European Commission
Directorate-General for Environment

Study on the evolution of some deforestation drivers and their potential impacts on the costs of an avoiding deforestation scheme

In the context of the Framework Contract No. DG ENV/G.1/FRA/2006/0073

Specific Contract No. DG.ENV.G.1 VA/11 ARES(2008) 52924

Executive Summary

ECORYS
Research and Consulting

International Institute for Applied Systems Analysis
IIASA www.iiasa.ac.at

Member of Consortium COWI

March 2010

Authors:
Koen Rademaekers, ECORYS
Lisa Eichler, ECORYS
Johannes Berg, ECORYS
Michael Obersteiner, IIASA
Petr Havlik, IIASA

Contributing authors:
Kentaro Aioki, IIASA
Steffen Fritz, IIASA
Aline Moisner, IIASA
Lillah Lucie Emmik Sørensen, COWI
Koen Overmars, ECORYS

ECORYS Nederland BV
P.O. Box 4175
3006 AD Rotterdam
Watermanweg 44
3067 GG Rotterdam
The Netherlands

T +31 (0)10 453 88 00
F +31 (0)10 453 07 68
E netherlands@ecorys.com
W www.ecorys.com
Registration no. 24316726

ECORYS Macro & Sector Policies
T +31 (0)31 (0)10 453 87 53
F +31 (0)10 452 36 60

Abbreviations

AiC	Action in Context
ASMGHG	Agricultural Sector and Mitigation of Greenhouse Gas
AZE	Alliance for Zero Extinction
BAU	Business As Usual
CER	Certified Emission Reductions
COP	Conference of the Parties
EC	European Commission
EPA	United States Environmental Protection Agency
EPIC	Environmental Policy Integrated Climate
EU	European Union
EU ETS	European Union Emissions Trading Scheme
FAO	Food and Agriculture Organization of the United Nations
FAOSTAT	Statistical Database of the Food and Agriculture Organization of the United Nations
FLEG	Forest Law Enforcement and Governance
FRA	Global Forests Resource Assessment
GATT	General Agreement on Tariffs and Trade
GDP	Gross domestic product
GGI	Greenhouse Gas Initiative
GHG	Greenhouse Gas
GLOBIOM	Global Biomass Optimization Model
G4M	Global Forest Model
HRU	Homogeneous Response Unit
IAD	Institutional Analysis and Development Framework
IFA	International Fertilizer Industry Association
IFRPI	International Food Policy Research Institute
IIASA	International Institute for Applied Systems Analysis
IPCC	Intergovernmental Panel on Climate Change
IPTS	Institute for Prospective Technology Studies
JRC	Joint Research Centre
IUCN	International Union for Conservation of Nature
MCPFE	Ministerial Conference on the Protection of Forests in Europe
Mha	Million hectares
MTOE	Million Tonnes Oil Equivalent
NASA	National Space Agency
NGO	Non-governmental organization
NPP	National Protection Plan
PBL	Dutch Planbureau voor de Leefomgeving
POLES	Prospective Outlook on Long-term Energy Systems
PPP	Purchasing power parity

RED	Reducing emissions from deforestation
REDD	Reducing emissions from deforestation and degradation
REDD+	Reducing emissions from deforestation and degradation including conservation, sustainable forest management and sink enhancement
REDD++	Reducing emissions from deforestation and degradation including conservation, sustainable forest management and sink enhancement and afforestation SPWP Secondary Processed Wood Product
ITTO	International Tropical Timber Organization
UNCED	United Nations Conference on Environment and Development
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
USDA	United States Department of Agriculture
WCMC	World Conservation Monitoring Centre
WTO	World Trade Organization
YSSP	Young Scientists Summer Program

Executive Summary

The implications of deforestation

Tropical forests are hosts to over half of all global animal and plant species. It is essential to preserve these forests in order to maintain the richness of life on Earth. Furthermore, it is widely recognised that the consequences of tropical deforestation reach further than the loss of biodiversity itself. Deforestation also causes disturbed water regulation and destroys the resource base and livelihoods for many of the world's poorest. With regard to global climate change, deforestation has severe negative impacts: as tropical deforestation is considered the second largest source of anthropogenic greenhouse gas emissions, the reduction of greenhouse gas emissions from tropical deforestation is now an essential component of international efforts to mitigate global warming and provide additional benefits to the climate system.

Despite policy efforts on reducing deforestation, **worldwide deforestation figures confirm that approximately 13 million hectares of forests (equivalent to about 4 times the size of Belgium or 0.3% of total worldwide forest cover) continue to be lost every year**.

Purpose of this study

This study aims to better understand the linkages between and the significance of different deforestation drivers, taking into account the changing global economic and political environment. The study furthermore estimates (using GLOBIOM and G4M models) the effects of changes in drivers (various scenarios are defined) on deforestation levels and assesses the marginal costs and challenges for reducing deforestation in order to limit climate change and preserve biodiversity. The objective is thus to assess to which extent our current consumption and production patterns as well as potential future shifts in these patterns affect deforestation levels and to draw conclusions on which policies and behaviours would likely have the worst consequences in terms of causing additional deforestation, as more effort should be put on preventing these particular developments in the future.

Drivers of deforestation

Given the fact that some regions are endowed with more biologically-diverse forest ecosystems than others, ***Chapter 2*** focuses on presenting current deforestation levels in the three hotspot regions: **Latin America and the Caribbean, Sub-Saharan Africa and Pacific Asia**. In addition, global and regional deforestation drivers and their impacts on deforestation levels as well as their possible evolution are presented. The analysis of drivers serves as input for modelling changes in economic, political and environmental drivers as a consequent step in the study.

On a global scale, the most important identified direct drivers for deforestation are agricultural expansion for food and energy production, followed by infrastructure development and wood extraction. The indirect drivers are seen to be reflected by the full interplay of institutional, demographic, economic, technological, and cultural variables rather than by single-factor causation. The main broad categories of global indirect deforestation drivers are: i) *economic growth* with an increased global GDP from about US$ 16 trillion in 1970 to US$47 trillion in 2005, which is projected to grow to up to almost US$ 100 trillion by 2030, assuming constant prices; ii) *demographic changes* with the world's population projected to increase from 6.4 billion in 2005 to 7.5 billion in 2020 to 8.2 billion in 2030; iii) i*nternational trade* with developed economies importing more and more natural resources from developing and transition economies; iv) *alternative energy policies* where the use of biomass and biofuels is increasingly encouraged and needs to be assessed as a driver of deforestation; and v) t*rade offs between different land uses*: policies as well as economic considerations on the profitability of various land uses play an important indirect role in increasing or relieving pressure on deforestation. Chapter 2 then provides more detailed region-specific driver analyses, including an assessment of the actors involved. The chapter closes with an analysis of the most likely future developments of the key deforestation drivers.

Developing the modelling framework – the global baseline

Chapter 3 establishes the framework for the consequent modelling process. First, the chapter presents a global baseline scenario (business as usual projection) against which alternative scenarios are compared. As a next step, realistic qualitative scenarios are constructed on various potential future shocks (i.e. changes in drivers) based on the findings of the driver analysis (Chapter 2). This basic framework, in combination with the models, will allow for reaching a quantitative understanding on how changes in drivers (i.e. policy shocks) influence the total future levels of deforestation as well as providing some indication on the marginal costs of achieving the EU's 2020 and 2030 policy goals on deforestation in case these shocks happen.

The seven policy shock areas

Seven shock areas (involving a total of 10 shock scenarios) are then identified for a quantitative modelling analysis for the three deforestation hotspot regions, including geographic explicit case studies for the Congo Basin region. The seven selected shock areas are:

1) The effect of <u>increased demand for biofuels</u> on deforestation: a shock is introduced in the model whereby a share of 15% of global transport energy in 2030 comes from biofuels that are produced from various combinations of 1st and 2nd generation biofuels. In total five different combinations of such biofuels demand shocks are modelled.

2) The effect of <u>increased demand for wood and wood products</u> (particularly stemming from the BRIC[1] countries): two shock scenarios are introduced, representing an additional demand for wood by 2030 of respectively 15% and 25% more than in the baseline. It is assumed (due to the specifications of the model) that this additional amount of wood is supplied from sustainable wood farming.

3) The effect of <u>increasing global meat demand</u>: an overall additional increase of 10% in animal calorie consumption is introduced in the model for 2020 (15% for 2030).

[1] BRIC = Brazil, Russia, India and China

4) The effect of a dual shock of increased meat and 1st generation biofuels demand: the above described meat and one biofuels shocks are combined and analysed.

5) The effect of further infrastructure development: a decrease in transportation costs is modelled, at the level of 10% in emerging economies and 5% in developing regions by 2030 as compared to baseline. The 5% decrease is modelled on a geographic explicit level for the Congo Basin case study.

6) The role of increasing biodiversity schemes is also modelled. Under this shock scenario, areas under protection for biodiversity purposes increase by 20% by 2030 as compared to the baseline (consisting of maintaining the current 10% of land area of all types of ecosystems protected).

7) Finally, the role of good governance and how it supports sound forest policy is analysed. Under this policy shock scenario two options - constant and improving governance - are considered for the geographic explicit case study, the Congo Basin. The constant governance option displays the baseline assumption.

The first four of these policy shock areas are analysed on a global scale and the two policy shock areas of infrastructure development and biodiversity protection are modelled both on a global scale as well as on geographic-explicit level. The impact of changing governance is modelled only in a geographic-explicit manner for the Congo Basin; this particular scenario did not show significant results due to current model restrictions and is therefore only presented in the annex.

In practical terms, this shock analysis means that for each scenario separately, the shock is incorporated in the baseline and the model re-run under these new assumptions.

Results of policy shock scenario runs

The outcomes of the scenario runs are presented in ***Chapter 4*** depicting the results of the 10 shock scenarios according to their impact on deforestation in terms of future deforested area as well as the associated marginal cost of reducing deforestation (in US$ per tonne of avoided CO_2). The modelling exercise developed for this study has shown that, when assessing the impacts of several rather extreme policy shock scenarios, it is possible to see which ones are the most striking ones in terms of further worsening deforestation levels.

The two policy shocks leading to the worst consequences in terms of additional deforestation are (a) an increase in consumption of 1st generation biodiesel (representing up to 15% of transport energy in 2030) **and (b) an increase in meat consumption** (15% more meat demand than in baseline for 2030): **these two scenarios lead to a deforestation level in 2030 that is, respectively, 46% (31 Mha) and 37% (25 Mha) higher than in the baseline.** Even if the biofuels policy shock is fed by a mix of 1st generation biofuels (a mix of biodiesel and bioethanol[2]), the results in terms of additional deforestation remain dramatic (30% or 20 Mha more deforestation than in baseline).
In the rather realistic case of a combined increase in 1st generation biofuels and meat consumption, the additional deforestation would even be **53%** (36 Mha) higher than in

[2] The mix is based on the same distribution as in 2007, so 75% biodiesel and 25% bioethanol.

the baseline scenario (which already takes into account an increase in those demands based on population and economic growth).
As regards **infrastructure development** leading to decreasing transportation costs (by 10% in emerging economies and by 15% in developing regions), the model shows that **it would lead to a 5% increase in deforestation, due to an easier access to formerly remote areas, where – as a consequence - agricultural expansion becomes easier at the expense of forests**.

On the contrary, in the case where the increased demand for biofuels would be fed by 2nd generation biofuels only, deforestation would actually decrease compared to the baseline. This is explained by the fact that increased wood demand and the subsequent improved valorisation of sustainably managed forests is likely to increase their economic competitiveness compared to cropland. As a result, investments in agricultural improvements appear as less costly than clearing forests, leading in the aggregate to decreased cropland expansion into forests.

It is also relevant to analyse the results for the three deforestation hotspots (Sub-Saharan Africa and Pacific Asia, as well as Latin America and the Caribbean).

Implications for Africa

Sub-Saharan Africa has been experiencing high deforestation rates accounting for a **net loss of approximately 4 million hectares per year** over the last 20 years (which equals about the size of Belgium or 0.3% of the entire African forest cover). The following direct drivers are identified as having significant influence on the high rate of deforestation in the region (in order of importance): agriculture (deforestation); fuel wood consumption (degradation); commercial logging and timber production (degradation); illegal logging (degradation); and infrastructure development (deforestation). In addition, indirect demographic, economic, technological, governance and socio-cultural drivers influence current deforestation patterns.

In the case of Sub-Saharan Africa, increased wood and meat demand, as well as infrastructure expansion, are likely to occur over the next 10 to 20 years, together with a contribution of the region to an increasing worldwide biofuels production. Besides, given the very low levels of governance in the region, biodiversity protection and enforcement of any types of forestry policies will likely remain very difficult in the years to come.

For Sub-Saharan Africa, modelling results have shown that increased global demand for 1st generation biodiesel and meat trigger the most severe additional deforestation, representing respectively 22% and 14% additional deforestation as compared to the baseline for the period between 2020 and 2030 (but “only” respectively 0.2% and 0.13% of current Sub-Saharan African forest cover).

Global policies favouring 2nd generation biofuels and infrastructure development, on the other hand, are likely to actually have beneficial impacts with regards to lowering deforestation rates in Sub-Saharan Africa. Today’s transportation and logistics infrastructure in Africa is still poorly developed and highly inefficient. This situation currently triggers inefficiencies in the industrial and, even more importantly, the agricultural sectors. New technologies and infrastructure development could help create a more efficient agricultural system with advanced agricultural activities (e.g. multiple harvests and transportation of fertilizers) and therefore increase the yield of the land already available instead of expanding farmland through deforestation to compensate for the lack of yield. A reduction of deforestation would therefore be the result. At the same time, global demands for 2nd generation biofuels would likely stimulate a switch to land use for producing the raw material inputs to meet this increasing demand and thus some marginal areas, or areas currently deforested for other agricultural purposes could be converted into more sustainable energy crop plantations.

For the geographic-explicit analysis on the Congo Basin, the model shows that increased biodiversity protection (if implemented effectively) can make a difference in terms of avoiding deforestation in the region by avoiding about half a million hectares of additional deforestation compared to baseline, which would represent about 20% of the current forest cover. Infrastructure developments, on the other hand, would reduce transportation costs and thus make agricultural production a more viable source of income in previously remote areas and consequently deforestation levels would increase (by 114%) if no avoiding deforestation scheme is put in place. However, infrastructure improvement not only acts as a cause for additional deforestation but could also foster efficiency gains in agriculture and forest management to such a degree that the implementation of an avoiding deforestation scheme (under the form of REDD+ for instance[3]) would become less costly than under baseline conditions. This is visible in the model results which show that the infrastructure development scenario allows for decreased deforestation as soon as the target for avoiding deforestation gets higher than 50% (of avoided deforestation). Thus, **if infrastructure development goes hand in hand with well-targeted forest protection, both the environment and the economy could win.** It should be noted, however, that results may differ if analysed for regions other than the Congo Basin.

In order to implement policies that avoid deforestation in Sub-Saharan Africa, two counteracting aspects have to be taken into consideration. On the one hand, **the results for every shock scenario have shown rather small quantities of deforestation compared to the other two regions analysed.** Together with the findings from the geographic-explicit case study, however, one can draw the conclusion that possibilities to avoid deforestation exist by – for example – increasing the area of biodiversity protection sites assuming that supporting governance improvements go hand in hand to ensure effective implementation. On the other hand, the poorly developed economies in Sub-Saharan Africa will demand comparably larger financial resources to implement policies in an efficient and effective manner. Therefore, when juxtaposing Sub-Saharan Africa to other regions, the aim of avoiding a comparably smaller degree of deforestation in this region may call for comparably larger financial efforts.

Implications for Pacific Asia

Pacific Asia is the hotspot region with the lowest deforestation rate, reporting **a net gain of approximately 1 million hectares per year** (which equals about 30% of the size of Belgium or 0.5% of the Pacific Asian forest cover). The direct drivers of deforestation identified in this region are, in order of importance: agricultural expansion (deforestation) for cash crops and to satisfy increasing food demand, wood extraction (deforestation), infrastructure expansion (deforestation), natural disasters (degradation), and the

[3] REDD+ stands for : Reducing emissions from deforestation and degradation, including conservation, sustainable forest management and sink enhancement

exploitation of natural resources, such as mining activities (deforestation / degradation). Furthermore, the rapid economic growth of the region will likely generate large demands for new infrastructure development in the coming years and similarly, greater affluence tends to increase the demand for meat.

For Pacific Asia, modelling results have shown that global demand increases in 1st generation biodiesel (or a mix of 1st generation biodiesel and bioethanol) and in meat would generate the most severe impacts for additional deforestation in the region. These demand increases would cause, respectively, 40% and 29% more deforestation than in the baseline for the period between 2020 and 2030, representing 2.4% and 1.7% of current Pacific Asian forest cover.

Policy-makers have a chance to avoid deforestation in the region by implementing policies in favour of sustainable wood farming, 2nd generation biofuels and constantly improving the regions infrastructure efficiency and effectiveness, thereby reducing the needs for additional deforestation for new infrastructure development. In addition, proactive actions pointing out the external costs of increased meat consumption and 1st generation biofuels use of any kind could lead to less demand and thus indirectly lower deforestation rates in other regions of the world.

Implications for Latin America & the Caribbean

Latin America and the Caribbean currently accounts for the **largest loss of tropical forests with 4.3 million hectares being deforested per annum** (which equals about 1.3 times the size of Belgium or 0.5% of the entire Latin American and Caribbean forest cover). The most important direct drivers of deforestation identified in Latin America are (in order of importance): agriculture (deforestation), infrastructure expansion (deforestation), and wood extraction (deforestation). In addition, various indirect economic, governance and socio-cultural factors play a role in stimulating continued deforestation.

In the short- and medium-term future, biofuels production for bioethanol, biodiesel, 2nd generation biofuels, or a combination thereof is projected to increase drastically and Latin-America is most likely to maintain the current position as world leader in biofuels production. Furthermore, meat demand is also likely to increase in the future due to an increasing population within the region as well as increasing demand worldwide.

Similar to Sub-Saharan Africa and Pacific Asia, the Latin America and Caribbean region also suffers the most severe negative impacts on deforestation levels when global demand for 1st generation biofuels and meat increases. In addition, however, this region also suffers significant increases in deforestation levels even when the demand for biofuels is satisfied by a mix of all three types of biofuels (1st generation biodiesel and bioethanol combined with 2nd generation bioethanol). These policy shock scenarios lead to significant annual deforestation levels, corresponding to 50% additional deforestation as compared to baseline in the case of 1st generation biodiesel and 42% in the case of a meat consumption increase.

In Latin America and the Caribbean, global developments towards 2nd generation biofuels is the only case leading to significantly reduced deforestation levels below the baseline. To some extent, sustainable wood farming policies could have a positive effect as well.

The Latin America and Caribbean region is predicted by the model to experience, across all scenarios, the highest levels of deforestation worldwide between 2020 and 2030 (on average more than 4 ½ times as much deforested area as in Pacific Asia and more than 8 ½ as in Sub-Saharan Africa). In no other region analysed will some extreme developments in drivers (both at regional and worldwide levels) cause such high levels of corresponding deforestation. Any policy in favour of additional 1st generation biofuels production or cattle farming will have the most drastic consequences for forest loss and nowhere else in the world could a push for 2nd generation biofuels production avoid more deforestation.

Costs of reducing deforestation

The modelling exercise developed for this study has also shown the associated annual marginal costs of avoiding certain degrees of deforestation under the various shock scenarios. Logically, the more ambitious the goals of avoiding deforestation are, the more costly the endeavour becomes. When comparing marginal costs[4] of a 50% avoiding deforestation scheme under the baseline scenario and under some shock scenarios, the modelling exercise shows that **marginal costs would increase by almost 60% if biofuels demand would rise to representing 15% of total transport energy in 2030 and if this additional demand would be satisfied with 1st generation biofuels only (scenario BIOF4). The same cost implications would occur if meat consumption was to increase by 15% compared to the baseline in 2030**. In case those two shocks are combined (which could be an evolution of world demand), marginal costs of avoiding deforestation (with a target of 50% of avoided deforestation) would more than double compared to the baseline scenario (with no shock on demand). This shows that **world demand developments could have significant implications in terms of financing a REDD mechanism**. In addition, the study shows that the stronger the avoiding deforestation target, the higher the likely variance in associated marginal costs when demand shocks occur; in other words, **with more ambitious avoided deforestation targets, the need for financing not only becomes higher but also less predictable as the impacts of possible shocks become more influential**.

However, the study does not allow for an estimation of total global costs of avoiding deforestation because it does not examine the various possibilities for REDD implementing schemes. This would nevertheless require also including transaction costs in the total price analysis, since those highly depend on the chosen REDD implementation scheme.

Conclusions

Overall, the study demonstrates that future policy decisions in various policy fields as well as future consumption and production patterns will directly or indirectly impact deforestation levels across the world.

The main conclusions (***Chapter 5***) underline that any policy measures or production and consumption trends promoting first generation biofuels or meat demand would have the most severe negative consequences for deforestation levels and associated marginal costs of avoiding the deforestation across all three regions between 2020 and 2030.

---

[4] The marginal cost of avoided deforestation can be interpreted as an annual incentive payment for postponing deforestation by one year. It is expressed in US $ / tCO2 avoided.

On a global scale, the main robust counter-measure to prevent potential negative consequences for deforestation across all scenarios is any measure that saves land and still produces the required increase in services such as food, energy and material supply (wood). Agricultural expansion (both for food and biofuels) is the single most important driver of deforestation projected up to 2030 and, thus, measures that decrease the land requirement per unit of food service delivered will help reduce deforestation. The most prominent measure in the agricultural sector is the increase of yields[5] through better management practices in agricultural production covering both the crop and livestock sectors. Other measures include demand side measures of less land intensive consumption patterns or introduction of efficiency measures in the total food chain targeting food wastes. Measures in the forest sector mostly point to measures that tackle degradation of forest carbon stocks through unsustainable forest management practices such as destructive high grading of a few commercially high yielding timber species using inadequate logging operations or failed forest regeneration after harvesting.

Even though this study primarily focussed on identifying which of the selected shocks is worst for future deforestation levels, some shocks turned out to have the potential to help reduce deforestation if implemented in the correct way, such as the mentioned wood demand scenario, as well as the development of a package of policies promoting 2nd generation biofuels. However, there are caveats to be made in the sense that policies promoting 2nd generation biofuels will need to be well designed to create the right incentives leading to the projected positive impacts on **gross deforestation**. In particular, issues about reinforcing institutions regulating and monitoring land competition, allocation of property rights, and finally careful local studies on the social constraints to attain the projected potentials of wood supply.

To recap, **worldwide policy priorities** should focus on **promoting a switch towards second generation biofuels**, **limiting meat consumption**, working on **sustainable infrastructure development**, and **sourcing wood demand from sustainable sources** to help save the world's forest from further deforestation. If prioritisation is required in terms of what regions to focus on first in order to reduce deforestation, then **Latin America and the Caribbean** stands out as the **focal region** given the much larger negative impacts across all policy scenarios in terms of additional deforestation and thus the potential gains and low-hanging fruits to be achieved via improved and more targeted policy-making. Finally, the study has also highlighted that deforestation rates are by no means only influenced by local practices and demands for resources. Rather, in today's globalised economy, **all regions are closely inter-linked and consumption and production patterns in one region can influence to a large extent deforestation rates in another region of the world.** Thus, the more developed and transition economies should pay close attention to how their domestic policies potentially *outsource* deforestation to other parts of the world.

[5] Current global models do not, however, allow for capping productivity intensity and efficiency gains; those results are shown by our analysis of the effects of the scenarios when the BAU includes a yield growth of 1% per annum.