

Coconut Carbon Sequestration Part 2 / Strategies for the Carbon Market & Simulating Potential Incomes for Coconut CDM Projects

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Abstract

The following article is a review of possible strategies of the coconut sector facing the carbon market, through the Clean Development Mechanism (CDM) of the Protocol of Kyoto, but also through Non-Kyoto (voluntary) initiatives. It sums up the conditions for certifying plantations, together with recent statistics of similar projects accepted by UNFCCC, which are currently displaying a rapid growth rate. It stresses the complexity of the CDM, but also the accessibility for coconut energy & afforestation + reforestation (A/R) projects, considering that coconut plantations do actually correspond to the definition of "forest".

Using recent scientific information on C cycle of coconut plantations and coconut oil, it proposes also a simulation of the expected potential profitability of coconut energetic and A/R projects. From the point of view of the farmer and of the oil mill, in absence of any CDM project (the reference here), the value-added comes mainly from local processing of the copra into coconut oil. When implementing a short-term A/R project (t-CER), the value-added by C fixation in the ecosystem would be ca. +15 to +19%, as compared to the copra and oil references. When implementing a long-term project (l-CER), the value-added would reach +40 to +52%. When implementing an energy-oil project solely, the value-added by C fixation in the coconut oil would be only +5% (this not including other benefits at national scale, however). When implementing a dual A/R + energy-oil project, the value-added by C fixation would be +19% for t-CER, and +45% for l-CER with respect to the copra and oil references. These results are just potential values given for example, suspected to vary much according to the actual conditions of coconut plantation productivity, management and also C market conditions. However, the simulation clearly supports every APCC initiative in this direction.

Keywords: Clean Development Mechanism (CDM)/Kyoto and Non-Kyoto/Mitigation/renewable energies/A/R CDM/*Cocos nucifera* L.

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Introduction

In the context of global warming, which is assumed (IPCC, 2007) to result mainly from emissions of anthropogenic greenhouse gases (GHG), the Kyoto Protocol came into force in February 2005 and committed industrialized countries (Annex I parties) to reduce their emissions during the period 2008-2012 by 5% of the amount recorded in 1990. The Protocol introduces three market mechanisms, namely the Kyoto Mechanisms. Annex I Parties would be able to achieve their emission reduction targets cost-effectively, by using these mechanisms. The Clean Development Mechanism (CDM) is one of the three flexible mechanisms that were set up by the Kyoto protocol to reduce climate change. It consists in developing projects in developing countries (non-Annex I parties) for reducing GHGs emissions or enhancing terrestrial C sequestration, resulting in decreasing the GHGs concentration of the atmosphere. Annex I Parties which have ceilings for GHG emissions (emission caps), assist non-Annex I Parties which don't have emission caps, to implement project activities to reduce GHG emissions (or remove by sinks), and credits will be issued based on emission reductions (or removals by sinks) achieved by the project activities. The credit from the CDM is called certified emission reduction (CER). Reductions in emissions shall be additional to any that would occur in the absence of the certified project activity. Annex I Parties can use CERs to contribute to compliance of their quantified GHG emissions reduction targets of the Kyoto Protocol. As a result, the amount of emission cap of Annex I Parties will increase. CERs will be based on activities during the period from the year 2000 up to 2012 can be used in achieving compliance of Annex I Parties in the 1st commitment period. Developing countries (DC or non-Appendix 1) are not committed to reduce their emissions. Land-use changes under the tropics account for 20% of global GHG emissions (IPCC, 2007), and their contribution is of high importance. However, the eligibility

of land use, land-use change and forestry (LULUCF) project activities under the CDM is limited to afforestation and reforestation (A/R). The Clean Development Mechanism (CDM) is presented as an opportunity for the DC to negotiate Certified Emission Reductions (CER) on the C market, following three directions: renewable energies, land use change (LULUCF) and substitution (Tab. 1).

The focus of this paper is to draw a panorama of the potentialities to implement CDM energy and afforestation-reforestation (A/R) projects through coconut plantations. The objectives of the study are (i) to make an inventory of the potential CDM alternatives that could be implemented, (ii) the requirements, constraints and limits of CDM implementation, (iii) to propose a checklist of the different steps and (iv) to estimate its potentials.

Kyoto Protocol, Clean Development Mechanism (CDM) and Certified Emission Reduction (CER)

Brief description

The Clean Development Mechanism (CDM) is presented as an opportunity for the DC to negotiate Certified Emission Reductions (CER) on the C market, following two directions (Tab. 1): renewable energies or substitution & land use change (LULUCF, limited to afforestation and reforestation, A/R).

UNFCCC Statistics for CDM projects

The current statistics of (UNFCCC, 2008) regarding the number of projects registered are the following:

- The 100 millionth certified emission reduction (CER) credits under the Kyoto Protocol's Clean Development Mechanism has been issued, marking an important environmental, development and carbon

Table 1: A brief description of the 3 CDM strategies and limitations for application to Certified Emission Reductions (CER).

CDM Projects	Brief Description	Limitations for obtaining CER
Energies: renewable, alternative, efficient "C source" projects	-Investments for such energies in DC -Transfer of technologies to DC →Permanent credits	<ul style="list-style-type: none"> • <u>"Additionality" criteria:</u> <ul style="list-style-type: none"> - Comparing the project to a reference (baseline) scenario. - The project must assess the % of GHG stored or saved, comparing with the absence of project. - Only for projects that would not be profitable without CDM subsidies.
Land-use and land-use change (LULUCF). "C sink" projects	2008-2012: only Afforestation or Reforestation, No agriculture, No management. Partially agroforestry. Coconut plantation can be readily considered as "forests". →Non-Permanent credits: long-term credits = 1-CERs or short-term (t-CERs) >=2012: still to be negotiated, especially for management (improving management on existing plantations).	<ul style="list-style-type: none"> • <u>"Leakage" criteria:</u> Demonstrating that the project does not displace GHG emissions elsewhere • <u>Compliance with other criteria:</u> e.g. Environment-friendly, sustainable development, biodiversity, social, etc.

market milestone on the road to a low-carbon future. The CDM is expected to generate more than 2.6 billion CERs by the time the first commitment period of the Kyoto Protocol ends in 2012, each equivalent to one ton of carbon dioxide.

- More than 3000 CDM projects are currently in the pipeline and 975 registered, in 49 developing countries
- more than 53% are energy projects,
- only 0.08% for afforestation or reforestation projects: this is very low, but at least, ten consolidated methodology have been approved recently, which is opening the gate, in particular for coconut plantations, provided that a methodology is accepted. However, a minimum of 30 more projects are nearly mature and will likely be achieved rather soon (Neeff et al., 2007).
- 83 projects are for agriculture (7%).

In 2006, project-based transactions attained a volume of 508 million carbon credits (not limited to CDM, but also non-Kyoto projects) at an average price beyond 10 USD per carbon credit, i.e. tCO₂e credit (The World Bank, 2007). According to Neeff *et al.* (2007), the forestry carbon projects are usually designed to deliver a considerable amount of C credits before 2012 (around 1.2 billion carbon credits). Most have opted for long-term CER (ICER), rather than short-term (tCER), see definition below. A typical large scale forestry project would cover 6000-8000 ha.

However, the CDM markets face three main constraints. First, only 1% of the annual emission reduction target per country could be achieved through CDM A/R. Second, the CERs from CDM A/R could not be fungible into the main C market, the European Trade System (EUTS). Third, CDM A/R provides non-permanent CERs while energy and renewable CDM projects provide permanent CERs.

Legal conditions for implementing a CDM project

When developing a CDM project activity, it is necessary to consider the following points:

- (1) The purpose of the CDM shall be to assist non-Annex I Parties in achieving sustainable development and in contributing to the ultimate objective of the Convention, and to assist Annex I Parties in achieving compliance with their commitments. The host Party's has to confirm whether a CDM project activity assists it in achieving sustainable development.
- (2) A CDM project activity is additional if GHG emissions are reduced below those that would have occurred in the absence of the registered CDM project activity. The additionality of a project is estimated by measuring the difference of emission reduction between the baseline emissions and GHG emissions after implementing the CDM project activity (project emissions). The baseline (scenario and emissions) for a CDM project activity is the scenario that reasonably represents GHG emissions that would occur in the absence of the proposed project activity. A baseline scenario has to be established in a transparent and conservative manner regarding the choice of approaches, assumptions, methodologies, parameters, data sources, key factors and additionality, and taking into account uncertainty; has to be on a project-specific basis; consider the relevant national and/or sectoral policies and circumstances, such as sectoral reform initiatives, local fuel availability, power sector expansion plans, and the economic situation in the project sector. The baseline shall cover emissions from all gases, sectors and source categories within the project boundary. Baseline emission under the selected baseline scenarios shall be calculated in accordance with approved methodologies by the Executive Council of CDM (EC-CDM), or by submitting a new method, proving that the land use project would (i) allow positive net C sequestration with regard to the baseline scenario (ii) not have been possible (financially) without subsidies from the CDM.
- (3) Public funding for CDM projects from Annex I Parties is not to result in the diversion of official development assistance (ODA) and is to be separate from and not counted towards the financial obligations of Annex I Parties.
- (4) Annex I Parties shall provide an affirmation that such funding does not result in a diversion of ODA and is separate from and is not counted towards the financial obligations of those Parties.
- (5) It is necessary to prepare a project design document (PDD) in order to be registered as a CDM project activity.
- (6) Participation in a CDM project activity is voluntary. A project participant P is (a) a Party involved, and/or (b) a private and/or public entity authorized by a Party involved to participate in a CDM project activity. Private and/or public entities may only transfer and acquire CERs if the authorizing Party is eligible to do so at that time. A written approval constitutes the authorization by a designated national authority (DNA) of specific entity(ies)' participation as project proponents in the specific CDM project activity. The approval of NGOs is generally required for the projects, as a warranty for CDM's integrity. NGOs can be committed to check the project, following some standards (e.g. Sinks Watch, CDM Watch, WWF, etc.). However, no or few examples of NGO approvals are available so far.

- (7) A double application to energy and LULUCF is eventually possible, but should be submitted separately (in 2 different projects).

Permanence

Permanence refers to the risk that the GHG sequestered or protected by a project may be reversed over time due to either human action or natural events. For example, it is possible that carbon sequestered through an afforestation project could be re-emitted due to the forest being cut down, burned, or damaged during a storm. An area that was being protected from logging could lose its protection status, and the area could then be deforested. The approach taken to deal with the non-permanence of GHG reductions differs widely between standards. For CDM projects the permanence issue was resolved by issuing credits that are temporary but can be re-issued or renewed after independent verification determines that sufficient carbon was still sequestered to account for the credits issued. Purchasing of these credits can be thought of as a lease or rental of emission reductions for a specific length of time. Annex 1 buyers must replace expired credits with either another non-permanent credit or with a permanent credit from another mechanism (Walker et al., 2008). The CERs which come from A/R CDM are not permanent and are divided into two classes: short-term (tCERs) and long-term (ICERs). The project participant shall select one of the following approaches to addressing non-permanence of the project activity: (a) Issuance of tCERs for the net GHG removals by sinks achieved by the project activity since the project starting date; or (b) Issuance of ICERs for the net GHG removals by sinks achieved by the project activity during each verification period. The approach chosen to address non-permanence shall remain fixed for the crediting period including any renewals. Each tCER shall expire at the end of the commitment period subsequent to the commitment period for which it was issued.

Each ICER shall expire at the end of the crediting period or, where a renewable crediting period is chosen, at the end of the last crediting period of the project activity.

Kyoto: conditions for the certification of coconut oil (permanent CER) and coconut plantations (non-permanent CER, I-CER and t-CER) by CDM

Coconut plantations could be used in four ways to reduce emissions and sequester C: (i) substitution of fossil fuel using biodiesel or biomass from coconut oil, (ii) sequestration of C through coconut plantation, (iii) enhancing C sequestration through coconut plantation management and (iv) conserving C sink in coconut "forest".

Renewable energies: certification of coconut oil:

Coconut is readily eligible to the Clean Development Mechanism (CDM) of the Kyoto Protocol regarding its production of renewable energies coming in substitution of a fossil energy normally consumed (coconut oil for energy, biomass for energy, etc.). This is application for permanent credits. CERs from coconut oil project shall only be issued for a crediting period starting after the date of registration of a CDM project activity. The crediting period could be: (i) a maximum of 7 years which may be renewed at most 2 times and (ii) a maximum of 10 years with no option of renewal. According to the potential of CERs, the project participant has to define if the project is a conventional or a small-scale CDM. A small-scale CDM corresponds to a simplified modality and procedure for project activities with emission reductions of less than or equal to 60 kt CO₂ equivalent annually. Using coconut oil as a renewable energy is an attractive concept, for several reasons:

- Coconut oil is naturally one of the best substitutes for diesel. The net calorific values are similar, the thermal efficiency is

equivalent and coconut oil is compliant with diesel engines, even pure, with minor modifications as long as those engines are indirect-injection systems.

- Several applications are possible for diesel engines: pure coconut oil, blend, methyl ester (biodiesel).
- On the same power basis, for rural electrification for example, the cost of investment is usually by far lower than solar solutions.
- In the case of coconut areas, the energy is available locally.

The ideal situation for promoting coconut oil seems to be remote areas, in conditions where the cost of diesel is prohibitive, where copra is available but copra incomes are low, where copra culture needs to be re-valorized and where energy is necessary for development. In the case of Vanuatu, the 90 000 ha of coconut plantations would provide enough pure coconut oil to feed the required amounts for diesel vehicles (Roupsard, 2001), leaving a lot for power generation. This case is exceptional, rather typical of small remote islands with a lot of coconut cultivation and little development of cars and energy in general, with respect to the population. Vanuatu offers a perfect example, especially in remote areas reasons (Ribier V. et al., 2004). The case of the pilot plant in North Santo is being developed (POPACA project).

Coconut CDM A/R

Regarding the Afforestation and Reforestation (i.e. non-permanent credits), part of the land use and land use change CDM-LULUCF, coconut is compliant with the definition taken for "forest". The following conditions should be matched (B. Locatelli, pers. comm.):

Condition A: "Forest structure"

- The elementary plots are bigger than 0.05 to 1 ha.
- The mature (adult) canopy covers at least 10 to 30 % of the soil.
- The height at maturity is higher than 2 to 5 m.

The precise values in the ranges are to be decided in each country by the Designated National Authorities (DNA) for CDM. The community of industries and lobbies that promote perennial crops might influence this debate if they were more organized or persuasive in this way (present eligible projects), especially because coconut plantations could actually be considered as "forests". In this definition of "forest", there is no distinction of species, rotation or so. Perennial and tree-crop plantations (oil palm, coconut tree, rubber tree, coffee, cocoa) and agroforestry may thus comply with this definition of "forest". In Marrakech, there is no definition for "tree", hence one usually uses the default FAO definition: "a woody perennial with a single main stem, or, in the case of coppice, with several stems, having a more or less definite crown ; includes bamboos, palms and others woody plants meeting the above criteria ». Global Forest Ressources Assessment, FAO, 2005: <http://www.fao.org./forestry/site/fra2005/en/>.

Condition B: "Afforestation or Reforestation of the land"

- Afforestation: if the land was not covered by "forests" for at least 50 years.
- Reforestation: if the land was not covered by "forests" on the 31st of December 1989.

Condition C: "Additionality" (for energy and C sink projects)

- Define a specific baseline scenario (reference) that would occur in absence of project and account for its C sequestration (C sink projects) or decrease emissions (C source projects), including CO₂ and other GHG, during the accounting period (C sink: 20 years renewable twice, or 30 years not renewable; and C sources: 7 years renewable twice or 10 years no renewable).
- Demonstrate (using a method already approved by the Executive Council of CDM (EC-CDM) or submitting a new method) that the land use project would (i) allow positive net C sequestration with regard to the baseline scenario (ii) not have been possible (financially) without subsidies from the CDM.
- Only the difference between sequestration by the project and sequestration by the baseline may apply for CER (Fig. 1), but not taking into account the reduction of emissions (e.g. CO₂ emissions for transport, labour etc.) of the baseline:

$$Add_p = (Abs_p - Em_p) - (Abs_b) - Lea \quad \text{eq. 1}$$

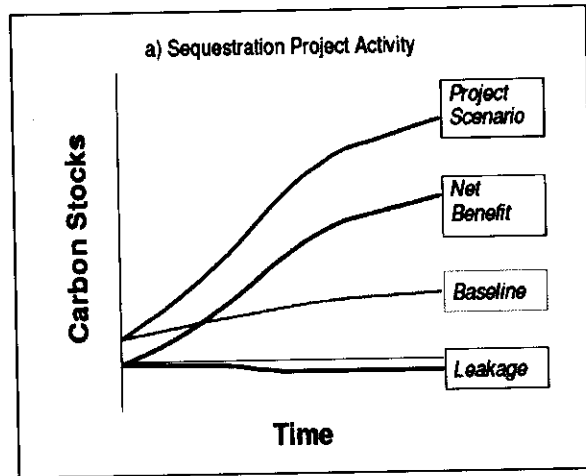
where *Add.* = additionality; *Abs.* = absorptions (i.e. NEP, or proxys for NEP, frequently biomass build-up) ; *Em.* = emissions (e.g. CO₂ emissions for transport, labour etc.) ; *Lea* = leakages; subscripts *p* and *b* for project and baseline, respectively. All terms expressed in equivalent CO₂e.

Most plantations already proved to be profitable, without subsidies. However, considering the decline of the coconut industry today, and the competition of oil palm for instance, it should be possible to develop comparative ecological arguments for maintaining or even restoring the coconut

activity, demonstrating that the profitability would rely on subsidies from CDM.

The crediting period of the A/R CDM project activity begins at the start of the A/R CDM project activity and can be either: a maximum of 20 years, may be renewed twice (total 60 years maximum) or a maximum of 30 years. A/R CDM projects that are expected to result in net GHG removals by sinks of less than 8,000 t-CO₂/year are considered to be small-scale A/R CDM. If a small-scale A/R CDM project activity results in net GHG removals by sinks greater than 8,000t of CO₂per year, the excess removals will not be eligible for the issuance of tCERs or ICERs. In order to reduce transaction costs, modalities and procedures are simplified for small-scale A/R CDM project activities.

Figure 1: Computing the net benefit in a C-sink project: source Walker et al. (2008)



Future CDM opportunities

Regarding the conservation of forests, management of forests, agricultural part of the land use and land use change CDM-LULUCF, plantations are not eligible during 2008-2012. However, the decision CP.13 notes the further consideration of policy approaches and positive incentives on issues relating to reducing emissions from deforestation and forest

degradation in developing countries; and the role of conservation, sustainable management of forests, and enhancement of forest carbon stocks in developing countries. There is great chance that forest conservation and management become eligible for the post-Kyoto mechanism.

Non-Kyoto C market

In addition to the Kyoto/CDM regulations, it must be stressed that the C market is also fully open for Non-Kyoto/Non-CDM initiatives. Most of them are shaped by governmental initiatives, and represented 17 millions carbon credits in 2006 (The World Bank, 2007); according to (Point Carbon, 2008), the total voluntary volume in 2007 was estimated to 75 millions t. There are also a number of volunteer C trades, involving individuals or private companies (extensively reviewed in Neeff *et al.* 2007). This option is of real economic interest, considering that CER are very difficult to achieve and that C prices on the market are currently low, due to imbalance between demand and offer.

A useful listing of type of Kyoto and Non-Kyoto buyers for forestry project is reported in Neeff *et al.* (2007).

Combining Kyoto + Non-Kyoto C market

According to the kind of ecosystem of reference some solutions are proposed below (Tab.2), for today (readily available) or for the next future (if CER became available for coconut activities, provided that projects are proposed and methodologies approved). The lesser the C stock in the baseline ecosystem, the better the expectations for C storage in the coconut plantation. Some examples of interesting baseline ecosystems: pastures, peat lands, fallows, crops, abandoned lands, savannas, deforested lands (before 1990), slashed and burned lands, devastated areas, etc.

Regarding rotations, one or several rotations are eligible. If a period of 20 yrs is

chosen, with 2 renewals (i.e. a total of 60 yrs), the stand can be cut off after 30 yrs and replanted for the next 30 yrs. Or else 30 yrs renewable once can be chosen, which is the equivalent of the first rotation.

- Standard baseline and additionality methods few and slow down the certification processes.
- It is not possible to certify any plantation if the land was "forested" (see definition above) on the 31st of December 1989.
- The approval of NGOs is generally required for the projects, as a warranty for CDM's integrity. NGOs can be committed to check the project, following some standards (*e.g.* Sinks Watch, CDM Watch, WWF, etc.). However, no or few examples of NGO approvals are available so far.
- The local CDM National Authority decides if the project contributes to sustainable development or not.
- A double application to energy and LULUCF is eventually possible, but should be submitted separately (in 2 different projects).
- For small LULUCF projects (<16 kt CO₂e yr⁻¹), procedures are more simple. Small energy projects are defined <15MW. They can be cumulated.

Checklist for implementing a coconut CDM project

- Specifications approved by the local CDM National Authority (DNA).
- Design of the project:

Table 2: Some solutions proposed for the coconut sector for obtaining subsidies from the C market (Kyoto and Non-Kyoto) through C sink projects, according to various scenarios of reference commitment periods.

Initial ecosystem of reference (before 1990)	Current (<2012) options for obtaining certification from CDM or Non-Kyoto	Future (>2012) options with CDM (if management becomes eligible) or Non-Kyoto	Information to be collected
Forest	None for Afforestation/Reforestation; OK for energy or substitution; Additionnality to be proved	Improved management	Comparative C balance (process) of reference and from the new ecosystem (process), including other GHG
Grassland or Pasture	First rotation of coconut plantation (Aff./Ref.). Additionnality to be proved Renewable energies or substitutions	First rotation of coconut plantation (Aff./Ref.). Additionnality to be proved Renewable energies or substitutions Improved management of planting and litter + intercropping. Additionnality to be proved	
Coconut palm plantations	None for Afforestation/Reforestation; Renewable energies or substitutions; Additionnality to be proved	None for Afforestation/Reforestation; Renewable energies or substitutions; Additionnality to be proved Improved management of planting and litter + intercropping. Additionnality to be proved	

Main limitations and possible strategies for coconut sector

Table 3: Limitations and possible strategies for the coconut sector

CDM Projects	Specific limitations for each CDM strategy	Possible strategies for the coconut industry
Renewable energies	-Additionality criteria -Leakage criteria	<ul style="list-style-type: none"> • Coconut oil or biodiesel (methyl ester) as substitute for fuel • Energy from biomass • Energy savings on coconut industry processes
Carbon sinks	-Only for afforestation, reforestation since 1990 during the first commitment period (2008-2012). OK for coconut plantations -Additionality criteria -Leakage criteria	<ul style="list-style-type: none"> • International commitment of the coconut industry (<i>e.g.</i> APCC) for promoting projects and methodologies • Investment for assessing the C balance of several systems that include a coconut cultivation period on a complete rotation cycle • Identify the cultivation and process techniques that will be more C-efficient than current practices • Demonstrate that some coconut systems are no more profitable without subsidies from CDM but are more environmental-friendly than competitors (<i>e.g.</i> oil palm) • Target the Non-Kyoto C market

* Compliance with CER: category of project (*e.g.* afforestation/reforestation or energy), additionality, leakage, other environmental and social criteria. For leakage, to prove that when implementing a coconut plantation in one place will not encourage the deforestation of an other plantation. In addition, to prove that it does not increase other GHGs emissions.

* Business plan (not required but essential): comparing costs and expected benefits.

- Estimating the profitability on the middle and long terms. For instance, variation of copra price: if the price of the copra decreases it may not be financially interesting for farmers to continue to cultivate the coconut. In addition, the opportunity cost of other land use may be much more attractive and the farmers may be willing to convert coconut plantations to

other land uses. The C carbon price may not be sufficient to compensate the price variation and losses to the farmers.

- Survey of C stock and emissions of GHG in the baseline ecosystem.
- Estimation of C sequestration (including other GHG) in the plantation. Not all compartments of the ecosystem need to be accounted for. However, for non-accounted compartments, it must be proved that there is no de-storage of C resulting from land use change. SOM is crucial for coconut plantations, see paragraph above.
- Choice between permanent (energy, only one choice), non-permanent short term or long term CERs (C sink).
- Approval of the project by the National Authority.

- Approval by NGOs and eventual control of implementation.
- Submission and approval to the E-C of the CDM.
- Project step verifications (by NGOs).

Estimating coconut performances for CDM. How does it compare to Oil palm ?

Due to its important potential C balance or Net Ecosystem Productivity (see companion paper, Part 1), say 4.7 to 8.1 tC ha⁻¹ yr⁻¹ at 20 year old (the maximum of leaf area index) and in optimum fertility and water conditions (Roupsard et al., 2006), the certification of coconut for C sinks appears attractive. This range of 4.7 to 8.1 tC ha⁻¹ yr⁻¹ should be considered only as a maximum estimation, since C sequestration should be also assessed for different ages, and in less favourable conditions (drought, deficiencies, diseases...). Moreover, we should eventually account for the copra export, depending on the scenarios of calculation. It appears more realistic to state that the actual value would range between 3.4 to 6.8, say a minimum of 3.4 tC ha⁻¹ yr⁻¹ used here the simulations (NEP in everything that is not copra). It should be also remembered that this value is expected to be minored by emission of other greenhouse gases, and the baseline absorptions should be accounted for (equation 1). To our knowledge, there would be few or no information available for other GHG in coconut plantations.

Would the above value be larger for oil palm, considering its larger net productivity? It is not sure at all, the link between net primary productivity and C balance is not univocal. We even believe that coconut plantations are likely to be in a better position than oil palm plantations for CDM, considering that:

- they require less water for processing and pollute less water-tables and rivers

- they spread in tropical rather than sub-equatorial areas, hence to a lesser extent in the natural habitat of rainforest
- they require less fertilizers for sustaining the yield
- they are more sustainable and less detrimental to the biodiversity
- they displace less amounts of populations due to land use change
- Oil palm cultivation is generally far more profitable, and hence fails the additionality criteria.

Supporting the contribution of scientific approaches of C sequestration

Direct scientific measurements of C sequestration (*e.g.* C stocks in chronosequences; CO₂ fluxes by eddy-correlation; GHG emissions by various methods) are not required for any application to CER. Simple surveys for the baseline and estimations from available literature are generally sufficient.

However, considerable advantages result from scientific approaches of C sequestration:

- More pools of C can eventually be taken into account in the computation of sequestration. A major impediment here is that, contrary to dicot trees, coconut does not allocate much of its C into permanent structures (stems, coarse roots), but allocates more than 86% into perishable structures (fruits, leaves, peduncles, fine roots) that will quickly turn into litter, and be respired by the ecosystem or contribute to the build-up of Soil Organic Matter (SOM). This "litter-oriented" fate of C is very peculiar, and cannot be accounted properly using regular forestry inventories of C sequestration, such as simple evaluation of C build up in the stems: it

will certainly require detailed studies of C accumulation in the SOM, in addition to the C accumulated in the biomass and in the necromass (litter).

- Reducing the standard deviation in the measurement of the C stock (soil, roots, using appropriate scientific methods) may help demonstrate statistically a C sink and increase CER, or alternatively demonstrate that one compartment can be neglected (costs reduced).
- Understanding the fate of C is central in the questions of fertility, growth, productivity, sustainability, energy and hence profitability and environment.
- Alternative management of the fertility is key to sustainable development.
- Functional models can be used for simulating the impact of alternative situations (management practices, climate, resources).
- Management practices are candidate to CDM for the second commitment period (> 2012) and should be documented (Hamel and Eschbach, 2002).

Simulations of profitability of CDM projects for coconut sector

The profitability of a CDM-LULUCF project is never straightforward, it relies notably on:

- the amount of C sequestered, with reference to the baseline scenario,
- the current C market, stressing that for LULUCF projects (non-permanent CER), the price per ton is expected to be much reduced as compared to renewable energies (permanent CER), which was recently (beginning of 2008) around 13 € (at the rate of 1.45 USD = 19 USD). The prices

rely on the ratio between offer and demand of credits, which is currently very low but will fluctuate. Tab. 4 gives a rough estimation for 2008, according to the type of CDM project and term chosen.

- The additional costs for complying with the various CDM criteria,
- the costs of submission,
- the cost of communication with NGOs and National Authorities.

A business plan is usually required for demonstrating the profitability of the project.

Helpful simulations were given in (Locatelli and Pedroni, 2004).

In the following, we will propose simulations for profitability of CDM coconut C sink, CDM coconut oil and combined projects, connecting to the work that has been done in the Philippines regarding the C balance of the biodiesel (methyl ester of coconut oil) process (Tan et al., 2004): 80 to 109% of CO₂ emission reductions by biodiesel, relative to diesel, depending on the processes,

The values presented in the companion paper (Part 1) were used for estimating very roughly the financial profitability of the C sink potential (referring to the CDM) of one plantation.

NB: The rough estimation presented below should only be considered as an example. Obviously the result can vary in a large way, depending on the ecology of the system, the initial system of reference and the copra and C markets. The parameters used for the simulation are given in Tab. 5a, some come from recent literature and economical statistics, some were calculated, some were estimated.

Tab. 5b (t-CER) and 5c (l-CER) shows that:

Table 4: Estimates of the price of credits on the C market for 2008. Using several sources and prognostics, including Point Carbon (<http://www.pointcarbon.com/>).

Date		€	USD
March 2008	Currency rate	1	1.5

Date	CDM Project	Type of CER	€/tCO ₂ e	USD/tCO ₂ e
2008	Renewable energies or C source	Permanent CER (tCO ₂ e or CO ₂ credit)	13	18.9
2008	Affor/Refor. or C sink	Temporary long-term l-CER (tCO ₂ e or CO ₂ credit)	11	16.0
2008	Affor/Refor. or C sink	Temporary short-term t-CER (tCO ₂ e or CO ₂ credit)	4	5.8

Table 5a: Parameters for comparing of the CO₂ balance and profitability for farmer and for local oil mill under CDM projects, C sink or/and oil energy. The parameters used for the simulation are given in the heading of Table5a, some come from recent literature and economical statistics, some were calculated, some were estimated.

Source	Date	Parameters	Values	Units
calculated		Conversion factor tC into tCO ₂	3.67	
APCC 2008	2007	Area cultivated in coconuts (World)	11.7	Mha
APCC 2008	2007	Copra production (World)	10.3	Mt
calculated		Copra yield (World average)	0.88	t copra ha ⁻¹ yr ⁻¹
APCC 2008	Dec 2008	Coconut oil price (CIF Rotterdam)	1144	US \$/toil
arbitrary		Added value factor for processing and distributing oil on local market	1.3	-
arbitrary		Local market Coconut oil price	830	US \$/toil
estimated		Ratio Price copra to farmer:Price oil CIF Rotterdam	0.4	\$ copra/\$oil
calculated		Copra price (paid to farmer)	435	US\$ t copra ⁻¹
arbitrary		Annual copra income per ha (farmer)	383	US\$ ha ⁻¹ yr ⁻¹
This study (minimum of 3.4 and 6.8)		C balance of the plantation (NEP) when copra is exported	3.4	tC ha ⁻¹ yr ⁻¹
Tab.4, This study	2008	C market price for renewable energies, CER	18.85	US\$ carbon credit ¹ or US\$tCO ₂ -1
Tab.4, This study	2008	C market price for Affor-Refor, l-CER	15.95	US\$ carbon credit ¹ or US\$tCO ₂ -1
Tab.4, This study	2008	C market price for Affor-Refor, t-CER	5.8	US\$ carbon credit ¹ or US\$tCO ₂ -1
arbitrary		Coconut oil extraction rate	0.6	kg oil kg copra ⁻¹
The Physics Factbook (http://hypertextbook.com/facts/)		Coconut oil density (at 20°C)	0.919	kg oil l oil ⁻¹
http://www.eia.doe.gov/emeu/international/prices.html	March 2008	Crude Petroleum oil price per barrel	105	US \$/barrel
calculated		Crude Petroleum oil price per t	798	US \$/t
Wikipedia		Volume of one barrel	159	l barrel ⁻¹
Wikipedia		Density of crude petroleum oil	0.83	kg crude oil l ⁻¹
estimated		C content of copra or of oil	0.7	kgC kg copra ⁻¹ or kgC kg oil ⁻¹
Tan et al. 2004		CO ₂ flow reduction coeff. by biodiesel	0.9	CO ₂ saved biodiesel / diesel, av. between 82-109%
arbitrary		Absorption by the baseline and leakage	0	
arbitrary		C loss during planting	0	%, as compared to the ecosystem of reference

Table 5b: Comparison of the CO₂ balance and profitability for farmer and for local oil mill under CDM projects, C sink (t-CER) or/and oil energy. Grey cells give important results (Table 5b).

	Profitability simulations	C balance (C unit)	C balance (CO ₂ e unit)	Farmer income	Value added for local oil mill	CDM Value	Total Value	CDM Added Value
		tC ha-1 yr-1	tCO ₂ e ha-1 yr-1	US\$ ha-1 yr-1	US\$ ha-1 yr-1	US\$ ha-1 yr-1	US\$ ha-1 yr-1	%
Current situation (no project)	(1) NEP Coconut cultivation with copra not included	3.4	12.5	0	0	0	0	
	(2) Copra exported for regular use (food, chemistry)	0.6	2.3	383	0	0.0	383	
	(3) Oil processed locally	0.3	1.2	383	115	0.0	498	
	Total (1)+(2)	4.0	14.7	383	0	0.0	383	0
	Total (1)+(3)	3.7	13.7	383	115	0.0	498	0
C sink (Affor/Refor) project	(4) NEP Coconut cultivation with copra not included, t-CER	3.4	12.5	0	0	72	72	
	(2) Copra exported for regular use (food, chemistry)	0.6	2.3	383	0	0.0	383	
	(3) Oil processed locally	0.3	1.2	383	115	0.0	498	
	Total (4)+(2)	4.0	14.7	383	0	72	455	19
	Total (4)+(3)	3.7	13.7	383	115	72	570	15
C source (Oil energy) project	(1) NEP Coconut cultivation with copra not included	3.4	12.5	0	0	0	0	
	(5) Copra turned into fuel for CDM and local market	0.3	1.2	383	115	23.0	521	
	Total (1)+(5)	3.7	13.7	383	115	23.0	521	5
Csink + Oil energy project	(4) NEP Coconut cultivation with copra not included, t-CER	3.4	12.5	0	0	72	72	
	(5) Copra turned into fuel for CDM and local market	0.3	1.2	383	115	23.0	521	
	Total (4)+(5)	3.7	13.7	383	115	95	593	19

Table 5c: Comparison of the CO₂ balance and profitability for farmer and for local oil mill under CDM projects, C sink (I-CER) or/and oil energy.
 Grey cells give important results (Table 5b).

	Profitability simulations	C balance (C unit)	C balance (CO ₂ e unit)	Farmer income	Value added for local oil mill	CDM Value	Total Value	CDM Added Value
		tC ha-1 yr-1	tCO ₂ e ha-1 yr-1	US\$ ha-1 yr-1	US\$ ha-1 yr-1	US\$ ha-1 yr-1	US\$ ha-1 yr-1	%
Current situation (no project)	(1) NEP Coconut cultivation with copra not included	3.4	12.5	0	0	0	0	
	(2) Copra exported for regular use (food, chemistry)	0.6	2.3	383	0	0.0	383	
	(3) Oil processed locally	0.3	1.2	383	115	0.0	498	
	Total (1)+(2)	4.0	14.7	383	0	0.0	383	0
	Total (1)+(3)	3.7	13.7	383	115	0.0	498	0
C sink (Affor/Refor) project	(4) NEP Coconut cultivation with copra not included, I-CER	3.4	12.5	0	0	199	199	
	(2) Copra exported for regular use (food, chemistry)	0.6	2.3	383	0	0.0	383	
	(3) Oil processed locally	0.3	1.2	383	115	0.0	498	
	Total (4)+(2)	4.0	14.7	383	0	199	582	52
	Total (4)+(3)	3.7	13.7	383	115	199	697	40
C source (Oil energy) project	(1) NEP Coconut cultivation with copra not included	3.4	12.5	0	0	0	0	
	(5) Copra turned into fuel for CDM and local market	0.3	1.2	383	115	23.0	521	
	Total (1)+(5)	3.7	13.7	383	115	23.0	521	5
Csink + Oil energy project	(4) NEP Coconut cultivation with copra not included, I-CER	3.4	12.5	0	0	199	199	
	(5) Copra turned into fuel for CDM and local market	0.3	1.2	383	115	23.0	521	
	Total (4)+(5)	3.7	13.7	383	115	222	720	45

- in absence of any CDM project, the value added to the coconut products comes from local processing of the copra into coconut oil, adding *ca.* 115 USD ha⁻¹ yr⁻¹ to the farmer's income of 383 USD ha⁻¹ yr⁻¹, *i.e.* adding 30% to the raw value.
- When implementing a t-CER C-sink project, the value-added by C fixation in the ecosystem would be a maximum of +72 USD ha⁻¹ yr⁻¹, *i.e.* *ca.* +15 to +19%. When using a l-CER, the value-added would be +199 USD ha⁻¹ yr⁻¹, *i.e.* *ca.* +40 to +52%. Clearly, l-CER is much more profitable.
- When implementing an energy-oil project, the value-added by C fixation in the coconut oil would be a maximum of +23 USD ha⁻¹ yr⁻¹, *i.e.* rather low (+5%). This is not including other benefits at national scale, like for example rural development, price stabilization for coconut oil locally, better commercial balance for energy, especially in the current context where petroleum prices are over 105 USD per barrel of crude oil.
- When implementing a C-sink + energy-oil project, the value-added by C fixation in the benefit would be +19% for t-CER, and 45% for l-CER, both with respect with the scenario where oil is produced locally.

It must be stressed that these are maximum estimations or the "potential" profitability, because in theory (equation 1), the creation of other greenhouse gases should be accounted for and retrieved, and the absorption by the baseline and the leakages should be deducted (both assumed to be zero here). The benefits generated from CO₂ sequestration during cultivation could be much larger than the CO₂ savings from substitution of diesel by biodiesel, all expressed per hectare of plantation.

General conclusions and recommendations for APCC

Today, the Clean Development Mechanism (CDM-Mitigation part) of the Kyoto Protocol is

an opportunity for the coconut sector of developing countries (DC) to collect subsidies from the carbon market, especially for energetic and substitution projects, for which many methodologies and projects have already been certified. However, most of the value added on local markets is the transformation of copra into energy oil, and not the certification of coconut oil for energy: hence, certifying oil under CDM would bring only negligible premium for farmers and local oil mills, although it might be of high interest for the commercial balance of coconut-producing countries.

The C sink part (A/R) is worth being implemented by APCC members for coconut. It is definitely a large C sink (when compared to world forests) and might potentially bring much larger incomes than energetic projects. However, the C is not stored in permanent biomass like in forests, but turned rapidly into litter and then, eventually, into soil organic matter (SOM): it means that certification by CDM should first accept methodologies for C stored in SOM.

We would recommend that APCC quickly prepares energy (for the benefit of coconut producing countries mainly) and substitution projects, following the methodologies already approved by CDM. Also that APCC prepares applications and methodologies for C sink (A/R) projects, and/or that farmers and oil mills and countries trade directly with Non-Kyoto partners for promoting coconut C sinks, which are potentially much more profitable than energy project. In addition, APCC should follow recent and future evolutions of CDM in terms of certification of C sink projects (over 30 more will be released in a close future), agricultural projects and management projects, getting ready for the second commitment period (> 2012).

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References

- Hamel, O. and Eschbach, J.-M. 2002. Impact Potentiel du Mécanisme de Développement Propre dans l'avenir des cultures pérennes. Etat des négociations internationales et analyse prospective à travers l'exemple de la filière de production du caoutchouc naturel, In: L'Avenir des Cultures Pérennes, Conférence Internationale de Yamoussoukro, Côte d'Ivoire, pp. 5-9
- IPCC 2007. IPCC Fourth Assessment Report. Available on internet at <http://www.ipcc.ch/>.
- Locatelli, B. and Pedroni, L. 2004. Accounting methods for carbon credits: impacts on the minimum area of forestry projects under the Clean Development Mechanism. *Climate Policy* 4 (2): 193-204.
- Neeff, T., Eichler, L., Deecke, I. and Fehse, J. 2007. Update on markets for forestry offsets. Serie Tecnica: Manual Tecnico - Centro Agronomico Tropical de Investigacion y Ensenanza (No.67): vii + 35 pp.
- Point Carbon 2008. <http://www.pointcarbon.com/>.
- Ribier V., L.J., Rouzière A. and Vaitilingom, G. 2004. Etude de faisabilité d'un projet de valorisation de l'huile de coprah à l'échelle villageoise. Le cas de la coopérative "LORY", Nord Santo. Rapport de mission pour le compte du Producers Organization Project of Vanuatu (POPACA).pp 35 + annexes.
- Roupsard, O. 2001. Simulating costs and benefits of the use of a blend of coconut oil and fuel by drivers in Vanuatu. Oral communication + spreadsheet simulation (excel), Pacific Island Climate Change Assessment Program (PICCAP) Meeting. Espiritu-Santo, Vanuatu. 19-24 November 2001
- Roupsard, O., Bonnefond, J.M., Irvine, M., Berbigier, P., Nouvellon, Y., Dauzat, J., Taga, S., Hamel, O., Jourdan, C., Saint-Andre, L., Mialet-Serra, I., Labouisse, J.P., Epron, D., Joffre, R., Braconnier, S., Rouziere, A., Navarro, M. and Bouillet, J.P. 2006. Partitioning energy and evapo-transpiration above and below a tropical palm canopy. *Agricultural and Forest Meteorology* 139 (3-4): 252-268.
- Tan, R.R., Culaba, A.B. and Purvis, R.I. 2004. Carbon balance implications of coconut biodiesel utilization in the Philippine automotive transport sector. *Biomass and Energy* 26: 579-585.
- UNFCCC 2008. <http://cdm.unfccc.int/Statistics/>.

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Walker, S.M., Pearson, T.R.H., Munishib, P. and Petrova, S. 2008. Carbon market opportunities for the forestry sector of Africa. Winrock. Winrock International. FAO African Forestry and Wildlife Commission 16th Session, Khartoum, Sudan 17-24 February 2008., pp. 73.