+ activities as inclusion of forecast losses of soil carbon could dramatically increase the number of credits available. Currently, the CDM only includes soil carbon in large projects (>16 000 tonnes CO_2 e yr^{-1}).

If rates of accretion of soil carbon are high in relation to rates of biomass development, and the additional carbon can be included in A/R or improved forest management methodologies, income should also be considerably increased.

Although inclusion of additional carbon pools is likely to increase the number of credits available for sale, costs will be associated with development of methodologies and measurement of additional pools. However, rates of soil carbon accretion as a result of root turnover and litter fall are not well known and may be highly variable. For example, in some areas crabs may consume almost all litter fall and aerobic bacteria present on the soil surface may reduce carbon before it is stored in the anaerobic zone. Where litter is carried out to sea, there will also be losses given that carbon projects generally work on the basis of carbon stocks within a given area rather than flows of carbon.

Because the current level of understanding of carbon cycling in mangrove ecosystems is low, time consuming methodological work is likely to be necessary before rates of accretion/conservation of soil carbon can be quantified, validated and credited. This has to be taken into account in relation to the potential benefits from eventual sale of credits.

A further consideration in relation to soil carbon in mangrove ecosystems is that in implementing small scale CDM projects there can be no hydrological changes made. This is because of the anaerobic nature of mangrove soils and release of methane and nitrous oxide (both greenhouse forcing gases) that occur upon rewetting. This is particularly important in relation to rehabilitation of abandoned shrimp ponds/rice paddy where hydrological changes would be required for restoration of mangrove ecosystems. A methodology for rewetting of peat soils is currently under review for inclusion under the Voluntary Carbon Standard (VCS) although not all mangroves are classified as growing on peat – some, according to the soil type, are considered wetlands.

[1] ~$160,000 + $14,000 every 5 years for verification.

In addition to the technical issues, investment in mangrove related carbon emissions reduction suffers risks associated with transitions in the global climate change architecture. Firstly, a post-2012 replacement for the Kyoto Protocol has yet to be agreed and the continuation of the CDM and its component methodologies beyond 2012 is therefore not certain. Secondly, voluntary markets for forestry related carbon sales will end once national level REDD mechanisms are established given that forestry related emissions reduction activities will be accounted for under the national level programme. Currently, REDD readiness activities are being undertaken in all Regional Fisheries Livelihoods Programme (RFLP) countries except Timor-Leste. Although it is likely that provision will be made to ensure that continuing projects are maintained or are subsumed into REDD, the terms are not yet clear.

Institutional and administrative issues must be taken into account in assessing the feasibility of setting up carbon sales. For example, costs will be associated with distributing and monitoring benefits to local communities in relation to mangrove activities such that income per hectare will be spread among many people and only a certain proportion will make it to the local level.

In all RFLP countries in there are also uncertainties over jurisdiction in mangrove areas. Overlaps commonly exist between local and national government agencies and between sectoral agencies. Lack of law enforcement at the local level can also mean that the laws that exist are not adhered to. Such issues should not, however, create problems providing agreement with national authorities can be arrived at prior to inception of any potential project. Further risks may exist in relation to selling carbon in international markets as few countries have established laws in relation to ownership, sale and trade of carbon and carbon rights. These would have to be negotiated during project implementation.

Globally, there are currently around 10 carbon projects focussing on mangrove areas, of which four are in Asia. Almost all focus on reforestation, restoration and conservation although readily available information for some of the projects is scarce.

Given the nature of mangrove ecosystems and potential for sequestering carbon/reducing emissions, the most profitable sites are likely to be (i) REDD activities in threatened degraded mangrove areas with peat soils; and (ii) A/R activities in abandoned fish ponds. Additionally, large project sites will have lower start-up and administration costs per unit area. Methodologies will, however, need to be refined to include rewetting and/or soil carbon dynamics unless a simple A/R or REDD project providing a more limited number of credits is to be considered. For this to be considered, the area would probably have to be in excess of 1 000 ha. It should also be considered that REDD activities would need to be in areas where the background rate of deforestation and degradation is high, or plans for deforestation and degradation exist and could be reversed, for carbon credits to be gained.

Given these limitations, and as income is unlikely to be more than US$ 200 per hectare per year under the best conditions, and probably considerably less given likely reductions of 30%+ for buffering under the VCS scheme, the mangrove area would almost certainly have to provide goods and services beyond carbon sequestration/ conservation.

Beyond technical and institutional issues, the essential element in any project will be finding a promising site and gaining the support of local communities and national authorities. Given the technical complexities and caveats, beginning from the ground level would seem essential, i.e. it would be better to begin with a definite problem that could be addressed rather than to set up a concept and then look for an area which fits the idea. If there are good sites and the community and government are supportive then the prospects for carbon crediting and for corporate support would be much higher.

Although working in several countries simultaneously and developing in-house expertise should reduce set-up costs, current carbon prices, the lack of well fitting methodologies and the need to provide communities with income within a short time frame (~3 years) suggests that the sale of carbon credits is not a practical course for RFLP to follow in providing alternative means of livelihood support to fisher communities.

However, under current conditions it is still possible that mechanisms could be developed to enable coastal communities to benefit financially from mangrove related activities. For example the following steps could be considered:

- Identify potential mangrove areas and consult with stakeholders to determine interest;
- Provide livelihoods support through traditional mangrove related activities and alternative means (e.g. disaster risk reduction) in association with national NGO and/or local government;
- Facilitate agreement over mangrove restoration/conservation between authorities and local community;
- Identify possible corporate[2] entity to provide sponsorship and facilitate agreement with local community and authorities over payment for mangrove conservation;
- Identify inter-governmental or civil society institution to act provide local technical support and act as intermediary;
- Work with consultants to:
    a. Work towards carbon accreditation including addressing any methodological issues, and also work towards accreditation with social and environmental standards (e.g. CCB); **or**
    b. Develop an alternative lower cost accreditation framework that does not yield carbon credits, but provides a socially and environmentally sound 'sustainable development product' focussing on payments for mangrove protection and aimed at corporate buyers.

As global carbon prices remain low, major carbon markets look set to remain relatively closed to forest related carbon credits (e.g. European Emissions Trading Scheme) and major players including the US and China are demonstrating reluctance in backing a post-Kyoto agreement that includes deep cuts in emissions, option b. may prove the only economically feasible alternative where mangrove areas are less than 1 000-2 000 hectares. Additionally, voluntary carbon markets for forestry will be extinguished by national REDD+ frameworks once established. Voluntary sales will only continue in the same form in non-REDD countries although it is likely that in REDD countries (all RFLP countries except Timor-Leste) that provision will be made for existing carbon projects.

Finally, given the variability of mangrove forests and the environmental, social and environmental situations in which they exist, it is of great importance is to locate potential field sites such that interventions can be designed with specific situations in mind, e.g. potential sequestration rates, threats to existing carbon, local support, etc.

[2] Corporate support for mangrove-carbon projects has also been provided, most notably by Danone, which has set up a funding mechanism and supported various international meetings. Others may become interested as confidence grows and *ad hoc* agreements between corporate entity and mangrove stakeholders could take many forms.

1. Introduction

Mangrove ecosystems are highly productive and contain large amounts of carbon both within vegetation and soils. As such they have great potential value in relation to climate change mitigation. They also have value in production of timber and non-timber forest products, including wood fuel and crabs in particular, and provide productive fishing grounds and nursery areas for juvenile fish and shrimp as well as a habitat for oysters, clams, estuarine crocodiles and snakes. Mangroves filter chemical and organic pollution from the water, which keeps the waters on reefs and seagrass beds cleaner (Murdiaso *et al* 2009). Mangroves also contribute substantially to coastal fisheries in terms of providing trophic and refuge support, and larval retention (Chong 2007).

Erosion control and entrapment of sediments by mangroves is of relevance in coastal ecosystems where removal of mangroves can lead to loss of land and saline intrusion. Removal of mangroves can also expose coastal populations and assets to increased risk from coastal hazards (FAO 2006c, Forbes and Broadhead 2007). In particular, mangroves provide a degree of protection against coastal hazards such as storms, tsunamis and cyclones.[1] Although they cannot prevent inundation, tall dense vegetation attenuates wave action and provides structure for survivors to cling to. Coastal forests also act as a windbreak in reducing the impact of cyclones and coastal storms on local communities. These functions are particularly pertinent given that climate change in Southeast Asia is expected to result in increasing intensity of floods, storms and droughts as well as sea level rise.

Mangroves are present on low energy coastlines around much of tropical Asia. Communities resident in and around mangrove areas are often highly dependent on fisheries resources and mangroves have traditionally played a role in fishing community's livelihoods by providing timber for boat building and wood for drying and smoking fish. As coastal populations have increased in recent years, fish stocks have been depleted and the extent of mangroves has been much reduced due to demands for wood and timber, and for land for expansion of agriculture and aquaculture and residential development. The high value of coastal land, easy accessibility of mangroves and the high value of wood from mangrove species for energy production have accelerated clearance. As a result, mangrove loss across Asia has been at higher rates than for other forest types.

The pressures on mangroves and associated fisheries resources mean that there is an acute need to introduce and encourage alternative livelihoods that are less detrimental to natural resources and that facilitate sustainable development and a balanced realisation of environmental, social and economic values.

For alternative 'environmentally sustainable' livelihoods to be viable, replacement of benefits from unsustainable fishing and mangrove exploitation activities is necessary. Much talk in recent years has centred on the possibility of selling environmental services as a means of sustaining communities in managing natural resources. Because a number of benefits from environmental services produced by forests, including mangroves, such as climate change mitigation, bio-diversity conservation, and those related to fisheries production, are accrued at the national and international levels while costs are born at the local level, mechanisms facilitating transfer of benefits from consumers to providers are a logical way of incentivising production. There has, however, been limited development of markets enabling people at the local level to benefit from continued provision of environmental services from forests.

Project scale schemes to pay local residents for provisions of water related environmental services have been developed around Asia and in some countries including the Philippines and Viet Nam, these have been adopted more widely. Payments for bio-diversity related services have yet to become widely established.

[1] Research carried out in Orissa following the super cyclone of 1999 showed that had mangroves been present around affected villages, loss of life would have been considerably lower (SANDEE 2007). During cyclone Sidr that struck southern Bangladesh in November 2007, the Sunderbans forests also helped to mitigate the effects of the cyclone (FAO 2008a).

Several impediments exist to wider implementation of payments for environmental services (PES) including determining who should be paid, what they should be paid for, what the production baseline is and whether the services are actually being provided. Lack of clarity over tenure – especially in remote areas – and differences in *de facto* and *de jure* rights erode the operability of PES because it is not clear who should be paid to provide the service. Where many people benefit from the utilization of resources it is also not generally feasible to pay them all off (Wunder 2007). As such, the potential to provide benefits to fisher communities through mangrove related conservation and management is limited, although it is possible that informal sale could be made, or national systems of payment could be established.

The one area in which payments for environmental services from forests have become more developed is in relation to climate change mitigation. Many of the problems encountered with other PES also apply, e.g. technical and political complexity, but these are gradually being overcome albeit with additional costs. Because mangroves contain and sequester large amounts of carbon, however, and because large quantities of carbon dioxide are released to the atmosphere when mangroves are cleared and converted, implications for global climate change are considerable (Murdiyarso and Adiningsih 2007). The value of mangroves is therefore concomitantly high.

Realising the value of mangroves for climate change mitigation in monetary terms is, to some extent, a distinct issue. Activities that reduce the amount of CO_2 emitted or increase the amount sequestered are potentially eligible for crediting under various current and anticipated compliance [2] and non-compliance (or voluntary) mechanisms and methodologies for climate chance mitigation. By deriving carbon credits from protection and/or rehabilitation of mangroves while simultaneously reducing fishing effort in adjacent waters, local communities could benefit from improved productivity of mangrove resources, income from carbon credit sale and, in the longer term, improved and more sustainable production of fisheries and forest products.

Voluntary and compliance markets have both been expanding in recent years although the extent of inclusion of forest and forestry has been limited, particularly in the case of mangroves. This is, however, changing as experience grows and standardised methodologies become available to account for carbon emissions in forests and mangroves.

Global mechanisms to market the climate change mitigation values of forests have been developed under the United Nations Framework Convention on Climate Change (UNFCCC), which recognizes the importance of land use and land-use change and forestry (LULUCF) activities in stabilizing atmospheric greenhouse gas concentrations. The Kyoto Protocol makes provision for associated activities. At present, only afforestation and reforestation (A/R) activities qualify under the Clean Development Mechanism (CDM) of the Kyoto Protocol, which aims to reduce emissions in developing countries by funnelling payments from industrialized countries to help meet their emissions targets. Only a handful of projects, have, however, successfully tapped CDM funds. More widespread implementation has been curtailed by methodological complexities related to leakage, permanence, additionality and monitoring. The low price of temporary credits available for A/R activities and the small proportion of revenue from CDM in relation to other revenues from A/R have also been an obstruction (Neeff and Henders 2007).

Apart from A/R activities, it has been estimated that the cost of reducing emissions from deforestation and degradation (REDD) will be low in comparison with current carbon credit prices (Chomitz 2007). As well as REDD, options open for consideration in a new climate change agreement include afforestation, reforestation and enhancement of sinks through forest restoration, and substitution of forest products for electricity and fuel (Robledo and Blaser 2008). Greater inclusion of forestry in a post-Kyoto agreement is greatly anticipated although many doubts remain over the expected effectiveness of REDD mechanisms (Lang 2008). In particular, it has been suggested that addressing deforestation and its “deeply-entrenched social causes” may prove to be more expensive than alternative ways of reducing emissions of greenhouse gases (Raffensperger 2007). The failure to reach encompassing agreement on an international framework on REDD at the United Nations

[2] Regulated under international agreements.

Climate Conference in Copenhagen in December 2009 (COP 15) and subsequent meetings suggests that there is still some way to go before forests become an integral part of international climate change mitigation regimes.

Owing to the difficulty of accessing, or present unavailability of internationally regulated 'compliance' markets for forest-related emissions reductions, voluntary carbon markets have become the main vehicle for investment in forestry-related climate change mitigation. Prices per tonne of CO_2 equivalent (CO_2 e) have been lower for avoided deforestation than for A/R projects, although great variation exists (Hamilton *et al*. 2008).

In anticipation of the inclusion of REDD activities in a post-2012 climate change agreement, many countries in Asia, are beginning processes to become 'REDD ready', i.e. preparing strategies and frameworks that will meet expected requirements of global REDD markets.

The workability of REDD will be depend on a wide range of political, institutional and technical issues. The Stern review emphasized defining property rights to forest land and determining rights and responsibilities of landowners, communities and loggers in effective forest management (Stern 2006). Institutional capacity is likely to pose a particular challenge in countries where forest cover remains high and governance systems are relatively undeveloped.

With respect to mangroves, carbon accounting has been particularly difficult in wetlands because of limited information on carbon stocks and on emissions. In particular, knowledge of the fate of carbon fixed by mangrove ecosystems and the nature and variability of carbon cycling remains poorly understood. Fluxes of other greenhouse gases (GHGs), particularly methane (CH_4) and nitrous oxide (N_2O) are also not well quantified or understood and although the 2006 revised National Greenhouse Gas Inventory Guidelines laid out methods for GHG accounting in these ecosystems, they remain incomplete (Murdiaso *et al.* 2009).

Given the current situation, a number of questions surround the feasibility of developing mechanisms and structures to acquire income from mangrove related climate change mitigation that may be utilised in supporting the livelihoods of fisher communities, including the following:

- How much can carbon emissions be reduced and how much income will this provide?
- How much will it cost to qualify for carbon emissions verification and how long will it take to receive income?
- Are methodologies available to facilitate realisation of the value of all carbon sequestered and stored in mangroves?
- What provision do current institutional measures make for the ownership and sale of carbon?
- What risks can be expected in relation to, e.g., natural hazards, market fluctuations, corruption, social strife and coastal erosion?
- What is the opportunity cost of the prospective land area in comparison with the highest and best use?

This report addresses these questions and others in determining whether carbon credits are currently worth pursuing as a means of supporting the livelihoods of fisher communities in coastal areas in the countries covered by the Spanish funded FAO Regional Fisheries Livelihood Programme: Cambodia, Indonesia, the Philippines, Sri Lanka, Timor-Leste and Viet Nam.

2. Assessment of mangroves and mangrove related institutional frameworks in RFLP countries

Across the sub-region, mangroves have been particularly susceptible to conversion and degradation owing to the high value of the land they occupy, easy accessibility and the value of wood from mangrove species for energy production. In Southeast Asia, the area of mangroves is estimated to have fallen from 5.1 million hectares in 2005 to 4.9 million hectares in 2010, representing a loss of 0.9 percent per year, significantly higher than the overall rate of forest loss in Southeast Asia of 0.5 percent. Table 2.1 shows rates of change in mangrove area in RFLP countries between 2000 and 2010. Although data may lack accuracy, and the regularity of monitoring may also be insufficient, the overall trend is for steady loss.

Table 2.1. Mangrove area in RFLP countries 2000-2010 (000s hectares)

	2000	2005	2010	Annual rate of change, 2000-2010
Cambodia	68	62	56	-1.9
Indonesia	3 593	3 448	3 207	-1.1
Philippines	257	257	257	0.0
Sri Lanka	11	12	12	0.9
Timor-Leste	2	2	2	0.0
Viet Nam	69	63	60	-1.4

Source: FAO 2010

Mangrove areas are often subject to unclear or overlapping jurisdictions. Standing at the land-sea interface, rights and responsibilities are often divided between fisheries and forestry government agencies while others such as provincial and district authorities and coastal directorates may also be involved. Legal provision for local management of mangroves may also be lacking as forests and land between high and low tide marks are often under state jurisdiction. Furthermore, in most countries, legislation governing ownership and sale of carbon rights is not well defined, if it is defined at all. These issues provide challenges for realising benefits at the local level, but are not insurmountable if political will exists to support local livelihoods and sustainable natural resource management, where viable mechanisms are available.

2.1. Cambodia

In Cambodia, the RFLP focal area includes the entire coastline. Cambodia's coastline has quite large areas of mangroves, particularly in the north-west in Koh Kong Bay. There are also estuarine mangroves in Kampong Som Bay and around Kampot (Spalding *et al.* 2010). Large areas of mangroves close to the Thai border were converted to shrimp ponds during the 1990s. Many of these have since been abandoned.

Since the 1990s, many mangrove areas have been clear-cut for charcoal production, with Thailand providing an important export market. Conversion to shrimp farms has resulted in the loss of mangroves, particularly close to the Thai border although many of these have since been abandoned (Spalding *et al.* 2010). Urbanisation and resort development have also had significant impacts and although it has been illegal to cut mangroves since 1994 as a fisheries protection measure, enforcement has been weak and charcoal production has continued within protected areas.

Annual rates of mangrove loss exceed the background rate of forest loss and have accelerated from 1.6 percent between 1990 and 2000 to 1.9 percent between 2000 and 2010. According to Royal Government of Cambodia (RGC) figures submitted to FAO in 2010 only 56 000 hectares of mangrove forest or 70 percent of the area present in 1990, remained in Cambodia (FAO 2010). Village level management committees have, however, had some success in reducing deforestation (Spalding *et al.* 2010).

Data from IUCN shows that 73 three percent of the mangrove area in Cambodia is found in Koh Kong Province with Peam Krasaop Wildlife Sanctuary containing 10 000 hectares (Table 2.2). Kampot

Province, contains around 9% of the national mangrove area, but large scale clearing for salt production has greatly reduced the spatial extent.

Table 2.2 Mangrove areas in Cambodia

Province	Area (ha)
Koh Kong	63 700
Kampot	13 500
Sihanouk Preah	7 900
Kep	800

Cutting of mangroves is illegal in Cambodia as a fisheries protection measure but enforcement of the law has been limited. Large areas of mangroves are incorporated within four protected areas, but charcoal production has continued. Village level committees formed to manage forestry and fisheries have, however, been successful in preventing loss of mangroves in Koh Kong province and around Ream Krasop park.

In Cambodia flooded forests, including mangroves, are under the management of the Fisheries Administration (FiA), which is under the Ministry of Agriculture, Fisheries and Forestry (MAFF). Management of flooded forests, including mangroves and mangrove protected areas is covered by the 2006 Fisheries Law while management of flooded forest is not considered in the 2002 Forestry Law, as specified in Article 3. Flooded or inundated Protected Areas are considered State Public Property and are under the jurisdiction of the Ministry of Environment (MoE) under the 2008 Protected Areas Law.

The Ministry of Agriculture, Forestry and Fisheries (MAFF) issued a sub-decree on Community Fisheries Management in 2005 and an implementing regulation on Guidelines for Community Fisheries in 2007 (Blomley, 2010). The Strategic Planning Framework for Fisheries: 2010 – 2019 includes the following targets for the management of inundated forests (RGC, 2010b):

The area of critical fisheries habitats [mangroves are relevant in this case] under sustainable management (from a 2009 baseline of 200 ha mangrove):

2010: At least 300 ha of flooded forest and mangrove are replanted

2015: At least 700 ha of flooded forest and mangrove are replanted

2019: At least 1 000 ha of flooded forest and mangrove are replanted.

2.2. Indonesia

The RFLP focal area in Indonesia covers Nusa Tenggara Timur (NTT, West Timor). Mangroves are located predominantly around Kupang in the south west, in Tanjung Oisina Mangrove Swamp Game Reserve, in Dataran Bena hunting Park, in Maubesi Nature Reserve and also on the adjacent island of Roti (Spalding *et al*. 2010).

Table 2.3 Mangrove areas in Nusa Tenggara Timur

Location	Area (ha)
Nusa Tenggara Timur (NTT)	40 641
Kupang District	6 344
Rote Ndao District	4 658
Kupang municipality	2 548

At the national level, 20 agencies are involved in coastal zone management in Indonesia. The Ministry of Forestry is the functional body for policies for conservation of mangroves, other coastal forests and marine protected areas (Dahuri 2007). The Ministry for Marine Affairs and Fisheries has the mandate at the national level for utilisation of renewable resources including mangroves.

The Coastal and Small Island Management (CSIM) Law of 2007 provides the legal basis for integrated coastal management (MFF 2008a). The Ministry of Marine Affairs and Fishery (MMAF) is the responsible authority at the national level. Establishment of marine protected areas is problematic, however, due to conflicts between the national park authority which is under the Ministry of Forestry and local authorities, which are responsible for coastline demarcation. Decrees issued prior to the CSIM law provide for granting of management rights to coastal communities and enable participation of local communities in monitoring.

2.3. The Philippines

The RFLP focal area in the Philippines covers North Mindanao. Mindanao has two thirds of the remaining mangroves of the Philippines, mostly in the northern and western areas. Mindanao is rarely visited by typhoons, except its northeastern section that is occasionally hit.

An area of mangroves of 4 000 ha is situated on Siargao Island off the north-east coast of Mindanao (Spalding *et al* .2010). In Western Mindanao, Murciellagos Bay has an area of 785 hectares of mangroves[3], while the adjacent Dipolog Bay has 1 520 hectares (RFLP report).

Some legislation exists to protect mangroves including restrictions on the development of new aquaculture and a requirement for the maintenance of greenbelt strips long the edges of aquaculture areas – up to 100 m in width in typhoon-prone areas (Spalding *et al.* 2010).

2.4. Sri Lanka

Mangroves in Sri Lanka are concentrated in fringes and around estuaries and lagoons (Spalding *et al.* 2010). The RFLP focal area in Sri Lanka covers Puttalam District in which the largest mangrove ecosystem in the country is located. The mangrove system is located in the Puttalam Lagoon – Dutch Bay – Portugal Bay complex and covers 3 385 hectares (IUCN data).

Some 1 500 ha of coastal area between Chilaw and Puttlam, most of it mangrove forest, have been developed for aquaculture, and about 63 percent of the previously existing mangroves in Puttalam Lagoon were lost in the ten-year period 1982 - 1992 (Samaranayake 2007). The area of shrimp farms is around 4 490 hectares although 2 884 hectares are abandoned. Some of this area is used for salt production, and in total there are 3 368 hectares used by the salt industry (RFLP report).

The Coast Conservation Department is mandated with "the sustainable development of coastal resources and the management of coastal processes to optimise social, economic and environmental status of Sri Lanka". However, under the Urban Development Authority (UDA) Act, No 41 of 1978, the entire coastal zone has been gazetted as an urban development area. Any development plans therefore have to be referred to the UDA (Samaranayake 2007). Additionally, the Department of Wildlife and Conservation designates and manages protected areas, the Forest Department manages forests including mangroves, the Ministry of Fisheries and Ocean Resources manages fisheries and the National Aquaculture Development Authority promotes the conversion of mangroves for prawn culture (MFF 2008b).

The existing legal framework recognises only public and private property but not communal property, which creates obstacles for implementing coastal management in which communities share benefits (MFF 2008b).

Puttalam district is included in a Special Area Management (SAM) plan. The overall SAM process is coordinated by the Special Area Management Coordinating Committee headed by the Divisional Secretary of the area and facilitated by the Coast Conservation Department. The Coordinating Committee includes the main governmental and non-governmental stakeholders including the fisheries Cooperative Societies in the SAM area (Samaranayake 2007).

2.5. Timor-Leste

The RFLP focal area covers the entire coastline of Timor-Leste. Mangroves are not extensive although fringing mangroves are found to the east of Dili, including in Metinaro and to the west in

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[3] Partnership for rural and technical services: http://parts-ngo.org/index.php?option=com_content&view=article&id=46&Itemid=40

Tibar and Maubara (Spalding *et al*. 2010; FAO 2003). On the south coast, Mangroves are restricted to estuaries and lagoons

There is a legal framework for environmental protection including specific regulations to protect mangroves, but enforcement is weak (Spalding *et al*. 2010).

2.6. Viet Nam

In Viet Nam, RFLP focal areas include the central provinces of Quang Tri, Hue and Quang Nam. Much of the mangrove area in Quang Nam is composed of Nipa palm and not true mangrove species and some areas are the result of previous replanting activities[4] (Table 2.4). There are also mangrove areas in the Tam Giang - Cau Hai lagoon near to Hue. According to Spalding *et al.* (2010) scattered estuarine mangroves are found in small areas to the north of Hue although these are not visible on Google Earth.

Nui Thanh may be of greater interest to RFLP as Cua Dai (Hoi An) mangroves area will soon be supported by a Denmark-funded climate change project (Song Ha, pers comm.).

Table 2.4. Mangroves in Quang Nam Province.

Location	Area (ha)	Species
Cửa Đại Area – Hội An	80	Nipa palm, mangrove.
Duy Xuyên (Duy Vinh, Duy Nghĩa, Duy Thành)	30	Nipa palm
Vụng An Hòa, Núi Thành	60	Diverse
Tam Nghĩa – Núi Thành	10	Mainly Nipa palm
Total	**180**	

Viet Nam has replanted large area of mangroves, mostly through government support. The Ministry of Agriculture and Rural Development (MARD) has committed to planting 100 000 hectares of mangrove forest between 2008 and 2015 to compensate for the loss of the mangrove forest area over the last six decades. These plans will raise issues of additionality in relation to mangrove carbon projects (McNally *et al.* 2010).

The east coast of Viet Nam is regularly subject to storms and typhoons from the South China Sea. Every year there are around 10 to 15 storms and typhoons which cause damage to houses, buildings and trees and also result in flooding, landslides and water logging. As such, storms and typhoons strongly impact on people's lives and national production (FSIV 2009).

In Viet Nam, the Directorate of Forestry under MARD is responsible for the administration of forests nationwide, including mangrove forests (McNally *et al.* 2010). The state owns all land but local users may be allocated long-term rights to manage and use forest and forest land and there is an overall policy to allocate forest land to households and other entities for a period of 50 years.

Mangrove forests are mostly held by Protection Forest Management Boards (PFMBs), by the local People's Committees (land yet to be allocated) or by State Enterprises. Sixty two percent of Viet Nam's mangrove forests are 'protection forests'and cannot be allocated to communities (McNally *et al.* 2010). Households, individuals and communities can, however, participate in the management of special-use, protection and production forests under contract to forest owners (state forest enterprises, and management boards of special-use and protection forests). There are a number of models of local forest ownership of mangroves in Viet Nam, involving co-management in particular.

Hawkins *et al*. (2010) suggest that unclear regulatory and management authority over mangroves in Viet Nam results from the overlapping mandates of MARD, the Ministry of Natural Resources and Environment (MONRE), and the People's Committees at the provincial, district, and commune levels (Table 2.5). They suggest that a sector-based approach cannot ensure effective mangrove management and that an inclusive, ecosystem-based, cross-sectoral approach is needed.

Table 2.5. Jurisdiction over mangrove forests in Viet Nam.

[4] More detailed information on mangroves in these areas is provided in "Survey, assessment and recommendations of measures for protection and restoration of wetland areas in the coastal areas in Quảng Nam".

Ministry of Natural Resources & Environment Management of land, including wetlands	Ministry of Agriculture & Rural Development Mangrove forest & fisheries management
• Land-use planning • Surveys and mapping • Land allocation • Land registration • Issuance of land-use certificates • Geology and mining • Water	• Forest-use planning • Forest protection and development • Forest boundary demarcation • Forest allocation and leasing • Forest conversion • Aquaculture and fisheries management

3. Carbon stocks and carbon sequestration in mangroves

Mangroves are important in climate change mitigation as they fix large amounts of carbon, a proportion of which is, importantly, sequestered in mangrove soils for long periods of time (Ong *et al.* 1995; Matsui and Yamatani 2000; Kaufmann *et al*. in prep.). Because mangroves and peat swamp forests have high root–shoot ratios and occur on organic-rich soils several metres deep, the claim has been made that they may contain the largest forest carbon pools on earth (Murdiyarso et al. 2009).

Much attention in recent years has been given to peat swamp forests and their role in climate change mitigation while mangroves have been prioritised to a much lesser extent. In contrast to peatlands, however, mangroves release negligible amounts of greenhouse gases and store more carbon per unit area (Chmura and Anisfeld 2003).

Large amounts of carbon are contained in mangrove soils as well as that contained in above and below ground biomass. Amounts stored are potentially of importance in REDD style schemes in which the focus is on retaining existing carbon stocks. Soils and vegetation are also important in sequestering carbon through root turnover and these fluxes will be of interest in relation to afforestation and reforestation activities.

3.1. Carbon stocks

Mangroves often have an organic-rich soil layer for the first ~0.5–5 m depth, followed by an abrupt transition to mineral soils or sands beneath (Murdiyarso *et al.* 2009). Soil carbon accounts for between 50 and 90% of total above and below ground carbon, the rest being contained in living biomass (Murray *et al.* 2011). As such, mangrove soils are of primary importance in relation to climate change mitigation, especially in relation to conversion of existing mangroves. In mangroves, peat formation primarily occurs through deposition and turnover of mangrove roots as above ground tissues rapidly decay or are transported from the system (Middleton and McKee, 2001).

Based on wide ranging measurements of soil carbon density in tidal saline wetlands around the world, and assuming a soil depth of 0.5 m, Chmura *et al.* (2003) estimated mangrove soil carbon storage at 1 012 ± 81 Mt CO_2e ha^{-1} although as average soil depths are closer to 1 m, soil carbon storage may equal over 2 024 Mt CO_2e ha^{-1}. More recently, Murray *et al.* (2011) have estimated global mean soil organic carbon in the first metre of soil to amount to 1 060 Mt CO_2e ha^{-1} in estuarine mangroves and nearly 1 800 Mt CO_2e ha^{-1} in oceanic mangroves.

At Matang mangroves in Malaysia, some 5.5 Mt CO_2e ha^{-1} yr^{-1} of soil carbon was estimated to have accumulated each year over the past 8 000 years such that conversion of the mangroves would result in the release of an estimated 275 Mt CO_2e ha^{-1} yr^{-1} to the atmosphere over a 10-year period (Ong 1993).

Following mangrove rehabilitation in abandoned shrimp pond in Thailand, soil carbon storage increased from 403 to 587 Mt CO_2e ha^{-1} in two years at lower tidal elevations. Levels of storage before and after regeneration were low compared to natural mangroves (1 357- 1954 Mt CO_2e ha^{-1}) but similar to deltaic sediment suggesting that large amounts of carbon were lost during pond construction, use and abandonment and that carbon storage could increase significantly. At higher tidal elevations, however, soil carbon storage fell by half after mangrove rehabilitation, suggesting that carbon decomposition was accelerated by drying of soils in higher tidal zones (Matsui *et al.* 2010). As such, it was concluded that areas in which mangroves grow well are likely to sequester carbon whereas areas in which drying occurs may become net sources of carbon.

The above ground biomass (AGB) of mangrove forests in Kien Giang Province ranges from 10 Mt DW ha^{-1} in riverine, upper intertidal scrub vegetation to 424 Mt DW ha^{-1} in a multi-stemmed *R. apiculata plantation*.[5] The mean AGB was 126 Mt DW ha^{-1}, equivalent to around 231 Mt CO_2e ha^{-1}. This is slightly lower than the IPCC default value of 180 Mt DW ha^{-1} (330 Mt CO_2e ha^{-1}) for terrestrial

[5] GTZ (2010), Assessment of Mangrove Forests, Shoreline Condition and Feasibility for REDD in Kien Giang Province, Viet Nam: A Technical Report, GTZ, Rach Gia.

tropical forest. However, much of the mangroves are in a degraded state and this carbon may only account for between 10 and 50% of the total ecosystem carbon. Above ground standing biomass of pristine mangroves at Matang mangroves in Malaysia was estimated at around 733 Mt CO_2e ha^{-1} (Ong 1993).

A range of AGB measurement made in Viet Nam, Thailand and Malaysia are shown below together with carbon dioxide equivalent figures (Table 3.1).

Table 3.1. Above ground biomass figures from *Rhizophora Apiculata*

Location	Age	AGB (Mt Dry Wt ha^{-1})	Mt CO_2e ha^{-1}
Ca Mau, Viet Nam	5	41.9	76.8
Ca Mau, Viet Nam	10	143.4	262.9
Ca Mau, Viet Nam	15	202.8	371.8
Ca Mau, Viet Nam	25	277.6	508.9
Ca Mau, Viet Nam	35	326.9	599.3
Thailand	3	65.4	119.9
Thailand	25	344.0	630.7
Thailand	15	159.0	291.5
Malaysia	5	106.4	195.1
Malaysia	18	352.0	645.3
Malaysia	85	576.0	1056.0
Malaysia	20	114.0	209.0

Source: Several sources cited in McNally *et al.* (2011).

Total ecosystem carbon storage (above and below ground) in three contrasting mangrove ecosystems, representing marine or oceanic mangroves in North Sulawesi (Bunaken National Park), river delta mangroves in Central Kalimantan (Tanjung Puting National Park) and lagoon-associated mangroves in Central Java (Segara Anakan) showed that total carbon storage is exceptionally high compared with most forest types, with a mean of 3 549 Mt CO_2e ha$^{–1}$ and range of 3 164–3 934 Mt CO_2e ha$^{–1}$ (Kauffman *et al.* in prep).

These carbon stocks result from a combination of large-stature forest (trees up to ~2 m in diameter) and organic-rich peat soils to a depth of 5 m or more. Above ground carbon stocks were widely variable depending on stand composition and history. Although above ground pools were up to 733 Mt CO_2e ha$^{–1}$ at the stand scale, below ground pools accounted for 72%–99% of the total ecosystem carbon. Ecosystem carbon pools and soil depths did not vary consistently with distance from the ocean edge.

Carbon stored in mangroves at sites in Palau ranged from 1 756 Mt CO_2e ha^{-1} in the seaward zone to 3 916 Mt CO_2e ha^{-1} in the landward zone, while in Yap (Federated States of Micronesia) carbon storage ranged from 3 128 to 5 078 Mt CO_2e ha^{-1}. Soils contained ~70% of the ecosystem carbon stocks (Kauffman *et al*. in prep).

Figures presented above suggest that 'ball park' figures of 1 000-2 000 Mt CO_2e ha^{-1} for soil carbon and of up to 1 000 Mt CO_2e ha^{-1} for above ground biomass, but that stocks may he higher on deep soils and covered with un-degraded mangroves.

3.2. Carbon sequestration

Using a large global dataset, Chmura et al. (2003) estimated soil carbon sequestration in salt marshes and mangroves at 2.1 Mt CO_2e ha^{-1} yr^{-1}; no significant differences were evident between salt marshes and mangroves.

Sediment CO_2 sequestration in mangrove sites in Japan, Viet Nam, Thailand and Indonesia were estimated at 7.0, 7.3, 18.0, 8.8 Mt CO_2e ha^{-1} yr^{-1}, respectively (Tateda *et al*. 2007).

Following mangrove rehabilitation in abandoned shrimp ponds in Thailand, soil carbon storage increased at 91.7 Mt CO_2e ha^{-1} yr^{-1} from 110 to 160 Mt C ha^{-1} in two years at lower tidal elevations.

At higher elevations, however, soil carbon storage fell by half suggesting that carbon decomposition was accelerated due to drying of soils (Matsui *et al.* 2010).

Global datasets estimate net primary productivity of mangroves at 13.625 ± 4.5 Mt C ha^{-1} yr^{-1} or just under 50 Mt CO_2e ha^{-1} yr^{-1} with litter fall, wood and root production accounting for ~31, 31, and 38% of the overall production respectively (Bouillon *et al*. 2008).

CO_2 fixation (above and below ground) in 10 year old reforested *Kandelia candel* mangrove in Thanh Hoa Viet Nam was estimated as 34.3 and 26.6 Mt CO_2e ha^{-1} yr^{-1} by gas exchange and growth curve analysis respectively. (Okimoto, *et al*. 2008).

An early study of the Matang mangroves in Malaysia estimated rates of above ground carbon accumulation in pristine mangroves at around 33 Mt CO_2e ha^{-1} yr^{-1} (Ong 1993).

A summary of Clean Development Mechanism projects in a range of forest types is shown in Annex I. The average carbon sequestration rate over all projects is 9.6 Mt CO_2e $ha^{-1}yr^{-1}$, with a range of 4-34 Mt CO_2e $ha^{-1}yr^{-1}$. The figures above show that CO_2 sequestration rates in mangroves may be much higher but also are also highly variable. Mangrove regeneration under good conditions is likely to provide very high rates of sequestration where soil carbon is included. Comparison with available information on worldwide projects working on carbon credit sales in mangrove areas shows that claimed sequestration rates are highly variable (carbon sequestration in Mt CO_2e $ha^{-1}yr^{-1}$, numbers in brackets refer to example numbers in Annex II): 33.2 (1), 8.8 (2) 16.875 (3), 1.33 (5), 23.8 (6), 28.7 (7).

3.3. Other greenhouse gas fluxes

Methane (CH_4) has a global warming potential 23 times that of CO_2 over a 100 year time horizon (Ramaswamy *et al.* 2001). Some tidal saline wetlands have been reported to be large sources of methane while others have been reported to be methane sinks. In Thailand, mangroves have been reported to be a net source of atmospheric methane with the source strength being very small compared with freshwater wetlands, although emissions vary with tidal period and position/species within the tidal range (Lekphet *et al.* 2003). Emission rates also vary seasonally with the highest rate in the rainy season followed by the summer and cold seasons (Lekphet 2005).

Tateda *et al.* (2007) estimated that the amount of nitrous oxide (N_2O) emission from mangrove ecosystems is lower than carbon fixation in terms of greenhouse impacts but that the concentration of N_2O in seawater in the rainy season and levels of N_2O in sub-surface sediments were high. The greenhouse effect in terms of CO_2 equivalent from N_2O released from mangrove sediments to the air was estimated at -1.8-7.0 Mt CO_2e ha^{-1} yr^{-1}, while that passing from sediment to water to air was estimated at -0.1-1.1 Mt CO_2e ha^{-1} yr^{-1}. The combined values were thus small compared to the CO_2 sequestration by mangrove ecosystem (18.3-36.7 Mt CO_2e ha^{-1} yr^{-1}).

3.4. Uncertainties

Published global estimates on central components of the mangrove carbon budget have several shortcomings (Bouillon *et al*. 2008):

(i) information on mangroves is very limited and carbon budgets are based on relatively small data sets; and

(ii) estimates on below ground allocation and wood production are still scarce. Moreover, mangrove systems occur in a wide range of environmental settings, and the degree of organic matter retention and export vary according to geomorphology, tidal amplitude, local climate, vegetation type, and biotic influences, etc.

In relation to point (ii), despite the large average stocks of carbon in mangrove soils, the range of soil carbon densities from single mangrove sites is broad with respect to the global range and great variability exists within regions (Chmura 2003). There is also high variability in carbon accumulation rates within different mangrove zones. Much of the variation can be explained by differences in suspended sediment supply and tidal water inundation.

More generally, many uncertainties exist in relation to carbon cycling, particularly as regards the fate of detritus. Most mangrove detritus that enters the sediment is degraded by micro-organisms while organic carbon that escapes microbial degradation is stored in sediments. Many mangrove forests, however, also lose a significant fraction of their net primary production to coastal waters, during tidal flows, although large differences occur between mangrove forests with respect to litter production and export (Kristensen *et al*. 2008).

Available estimates of various carbon sinks (organic carbon export, sediment burial, and mineralization) suggest that >50% of the carbon fixed by mangrove vegetation is unaccounted for (Bouillon *et al*. 2008). It is likely that tidal exports of dissolved inorganic carbon and fluxes from intertidal sediments, that are currently underestimated, make up a large proportion of the unaccounted carbon.

Measurements made show that mangroves release high levels of dissolved inorganic carbon to estuaries and function in removing CO_2 from the atmosphere and releasing it into estuarine waters (Miyajima *et al*. 2009). Sunlight destroys molecules during transport offshore, removing about one third of mangrove-derived dissolved inorganic carbon, while the remainder is thought to be distributed over the oceans (Dittmar *et al*. 2006).

These uncertainties have to be taken into account when planning carbon projects as variability increases sampling intensity and cost. More importantly, as carbon accounting is generally conducted on an area basis, export of carbon to areas outside the project area, as may be common, will count as an emission regardless of whether the carbon is ultimately accreted or released into the atmosphere.

High levels of variability and an incomplete understanding of carbon cycling and the cycling of other greenhouse gasses are likely to act as impediments in bringing carbon projects in mangrove areas to market. In particular, carbon accounting frameworks covering the wide range of situations that may be encountered in implementing efforts to increase sequestration, or reduce emissions, of carbon in mangroves need to be developed. Existing accounting methodologies applicable to forests in general can be used for some mangrove related climate change mitigation activities, although there are significant limitations as discussed in the following section.

4. Accommodation of mangrove carbon sequestration in climate change mitigation mechanisms and standards

As detailed in the preceding sections, there are several distinct carbon sinks in mangrove ecosystems including above and below ground living biomass, leaf litter and dead wood, soil carbon, carbon suspended as detritus in water bodies and dissolved organic carbon (DOC).

Broadly, climate change mitigation activities in mangroves can consider the following areas:

- rehabilitating degraded mangroves (involving sequestration of carbon in above and below ground biomass);
- re-establishing mangroves including changes in soil hydrology (involving sequestration of carbon in above and below ground biomass and soil); and,
- Reducing deforestation and degradation in mangroves (potentially involving reduction of losses of carbon from above and below ground biomass *and* soil).

Two main carbon payment mechanisms for climate change mitigation are currently applicable for forestry. The Clean Development Mechanism, which having been developed under the Kyoto Protocol qualifies as a 'compliance' mechanism credits from which can be sold in compliance markets which normally fetch relatively high prices, and the Voluntary Carbon Standard (VCS), which qualifies as a 'non-compliance' or voluntary standard. Carbon emissions reduction can, of course, also be sold 'over the counter' on an unregulated basis as agreed by the contracting parties although one of the carbon standards is often adopted. There are also other carbon emissions reduction standards such as the Gold Standard, but of all the voluntary standards, none cater for forests or are as widely recognised as the VCS.

Both the CDM and VCS consider pools of carbon but not fluxes, which means that even if carbon is fixed and transported outside the defined project area, it will not be eligible for carbon credits. This is relevant in the context of 'out-welling' of detritus and DOC from mangrove areas into coastal waters. If carbon fluxes are to be accounted for, a change in the current system of accounting will be required (DFN 2010).

Only net growth of above and below ground biomass is considered by the small scale CDM methodology[6] applicable to mangroves (AR-AMS0003) while burial of litter resulting from annual turnover is also considered in large-scale AR-CDM methodologies and under the Voluntary Carbon Standard. More details of both schemes are provided in the following sections.

4.1. Clean Development Mechanism (CDM)

The Clean Development Mechanism (CDM) of the Kyoto Protocol, which aims to reduce emissions in developing countries by funnelling payments from industrialized countries to help meet their emissions targets, covers only afforestation and reforestation (A/R) activities.

To be eligible for the CDM project participants have to provide evidence that the land within the planned project boundary does not contain forest or young trees that will become forest under the definition defined by the designated national authority (DNA) or is temporarily unstocked forest.[7] They must also demonstrate, for reforestation projects, that the land was not forest at the end of 1989 and for afforestation products that the land has not been forest for at least 50 years.

Only a few forestry projects have successfully registered for CDM. There are currently a total of 56 A/R projects at various stages of development in the CDM pipeline, only 15 of which are registered and none of which have yet been issued Certified Emission Reductions (CERs) (McNally *et al.* 2010). More widespread implementation has been curtailed by methodological complexities related to leakage, permanence, additionality and monitoring. The low price of temporary credits available for

[6] Less than 16 000 CO_2e/yr

[7] http://cdm.unfccc.int/methodologies/ARmethodologies/tools/ar-am-tool-10-v1.pdf

A/R activities and the small proportion of revenue from CDM in relation to other revenues from A/R have also been an obstruction (Neeff and Henders 2007).

Large scale projects (>16 000 Mt CO_2 equivalent per year) include above- and below ground biomass carbon pools and also dead wood, litter and Soil Organic Carbon (SOC) although the CDM tool for estimating SOC is not applicable to organic soils or wetlands.[8]

Small scale A/R projects must fulfil the following conditions:[9]

(1) Net anthropogenic GHG removals by sinks must be less than 16 000 tonnes of CO_2 per year; and

(2) The projects must be developed or implemented by low-income communities and individuals as determined by the host Party.

Implementation of small scale projects is less complex than large scale and probably more relevant for the RFLP where the extent and fragmentation of mangroves in project focal areas and time limitations are deciding factors.

There are currently 8 approved small scale A/R methodologies and 12 large scale methodologies approved with another 4 awaiting review.

Small scale AR-CDM project methodologies include the following:

AR-ACM0002 Afforestation or reforestation of degraded land without displacement of pre-project activities;

AR-AMS0001 Simplified baseline and monitoring methodologies for small-scale A/R CDM project activities implemented on grasslands or croplands with limited displacement of pre-project activities;

AR-AMS0002 Simplified baseline and monitoring methodologies for small-scale afforestation and reforestation project activities under the CDM implemented on settlements;

AR-AMS0003 Simplified baseline and monitoring methodology for small scale CDM afforestation and reforestation project activities implemented on wetlands;

AR-AMS0004 Simplified baseline and monitoring methodology for small-scale agroforestry – afforestation and reforestation project activities under the clean development mechanism;

AR-AMS0005 Simplified baseline and monitoring methodology for small-scale afforestation and reforestation project activities under the clean development mechanism implemented on lands having low inherent potential to support living biomass;

AR-AMS0006 Simplified baseline and monitoring methodology for small-scale silvopastoral – afforestation and reforestation project activities under the clean development mechanism; and,

AR-AMS0007 Simplified baseline and monitoring methodology for small-scale A/R CDM project activities implemented on grasslands or croplands.

AR-AMS0003 is applicable for mangrove areas but does not allow for change in the hydrological process, because of CH_4 and NO_x emissions from rewetting land (DFN 2010). Many mangrove areas have been degraded by wood cutting for fuel wood and charcoal production and the methodology is aimed at A/R projects in such degraded mangroves. Otherwise, in areas where land has been converted following degradation to other uses by bunding for agricultural production or excavation and construction of dykes for aquaculture, the methodology would not be applicable.

Importantly, the following eligibility criteria which apply for AR-AMS0003, include the following:[10]

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[8] http://cdm.unfccc.int/methodologies/ARmethodologies/tools/ar-am-tool-16-v1.pdf

[9] http://cdm.unfccc.int/methodologies/documentation/meth_booklet.pdf

[10] http://cdm.unfccc.int/methodologies/DB/Y77PTS8P50VTJBHQ46A06GZ6EZSIVL

- Project activities conform to applicable national policies and legislation for wetlands;
- Afforestation or reforestation is on degraded wetlands, which may be subject to further degradation and have a tree and / or non tree component that is declining or in a low carbon steady-state;
- Project activities shall not lead to changes in hydrology. (GHGs emitted from wetlands may consist of CO_2, CH_4 and N_2O but this condition ensures that hydrology is not changed and that the chemical properties of the wetland soils influencing the GHG emissions therefore will not change[11]); and,
- Carbon pools considered are above- and below-ground biomass (i.e. living biomass) of trees. (soil carbon is not included).

Project participants must demonstrate that the project land is degraded and eligible for the project and that the project activity is additional. Additionality is proved by demonstrating that the project activity would not have occurred anyway due to the existence of barriers related to investment, institutions, technology, local tradition, prevailing practice, ecological conditions, or social conditions.

A new CDM methodology has recently been submitted by International Union for the Conservation of Nature, which, if approved will enable sale of carbon credits for large-scale restoration of degraded tidal (mainly mangrove) forests. The methodology may not be commonly applicable in Asia as it explicitly excludes ecological mangrove restoration, reclamation or displacement of fish ponds (William Battye, pers comm.)

Project costs include project development, implementation and operational costs as well as the CDM transaction costs. McNally *et al.* (2011) have estimated costs for Viet Nam as follows:

- The CDM transaction costs are one-off, up-front costs for CDM registration and amount to around US$ 160 000, including CDM consultants, validation and registration fees. Costs for verification, which must be completed every five years, are approximately US$ 14 000.
- Project development costs including designing the project, negotiating approval, consultation with the communities, establishment of a management team and training amount to around at least US$ 130 000.
- Project implementation, including planting costs are around US$ 1 500ha^{-1}.
- Project management and perhaps periodic inter-planting may be a further US$ 30 000 yr^{-1} although part of this could be paid to communities.

Over a 16 year project period, these costs come to US$ 1 562 000 for 500 hectares. This means that for a site where sequestration rates were 20 Mt CO_2e ha^{-1} yr^{-1}, a carbon credit price of U$$ 10 would be necessary to make a project economically viable. With a rate of 30 Mt CO_2e ha^{-1} yr^{-1}, a price of US$ 7 would be necessary. With a rate of above 32 Mt CO_2e ha^{-1} yr^{-1}, the project would exceed the maximum size for a small CDM project, although the arithmetic would still apply for a voluntary carbon project using a CDM methodology (see below).

With the current price of temporary Certified Emissions Reductions[12] (tCER) of around US$ 4, only a site where sequestration rates were over 49 Mt CO_2e ha^{-1} yr^{-1}, would be profitable. It is possible that such rates would be attainable under the right conditions and with soil carbon pools included (which for a small project would only be possible under VCS – see below).

It should be noted that these calculations do not take into account risks such as failing to be registered, forest loss, large scale erosion, planting failure, etc. at the same time, benefits that mangroves provide

[11] IPCC Good Practice Guidance for Land Use, Land-Use Change and Forestry, available at http://www.ipcc-nggip.iges.or.jp/public/gpglulucf/gpglulucf.html

[12] tCERs are available for forestry projects under CDM and sell for around a third of the price of the standard CERs (McNally *et al.* (2011). Also see: http://www.carbonpositive.net/viewarticle.aspx?articleID=1304

such as non-wood forest products (NWFPs), coastal protection and support for fisheries protection, etc. are not taken into account.

There are likely to be changes in the CDM scheme after expiration of the Kyoto agreement in 2012 and as such, investment in a CDM project may be inadvisable, especially given the lack of financial feasibility for small areas.

4.2. Voluntary Carbon Standard (VCS)

The Voluntary Carbon Standard includes forestry in the AFOLU (Agriculture, Forestry and Other Land Uses) group of emissions reduction activities.[13] Three project categories could potentially be applied to mangroves (McNally 2011):

- Afforestation, Reforestation and Revegetation (ARR). There are no VCS approved methodology for afforestation/reforestation yet, but CDM methodologies could be used.
- Reducing Emissions from Deforestation and Degradation (REDD). Projects must demonstrate a baseline scenario and the expected reduction in carbon emissions and must also account for leakage and permanence risks. There are three project categories:
    - Avoiding planned deforestation (APD). Evidence of planned conversion is required;
    - Avoiding unplanned frontier deforestation and degradation (AUFDD); and
    - Avoiding unplanned mosaic deforestation and degradation (AUMDD).
- Improved Forest Management (IFM). There are four project categories:
    - Conversion from conventional logging to reduced impact logging (RIL);
    - Conversion of logged forests to protected forests (LtPF);
    - Extending the rotation age of evenly aged managed forests; and,
    - Conversion of low-productive forests to high-productive forests (LtHP).

If forest degradation is legally sanctioned, then stopping forest degradation (e.g. logging) is an eligible activity under IFM, otherwise it qualifies under REDD. Different project categories can be combined into a single project.

Currently approved VCS methodologies in different categories include:

- VM0003 Methodology for Improved Forest Management through Extension of Rotation Age;
- VM0004 Methodology for Conservation Projects that Avoid Planned Land Use Conversion in Peat Swamp Forests;
- VM0005 Methodology for Conversion of Low-productive Forest to High-productive Forest;
- VM0006 Methodology for Carbon Accounting in Project Activities that Reduce Emissions from Mosaic Deforestation and Degradation;
- VM0007 REDD Methodology Modules (REDD-MF); and,
- VM0009 Methodology for Avoided Mosaic Deforestation of Tropical Forests.

CDM A/R methodologies are also eligible under VCS. A number of additional methodologies are under development, although no methodologies relate specifically to mangroves. A "Peatland Rewetting and Conservation" (PRC) category was, however, issued for public consultation 19 May

[13] The "Voluntary Carbon Standard 2007.1" provides general guidance for developing VCS projects. The "Guidance for Agriculture, Forestry and Other Land Use Projects" provides specific guidance to AFOLU projects.

2010 with final release targeted for January 2011.[14] This methodology may be useful for mangrove rewetting as, in some cases, mangroves are considered peatlands. In order to use the PRC guidelines, a project area should meet the definition of peatland.[15]

At the time of writing, VCS had not heard of any proposals to develop a REDD methodology with the inclusion of soil carbon, which would fall under both the REDD and PRC categories.

There are several important differences between CDM and VCS (MvNally *et al.* 2011).

- Registration with the VCS is less complex and less time consuming than CDM and transaction costs are lower.
- VCS forestry projects adopt a buffer approach to impermanence which serves to reduce revenues per hectare.
- VCS allows consideration of all carbon pools even for small-scale projects, including above-ground biomass, below ground biomass, dead wood, litter, soil carbon and wood products.
- Under VCS, AFOLU projects can have a crediting period from 20 to 100 years (compared to 16 years on a renewable basis or 30 years on a one-off basis for AR CDM projects).
- The VCS scheme is voluntary and is thus not limited to the term of the Kyoto Protocol.
- Projects on land converted from 'native ecosystems' within 10 years prior to the project start date are not eligible under the VCS, while under the CDM, land that has been 'forest' in the period since 1989 is not eligible for reforestation.

VCS has a buffer approach to managing risk associated with impermanence in forestry activities. Under this approach, a proportion of the carbon credits may not be sold until risk is proven to be low. The required buffer may be as high as 60% where risk is judged to be high and only 10% of the buffer can be released every five years if risks are proven to be low. The price of the resulting credits has proven to be higher than that of the temporary Certified Emissions Reductions (tCERs) sold under the CDM for forestry projects.

Set-up costs for VCS projects can be considerable although projects are commonly believed to be less complex than under the CDM. A large VCS project in lowland forest in Cambodia is estimated to have cost US$ 300 000 – US$ 400 000 (Tom Evans pers. comm.). As such, it is likely to be uneconomically feasible to certify small projects unless costs could be considerably reduced through availability of existing inventory data or if the potential emissions reductions were very large and immediate (e.g. cancellation of a shrimp farm zoning decision that would reverse an expected 100% deforestation event in the space of a few years).

4.3. Key considerations

The main considerations in applying for carbon verification are high set-up costs, insufficient methodological development and a lack of knowledge of carbon cycling in mangrove ecosystems, on the one hand, and low carbon prices on the other. More general risks identified in investing in forest carbon have recently been identified by Forest Trends (2011, Box 1).

The average sale price of forest credits cited by Chenost *et al*. (2010) was 3 Euros (~US$ 3.9) per Mt CO_2e for CDM and 4.7 (US$ 6.1) per Mt CO_2e for voluntary over-the-counter markets[16]. Given that

[14] http://www.v-c-s.org/docs/VCS-Program-PRC-Public-Consultation-Document.pdf

[15] Peatlands are a subset of the FAO class of histosols (or: organic soils). The FAO (2006/7) definition of organic soil (histosol) is complex; it refers to thickness of soil layers and organic content in relation to their origin, underlying material, clay content and water saturation. Under the VCS PRC, a peatland is an area with a layer of naturally accumulated organic material (peat) of at least 30 cm in thickness at the surface (excluding the plant layer), which consists of at least 30% organic material by dry weight. Peat originates because of water saturation. Peat soil is either saturated with water for long periods or (artificially) drained. (PRC public consultation document: http://www.v-c-s.org/docs/VCS-Program-PRC-Public-Consultation-Document.pdf)

[16] US$ conversions assume exchange rate of US$1.3 per Euro.

international negotiations on a post-Kyoto climate change mitigation mechanism are progressing only slowly and large global emitters and potential buyers of carbon are demonstrating reluctance in agreeing to deep cuts in emissions, while major carbon markets look set to remain relatively closed to forest related carbon credits (e.g. European Emissions Trading Scheme), carbon prices are not set to increase rapidly. The global economic slowdown is also likely to keep carbon prices low and as such times for investing could be better.

Murray *et al.* (2011) estimated that, assuming costs at upper bounds, returns on mangrove protection at carbon prices of US$ 5 per Mt CO_2e are negative in 40-50% of mangrove countries and around 15% of countries at carbon prices of US$ 15. The costs of protection used were mean values for each country and consisted of protected-area establishment and management costs plus opportunity costs. The study did not, however, take into account the high transaction costs of bringing carbon to market and the negative correlation between opportunity costs of land and quality of institutional environments. As such, mangrove protection costs may be raised in countries with low opportunity costs by costs associated with institutional inefficiencies.

Box 1. The key risks identified by stakeholders in investing in forest carbon.

(1) uncertainty around whether or not regulatory markets will include forest carbon, which has adversely affected demand;

(2) a lack of clarity on legal issues associated with project design and transactions; and,

(3) a lack of approved methodologies for measuring forest carbon in the voluntary market.

Additionally, projects have high costs associated with carbon measurement and forest management that are borne prior to assessment of potential revenues.

It remains to be seen whether key up-front costs will continue be borne primarily by philanthropic and public sector sources, or whether the private sector will engage more actively and broadly.

Source: Forest Trends (2011)

In Viet Nam, McNally *et al.* (2011) identified the following critical issues:

- The willingness of the local People's Committee to devolve ownership and power over mangrove areas to local people, particularly when competing with other potential lucrative uses of the tidal flats such as renting/selling to clam or aquaculture farmers;
- The problem of allocating limited areas of mangrove forest between large numbers of households due to dense populations in most coastal areas and the current use of the mangrove areas by many households (this would support community, rather than household allocation);
- The need to provide sufficient incentives per hectare of forest to the local management team to ensure that the mangroves are adequately protected and tended (based on CER revenue sharing and rights to other benefits from the mangroves (such as deadwood, aquatic products etc.); and,
- The exclusion of some households from mangrove areas in order to have clearly defined beneficiaries, particularly those who are traditional users of the area and those who need to go through the mangroves to access the bare inter-tidal flats and fishing grounds. It could be the landless poor are most affected.

Taking into account these risks and complexities and in view of the mangrove resources in RFLP countries and the needs of the project to provide livelihood benefits to fishing communities, recommendations are given in the next section.

5. Recommendations

Given the mangrove resource situation in the six RFLP countries, the current state of knowledge of carbon cycling in mangroves, the current state of carbon verification standards and the current and likely future prices of carbon, it is recommended that efforts are made to develop potential mechanisms enabling coastal communities to benefit financially from mangrove related activities. For example the following steps could be considered:

- Identify potential mangrove areas and consult with stakeholders to determine interest;
- Provide livelihoods support through traditional mangrove related activities and alternative means (e.g. disaster risk reduction) in association with (a) national NGO(s) or local government;
- Facilitate agreement over mangrove restoration/conservation between authorities and the local community;
- Identify possible (a) corporate[17] entity/ies to provide sponsorship and facilitate agreement with the local community and authorities over payment for mangrove conservation;
- Identify inter-governmental or (a) civil society institution(s) to act provide local technical support and act as intermediary;
- Work with consultants to:
    a. Work towards carbon accreditation including addressing any methodological issues, and also work towards accreditation with social and environmental standards (e.g. CCB); **or**
    b. Develop an alternative lower cost accreditation framework that does not yield carbon credits, but provides a socially and environmentally sound 'sustainable development product' focussing on payments for mangrove protection and aimed at corporate buyers.

Option b. may prove the only economically feasible alternative where mangrove areas are less than 1 000 – 2 000 hectares. The exception would be in an area of mangroves planned for conversion to aquaculture where large amounts of carbon could be released although, even under these circumstances methodological developments to existing carbon accounting frameworks would be necessary.

More generally, given the variability of mangrove forests and the environmental, social and environmental situations in which they exist, it is of great importance to locate potential field sites such that interventions can be designed with specific situations in mind, e.g. potential sequestration rates, threats to existing carbon, local support, etc. The backing of local people and of authorities will also be of primary importance in developing projects. The existence of clear alternative economic and non-economic benefits from mangroves is further likely to support project success, as will the levels of interest and demand from the local communities and authorities.

[17] Corporate support for mangrove-carbon projects has also been provided, most notably by Danone, which has set up a funding mechanism and supported various international meetings. Others may become interested as confidence grows and *ad hoc* agreements between corporate entities and mangrove stakeholders could take many forms.

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Annex I. CO_2 reductions by global CDM forestry projects as of 10 Feb 2011

Registered	Title	Country	Methodology *	Reductions **	Area (ha)	Crediting Period	Reductions Mt CO_2e ha^{-1} yr^{-1}
10-Nov-06	Facilitating Reforestation for Guangxi Watershed Management in Pearl River Basin	China	AR-AM0001 ver. 2	25 795	4000	01 Apr 06 - 31 Mar 36 (Fixed)	6
30-Jan-09	Moldova Soil Conservation Project	Republic of Moldova	AR-AM0002 ver. 1	179 242	20,289.91	11 Sep 08 - 10 Sep 28 (Renewable)	9
23-Mar-09	Small Scale Cooperative Afforestation CDM Pilot Project Activity on Private Lands Affected by Shifting Sand Dunes in Sirsa, Haryana	India	AR-AMS0001 ver. 4	11 596	369.87	23 Mar 09 - 22 Mar 29 (Renewable)	31
28-Apr-09	Cao Phong Reforestation Project	Viet Nam	AR-AMS0001 ver. 4	2 665	365	01 May 09 - 30 Apr 25 (Renewable)	7
05-Jun-09	Reforestation of severely degraded landmass in Khammam District of Andhra Pradesh, India under ITC Social Forestry Project	India	AR-AM0001 ver. 2	57 792	3070.19	02 Jul 01 - 01 Jul 31 (Fixed)	19
11-Jun-09	Carbon sequestration through reforestation in the Bolivian tropics by smallholders of "The Federación de Comunidades Agropecuarias de Rurrenabaque"	Bolivia	AR-AMS0001 ver. 4	4 341	247 ha (plan for 6000 ha)	12 Feb 08 - 11 Feb 29 (Fixed)	N/A
21-Aug-09	Uganda Nile Basin Reforestation Project No.3	Uganda	AR-AMS0001 ver. 5	5 564	341.9	24 Nov 08 - 23 Nov 28 (Renewable)	16
06-Sep-09	Reforestation of croplands and grasslands in low income communities of Paraguarí Department, Paraguay	Paraguay	AR-AMS0001 ver. 4	1 523	215.2	25 Jul 07 - 24 Jul 27 (Fixed)	7
16-Nov-09	Afforestation and Reforestation on Degraded Lands in Northwest Sichuan, China	China	AR-AM0003 ver. 3	23 030	2,251.80	04 Jan 07 - 03 Jan 27 (Renewable)	10
16-Nov-09	"Reforestation, sustainable production and carbon sequestration project in José Ignacio Távara´s dry forest, Piura, Peru"	Peru	AR-AM0003 ver. 4	48 689	8,980.52	02 Nov 09 - 01 Nov 29 (Renewable)	5
07-Dec-09	Humbo Ethiopia Assisted Natural Regeneration Project	Ethiopia	AR-AM0003 ver. 4	29 343	2728	01 Dec 06 - 30 Nov 36 (Fixed)	11

Registered	Title	Country	Methodology *	Reductions **	Area (ha)	Crediting Period	Reductions Mt CO_2e ha^{-1} yr^{-1}
02-Jan-10	Assisted Natural Regeneration of Degraded Lands in Albania	Albania	AR-AM0003 ver. 4	22 964	6272.36	20 Dec 04 - 19 Dec 24 (Renewable)	4
15-Jan-10	The International Small Group and Tree Planting Program (TIST), Tamil Nadu, India	India	AR-AMS0001 ver. 5	3 594	106	01 Jan 04 - 31 Dec 33 (Fixed)	34
16-Apr-10	Forestry Project for the Basin of the Chinchiná River, an Environmental and Productive Alternative for the City and the Region	Colombia	AR-AM0004 ver. 3	37 783	4,538.70	04 Jun 02 - 03 Jun 22 (Renewable)	8
27-May-10	Nerquihue Small-Scale CDM Afforestation Project using Mycorrhizal Inoculation in Chile	Chile	AR-AMS0001 ver. 5	9 292	312.1	01 Jan 03 - 31 Dec 22 (Renewable)	30
21-Jul-10	Reforestation as Renewable Source of Wood Supplies for Industrial Use in Brazil	Brazil	AR-AM0005 ver. 2	75 783	11711.37	10 Nov 00 - 09 Nov 30 (Fixed)	6
15-Sep-10	Reforestation on Degraded Lands in Northwest Guangxi	China	AR-ACM0001 ver. 3	87 308	8671.3	01 Jan 08 - 31 Dec 27 (Renewable)	10
03-Dec-10	'Posco Uruguay' afforestation on degraded extensive grazing land	Uruguay	AR-ACM0001 ver. 3	21 957	820	03 Dec 10 - 02 Dec 40 (Fixed)	27
07-Jan-11	AES Tietê Afforestation/Reforestation Project in the State of São Paulo, Brazil	Brazil	AR-AM0010 ver. 4	157 635	13,939	15 Dec 00 - 14 Dec 30 (Fixed)	11
Review Requested	Argos CO2 Offset Project, through reforestation activities for commercial use	Colombia	AR-AM0005 ver. 3	36 930	2754	01 Feb 05 - 31 Jan 30 (Fixed)	13
Requesting Registration	Reforestation of grazing Lands in Santo Domingo, Argentina	Argentina	AR-AM0005 ver. 3	66 038	2292	02 May 07 - 01 May 27 (Renewable)	29
Requesting Registration	Ibi Batéké degraded savannah afforestation project for fuelwood production (Democratic Republic of Congo)	DR Congo	AR-ACM0001 ver. 3	54 511	4225.5	01 Jul 08 - 30 Jun 38 (Fixed)	13
Review Requested	India: Himachal Pradesh Reforestation Project – Improving Livelihoods and Watersheds	India	AR-ACM0001 ver. 3	41 400	222,951	01 Jul 06 - 30 Jun 26 (Renewable)	

* AM - Large scale, ACM - Consolidated Methodologies, AMS - Small scale
** Estimated emission reductions in metric tonnes of CO_2 equivalent per annum (as stated by the project participants)

Annex II. Worldwide projects working on mangrove carbon credit sales - past, present and future

Of the RFLP countries, there are currently mangrove carbon projects in Indonesia, Thailand and Viet Nam.

1. Batam City, Indonesia

Funding agency/sponsor: The project is led by **YL Invest Co., Ltd., Japan**, and implemented by MoF of Batam City, the Republic of Indonesia, PT. Yamamoto Asri (the Indonesian subsidiary of YL Invest Co., Ltd., Japan) and the local community.

Budget: ukn

Start date: Sept 6th 2006 (backdating from 2010 CDM proposal submission?)

End date: 30 years

When carbon sales expected? currently "Operational"

Conservation or rehabilitation? Afforestation or Reforestation

Soil carbon included in emissions assessment: No (above ground and below ground part of the carbon pool, but not the dead wood, litter or soil)

Sequestration rate: Estimated total reduction = 114 623 ton CO2-e (115 ha over 30 yrs) or 3 821 tonnes of ton CO2/yr or 33.2 ton/ha/yr.
(*Monitoring of baseline net GHG removals by sinks is not necessary according to the applied methodology AR-AMS003.)
Carbon stock: "According to AR-AMS0003 Version 01, the baseline of the project can be taken as zero as carbon stocks are stabilized in the land prior to the project implementation."

Carbon standard: CDM (JACO verified) lCERs issued

Carbon buyer: YL Invest Co. (Japan)

Area: 115 hectares

Reference:

http://cdm.unfccc.int/Projects/Validation/DB/Q94TKNG9V6GRFOTRKPLWDV2GHBCFWW/view.html

http://www.forestcarbonportal.com/project/small-scale-and-low-income-community-based-mangrove-afforestation-project-tidal-flats-three-

2. Indonesia

MAP Locations: Bengkalis Island – Riau, Simeulue Island, Aceh.

Partner Locations: Tomini Bay, Sulawesi, West Bali, Bali.

Funding agency/sponsor: Danone, UNDP-GEC, IUCN-ELG, US dept of forestry

Budget: € 1,798,782 - € 2,308,642

Start date: Five years from final project approval. Approx Feb 2010

End date: Estimated Jan 2015

When carbon sales expected? Ukn

"At this stage it is not possible to detail the exact model for accessing and utilizing carbon finance……" (pg 15)

Conservation or rehabilitation? Conservation and rehabilitation.

Soil carbon included in emissions assessment: yes

Sequestration rate: 2.4 ton-C ha-1 year-1 estimated for Indonesia.

Minimum of 500 ha and maximum of 1000 ha restored will result in 1000-2000 tons/CO2/yr for the life of the certificate (25 yr avg)

Minimum of 1000 ha conserved (minimum carbon stock of 700,000 tons and maximum of 1,400,000 tonnes)

Maximum of 3000 ha conserved with minimum carbon stock of 2,100,000 tonnes and maximum total carbon stock of 4,200,000 tonnes.

Carbon stock: 700 tonnes/ha degraded and 1,400 tonnes/ha rehabilitated

Carbon standard: VCS, with additional Climate Community and Biodiversity Alliance verification.

Carbon buyer: Danone? ("aim for REDD project" pg 15)

Area: 1500 to 15, 000 hectares +

Reference:
http://www.cbd.int/lifeweb/eoi/map%20concept%20paper%20for%20danone%20group.pdf

*Interesting info about restoration of Bali mangrove forest costing $60,000 a hectare. MAP-Indonesia's average cost is $1000/ha. Pg 7

3. Weru River basin in Chanthaburi province, Thailand

Funding agency/sponsor: Ministry of Natural Resources and Environment, Greenhouse Gas Management Organisation

Budget: ukn

Start date: (news article Nov 28, 2010) area earmarked, pilot project planned

End date: ukn

When carbon sales expected? ukn

Conservation or rehabilitation? conservation

Soil carbon included in emissions assessment: ukn

Sequestration rate: "it is believed" one rai of forest can absorb 2.7 tonnes of carbon a year. This equates to 16.875 tonnes carbon/ha/yr.

12 Euros per 0.4 acre on average according to enews article below. This equates to 74 Euros (~$101) per hectare or 118 611 for the whole area.

Carbon stock: ukn

Carbon standard: CDM? "Thailand has not signed up but is undertaking voluntary carbon exchange in various fields, without the verification and price controls required under the UNFCCC"

Carbon buyer: In Thailand, there is still no carbon market related to the selling and buying of carbon credits, but there are OTC trades taking place, in which developers of CDM projects and countries within the Annex I are trading credits through delegates, financial funds, and brokers.

Area: 10,000 rai (1600 ha)

Reference:
http://www.tgo.or.th/english/index.php?option=com_content&task=section&id=6&Itemid=30

http://www.nationmultimedia.com/home/2009/07/29/national/Boost-for-Thai-carbon-credit-30108570.html

http://www.bangkokpost.com/news/local/208461/carbon-trading-pilot-begins http://enews.mcot.net/view.php?id=11043

4. Kien Giang, Mekong Delta, Phu Quoc Island, Vietnam

Funding agency/sponsor: Google Earth (implemented by: CartOng, and GTZ. REDD pilot)

Feasibility study funded by: GTZ (GIZ) and AusAID

Not much information. Project may have been discontinued.

Budget:

Start date: Feasibility study July – Nov 2009

End date:

When carbon sales expected?

Conservation or rehabilitation? Reforestation, REDD?

Soil carbon included in emissions assessment:

Sequestration rate:

Carbon stock:

Carbon standard:

Carbon buyer:

Area:

Reference:

http://www.gtz-mnr.org.vn/index.php?option=com_content&task=view&id=124&Itemid=9

http://www.ausaid.gov.au/vietnam/projects/kiengiang.cfm

(this one doesn't mention Carbon Credits but is in the same area with the same organisations so should be the same project?)

5. Sine Saloum and Casamance deltas, Senegal

Funding agency/sponsor: Danone Fund for Nature (DFN, with IUCN and Ramsar). Implementation by Oceanium.

The Ramsar Convention is using the project activities as a pilot to promote wetlands environmental services in the framework of Climate Change mitigation.

Budget: ukn

Start date: Project activity started 25/02/2008

Proposal to CDM, Nov 10, 2010

End date: 30 years

When carbon sales expected? this year?

Conservation or rehabilitation? Reforestation, restoration

Soil carbon included in emissions assessment: No (above ground and below ground part of the carbon pool, but not the dead wood, litter or soil)

Sequestration rate: The net anthropogenic GHG removals by sinks as a result of the proposed A/R CDM project activity is anticipated to be around 67,850.90 tons of CO_2 equivalent during the first crediting period (between 2008 and 2037)

Annual average predicted: 2,262 tonnes of CO2e

Equivalent to 1.33 tonnes of CO2e/ha/yr

Carbon stock: Degraded wetlands, where changes in the carbon stocks in living biomass pool of trees and non-tree vegetation are assumed to be **zero** in the absence of project activity.

Carbon standard: CDM (tCERs)

Carbon buyer: Danone

Area: 1700 ha (plant 10000 trees/ha, thin to ~600 trees/ha after 6 years)

Reference:

http://cdm.unfccc.int/Projects/Validation/DB/RBOVN64H2NX9E4NB9MSDZ9369YYKLZ/view.html

***Methodology info:**

"the first registered project worldwide using AR-AMS0003."

TARASM: (which considers all the equations of AR-ASM0003) http://wbcarbonfinance.org/Router.cfm?Page=BioCF&FID=9708&ItemID=9708&ft=DocLib&CatalogID=44971

CDM:

http://cdm.unfccc.int/methodologies/DB/Y77PTS8P50VTJBHQ46A06GZ6EZSIVL/view.html

6. Gazi Bay, Kenya

Funding agency/sponsor: Aviva – will pay for initial fencing and planting, along with costs of project validation and a contribution to coordinator post.

Volunteers from: Earthwatch Institute, Kenya Marine and Fisheries Research Institute [KMFRI] and Edinburgh Napier, Edinburgh, and Bangor Universities in the UK, CAMARV

Budget: ukn

Start date: 2009

End date: 1 year

When carbon sales expected? June 2011

Conservation or rehabilitation? Restoration

Soil carbon included in emissions assessment: yes (in woody biomass and sediment)

Sequestration rate: 2023 tCO_2 benefit per annum ($12,138 potential annual income from carbon credits)

Carbon stock: no formal attempt has been made to estimate total carbon stocks but …

"This equates to approximately 155,000 t aboveground and 23,250 t belowground (178,250 t total) in the Gazi area. In addition, mangroves sequester around 1.5 t C/ha/yr-1 in accretion of new sediment, and approximately 5 t C/ha/yr-1 in new biomass (for a mature forest – rates are higher for young forests and plantations). Hence the forest sequesters an additional ~4030 t C every year."

Carbon standard: VCM

Carbon buyer: Plan Vivo Charity

Area: 1730 acres (170 ha)

Reference: Kenya Marine and Fisheries Research Institute (KMFRI)

http://www.camarv.org/index.html

http://www.mediaglobal.org/article/2009-10-06/carbon-trading-hits-east-africa

http://www.planvivo.org/wp-content/uploads/gazi_pin_PlanVivo_Kenya.pdf http://www.kmfri.co.ke/#

7. Republic of Panama

Funding agency/sponsor: funding requested from DFN (800,000 euros), Environmental Authority of Panama (ANAM), and TNC

Budget: 1,200,000 euros

Start date: starting before June 2010

End date: 3 years (but overall project lifetime, 22 years)

When carbon sales expected? 1 year, 1.2 years, 2 years, 2.7 years and 4 years

Conservation or rehabilitation? Restoration (1400 ha) and conservation (600 ha)

Soil carbon included in emissions assessment: unk

Sequestration rate: In 22 years 1400 ha restoration will sequester 7.84 ton C/ha/yr or 241,360 t Carbon emissions in total (885,791 t CO_2) while 600 ha REDD will (presumably) avoid 16.0 ton C/ha/yr or 211,140 t Carbon emissions in total (744,883.8 t CO_2).

Carbon stock: unk

Carbon standard: CDM, Voluntary Carbon Standard (VCS) or Climate, Community and Biodiversity Alliance (CCB Standard).

Carbon buyer: Carbon credits will be awarded to the landowners by the National Environmental Authority through its carbon registry. (unk buyer)

Area: 2000 hectares

Reference: http://www.cbd.int/lifeweb/project.shtml?id=8f1a5a51-d2e7-48c1-b78c-eb1ec2a040ab

8. Wetland in Cuero and Salado Wildlife Refuge (pilot area) Honduras

Funding agency/sponsor: requested from Danone Fund for Nature (DFN). Implementation by: ICF, FUCSA, PROLANSATE and FUCAGUA).

Budget: 50,000 Euros (total project preparation financing) 600,000 Euros (budget for project execution. Total = 650,000 Euros

Start date: (proposal dated - Oct 2009)

End date: 3 years after start date

When carbon sales expected? ukn

Conservation or rehabilitation? Conservation and restoration

Soil carbon included in emissions assessment: Yes (outline of method included)

Sequestration rate: ukn

Carbon stock: ukn

Carbon standard: VCS, the gold standard, or the FGP Platinum standard.

Carbon buyer: (DFN?)

Area: 13 000 hectares

Reference: http://www.cbd.int/lifeweb/project.shtml?id=6353e3b0-3b37-411d-9d5c-ce2c439e2a60

9. Solomon Islands, Island of Ranonga in Western Province, Choiseul Province, Malaita Province

Funding agency/sponsor: AusAID (implemented by WorldFish Center)

Budget: grant of: $321,000

Start date: 1 April 2009

End date: 31 March 2012

When carbon sales expected? ukn

Conservation or rehabilitation? Restoration and conservation

Soil carbon included in emissions assessment: ukn

Sequestration rate: ukn

Carbon stock: ukn

Carbon standard: Investigating voluntary markets and CDM

Carbon buyer: ukn

Area: ukn (small pilot area to provide blueprint for protecting 50,572 hectares nationwide.)

Reference:

www.worldfishcenter.org/resource_centre/WorldFish%20project%20brief-%201945.pdf

10. Fiji, Samoa, Solomon Islands, Tonga and Vanuatu,

Funding agency/sponsor: German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) (implemented by: IUCN- Oceania)

Budget: $3.4 million (2.3 million euro)

Start date: Dec 2009 (received funding)

End date: end of 2013

When carbon sales expected?

Conservation or rehabilitation? Conserved and/or restored

Soil carbon included in emissions assessment:

Sequestration rate:

Carbon stock:

Carbon standard:

Carbon buyer:

Area:

Reference:

http://www.friendsofmangrove.org.my/newsmaster.cfm?&menuid=45&action=view&retrieveid=45 (no mention of carbon credits)

http://www.iucn.org/about/union/secretariat/offices/oceania/oro_programmes/oro_initiatives_pmi/oro_mescal/ (mention of carbon credits)

http://www.iucn.org/about/union/secretariat/offices/oceania/oro_newsarchive/?5610/IUCN-aids-Pacific-Islands-to-improve-on-mangrove-management (mention of REDD)