Carbon sequestration options in the international climate regime

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List of Abbreviations

AAU	Assigned Amount Unit
AGBM	Ad hoc group on the Berlin mandate
AOSIS	Alliance of Small Island States
A/R	Afforestation and reforestation
CCS	Carbon Dioxide Capture and Storage
CDM	Clean Development Mechanism
CER	Certified Emission Reduction
CO_2	Carbon Dioxide
COP	Conference of the Parties
ERU	Emission Reduction Unit
EU	European Union
GDP	Gross Domestic Product
GWP	Global Warming Potential
INC	Intergovernmental Negotiation Committee
IPCC	Intergovernmental Panel on Climate Change
LR test	Likelihood-ratio test
LULUCF	Land use, Land-use Change and Forestry
NBRM	Negative binomial regression model
OPEC	Organization of the Petroleum Exporting Countries
PRM	Poisson regression model
QUELRO	Quantified emission limitation and reduction obligation
RMU	Removal Unit
tCER	Temporary Certified Emission Reduction
UK	United Kingdom
UNFCCC	United Nations Framework Convention on Climate Change
USA	United States of America
ZIP	zero-inflated Poisson
ZINB	zero-inflated negative binomial

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Chapter 1

Introduction

1. Introduction

1.1. Climate change – the scientific basis

Since the end of the 20th century, the relation of humans to the climate has changed considerably. While climate was long perceived as something given, nowadays the perception of climate is focused on issues related to the human influence on the climate (Cubasch and Kasang 2000).

The greenhouse effect was described as early as 1827 by the French scientist Fourier. He found that trace gases (e.g. water vapor, carbon dioxide, methane, nitrous oxide) let the sunlight pass freely to the Earth´s surface, but absorb and trap the sunlight which is reflected back towards space as infrared radiation (heat). Therefore, these trace gases are also called greenhouse gases. At Fourier´s time, the greenhouse effect was discussed mainly with view on its role for maintaining a life-sustaining environment on the earth. At the end of the nineteenth century, however, the Swedish scientist Arrhenius was the first to point out that the growing volume of carbon dioxide emissions due to the Industrial Revolution was changing the concentration of greenhouse gases in the atmosphere and was leading to an increase in the Earth´s surface temperature (Grubb 1999). It took until 1957 - the International Geophysical Year – for the international research community to address this question more seriously. The First World Climate Conference in 1979 was one of the first major international meetings on the issue of climate change (UNFCCC 2003a). A result of this conference was the increased support of research on the scientific basis of climate change which finally led to the establishment of the Intergovernmental Panel on Climate Change (IPCC) in 1988. The findings of the First and Second Assessment Report of the IPCC published in 1990 and 1996 concluded that the concentration of greenhouse gases in the atmosphere was rising due to human activities and that this would lead to rising temperatures and a human-induced climate change[1] (Grubb 1999). The Third Assessment Report of the IPCC published in 2001 reinforced the conclusions of the earlier reports, stating that the global average surface temperature has increased over the 20th century by about 0.6° C, and, that there is evidence that most of the warming observed over the last 50 years is caused by anthropogenic activities. (IPCC 2001)

1.2. The international climate policy regime

Against the background of the results of the First Assessment Report of the IPCC, the Second World Climate Conference held in 1990 called for the creation of a global treaty

[1] A certain degree of climate change due to natural reasons has existed since the formation of the earth.

and initiated negotiations on a convention on climate change by establishing the Intergovernmental Negotiation Committee (INC). In 1992, the INC adopted the United Nations Framework Convention on Climate Change (UNFCCC) which was subsequently opened for signature at the United Nations Conference on Environment and Development in the same year. The UNFCCC entered into force on 21 March 1994 (UNFCCC 2003a). Article 2 addresses the objective of the convention (UNFCCC 1992):

> *"The ultimate objective of this Convention and any related legal instruments that the Conference of the Parties may adopt is to achieve, in accordance with the relevant provisions of the Convention, stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. Such a level should be achieved within a time-frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened and to enable economic development to proceed in a sustainable manner."*

Ever since 1995, Parties have met annually at the Conferences of the Parties (COP). The COP is the ultimate decision-making body of the UNFCCC responsible for the implementation of the Convention as well as its further development. However, soon Parties noticed that the relatively general provisions of the UNFCCC would not be enough to achieve the goal of stabilizing the greenhouse gas concentration in the atmosphere. Therefore, at the first conference of the Parties (COP 1) in Berlin, the negotiation of more detailed and binding commitments were initiated (Oberthür and Ott 1999). A framework sketching basic rules and including legally binding commitments for a set of industrialized countries and countries with economies in transition (Annex B countries[2]) - now known as the Kyoto Protocol - was adopted at COP 3 in Kyoto, Japan in December 1997. In the Kyoto Protocol, so called Annex B countries have agreed to reduce their overall greenhouse gas[3] emissions by at least 5% below 1990 levels in the first commitment period (2008-2012). However, implementation details are not addressed by the Protocol. In 1998, COP 4 decided the Buenos Aires Plan of Action which laid out a work program for the negotiation on open implementation issues. After a deadlock at COP 6 in La Hague, the Buenos Aires Plan of Action could be finalized in 2001 at COP 7 in Marrakech. The resulting decisions - also labeled the Marrakech Accords - were a milestone in the negotiations on the rules and

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[2] The terms Annex B and Annex I country are often used interchangeably. This is, however, not exact. Annex I refers to the UNFCCC. Parties with emission reduction targets are listed in Annex B of the Kyoto Protocol, therefore labelled Annex B countries. Only two countries (Turkey and Belarus) are Annex I countries without being listed in Annex B of the Kyoto Protocol.

[3] The greenhouse gases included in the Kyoto Protocol are carbon dioxide (CO_2), methane, nitrous oxide, HFCs, PFCs as well as SF_6.

modalities for the Kyoto Protocol. With the Russian ratification of the Kyoto Protocol, it entered into force on 16 February 2005.

The three flexible mechanisms of the Kyoto Protocol – Joint Implementation (JI), the Clean Development Mechanism (CDM) and emissions trading are supposed to lead to an efficient compliance with the Kyoto commitments. The first two allow Parties with emission targets to conduct emission reduction or sink enhancement projects in other countries and use the resulting emission credits for compliance with their commitments. Emission trading creates an international market on which emission allowances and credits can be traded. Further details on these mechanisms, especially the CDM, will be dealt with in later chapters of this study.

1.3. Carbon sequestration as a climate mitigation option

Mitigation options for limiting the increase of the greenhouse gas concentration in the atmosphere comprise either emission reduction (avoiding emissions at the source) or removal and storage of greenhouse gases. Article 3.1 - in stating the goal of the Kyoto Protocol - uses the expression 'reducing the overall emissions'. However, national emission inventories include emission reduction as well as removal of greenhouse gases through certain sequestration activities.

Carbon sequestration activities have in common that they do not avoid the production of CO_2, but lock carbon (dioxide) away from the atmosphere for a certain period of time. This long-term storage of carbon can take place either in the terrestrial biosphere, underground or in the oceans. Carbon sequestration in the terrestrial biosphere refers to activities leading to an increase in carbon stocks in the terrestrial biomass as for example through afforestation. Such carbon sequestration activities have entered the Kyoto Protocol as the 'Land use, Land-use change and Forestry (LULUCF)' issue. Often LULUCF has simply been referred to as the 'sinks issue'[4]. As the rules and modalities for accounting for LULUCF significantly affected the already agreed Kyoto targets, negotiations on this issue were one of the most contentious issues in the climate negotiations. A sequestration option, which has only recently entered the climate policy arena, is the one of carbon dioxide capture and storage (CCS). This refers to activities which capture carbon dioxide at large point sources like power plants and store it subsequently in reservoirs.

The literature on LULUCF and CCS has so far evolved rather independently from each other. The literature on carbon sequestration in the terrestrial biosphere is extensive,

[4] It has to be mentioned, though, that this term is not really exact since LULUCF comprises human-induced emissions as well as removals (sinks) of greenhouse gases in the land-use sector.

covering natural as well as social sciences. The economic part has mainly focused on costs of different options as well as policy aspects regarding the temporary nature of carbon sequestration in biomass. This body of literature has, to a great extent, developed parallel to the discussion on the integration of LULUCF into the international climate regime. Most of the literature on carbon capture and storage deals with technical aspects of capturing, transporting and storing carbon, and costs associated with this. While the early literature on carbon dioxide capture and storage was mainly based on the idea of ocean sequestration, it is now focusing on storage of CO_2 in geological reservoirs. Some recent studies address different aspects of seepages of CO_2 from reservoirs. However, only very few studies examine issues related to the integration of carbon dioxide capture and storage into the international climate regime.

The present study deals with some of the policy-related issues of carbon sequestration which so far have not been considered sufficiently in the literature.

These issues are:

1. The negotiation process on the integration of LULUCF into the Kyoto Protocol, including the respective negotiating positions of Parties to the UNFCCC as well as their main driving forces.
2. Market effects of the inclusion of forestry projects in the CDM, including consequences for the price of emission permits in the international market and the redistribution of benefits and losses between countries and regions.
3. Factors determining CDM host country attractiveness, including implications for the geographical distribution of CDM projects.
4. Inventorying and accounting of CCS under the Kyoto Protocol considering different cross-border cases and non-permanence of storage, including economic implications of possible releases of CO_2 from storage reservoirs.

In the following section, the structure of the thesis is described briefly.

1.4. Structure

Chapter 2 includes an analysis of the negotiation process on LULUCF in the context of the UNFCCC. Contrary to most of the studies on the negotiation process, it is not restricted to a qualitative analysis, but applies quantitative methods for investigating negotiating positions of Parties. Factors influencing the positions of countries are identified using a multinomial regression model. Furthermore, a zero-inflated Poisson model is applied to analyze the participation of countries in the submission process on LULUCF.

The economic consequences of decisions taken in the negotiations on LULUCF are examined in Chapter 3. Its focus lies on forestry options in the CDM. As most of the economic models of the international market for emission permits are neglecting carbon sequestration options in the climate regime, marginal sequestration cost curves reflecting different LULUCF policy scenarios are developed and integrated into a partial equilibrium model of the international market for emission permits. The results shed light on the effect of different policy scenarios on the market price of emission permits as well as the distribution of benefits and losses between countries and regions.

While marginal cost curves, as used for the analysis in Chapter 3, are purely based on the potentials and costs of mitigation options, other factors are likely to influence investment into CDM projects as well. Therefore, Chapter 4 investigates the attractiveness of host countries for CDM investments taking into account that not only the mitigation potential, but also the institutional CDM capacity and the general investment climate are relevant factors. A cluster analysis is conducted to classify 114 CDM host countries regarding their attractiveness for CDM investments. The results can give an indication of what a future geographical distribution of CDM projects might look like.

While a whole set of rules and modalities has been elaborated for integrating LULUCF into the climate regime, the debate on whether and how to account for CCS under the Kyoto Protocol is rather new. Therefore, Chapter 5 deals with the implementation of CCS into the international climate regime. It is one of the first studies investigating implications for inventorying and accounting of CCS, considering the possibility of cross-border cases and non-permanence of storage. Furthermore, economic implications of the non-permanence of storage are examined under varying assumptions on seepage and discount rates as well as crediting periods.

Chapter 6 summarizes the main results of the previous chapters, concludes and highlights some policy implications.

Chapter 2

The History of LULUCF – an Analysis of Negotiating Positions in the Climate Regime

2. The History of LULUCF – an Analysis of Negotiating Positions in the Climate Regime[5]

2.1. Introduction

In Chapter 1, it has been mentioned that the basic structure of the climate regime was decided at COP 3 in Kyoto. However, international regimes are under constant development. Many times certain aspects which are left open to be resolved at later stages of negotiations, and which are considered to be of rather technical nature, later turn out to be major issues with great impact on the overall effectiveness of the regime (Depledge 2001). The introduction of land use in the climate change regime – officially labeled as Land use, Land-use change and Forestry (LULUCF) – is such an issue.[6] In using the example of the negotiations on LULUCF in the Kyoto Protocol, I combine qualitative background information with a quantitative approach to explain negotiating positions and behavior of Parties to the UNFCCC. As most of the studies on negotiating positions in international climate policy are of rather qualitative nature, the use of statistical analysis is rather new and can provide additional insights into the negotiation process. The results obtained from this study can contribute to a better understanding of the negotiation process in general as well as the role of sequestration in the negotiation of emission reduction targets. The latter might be especially relevant because negotiations on emission reduction targets for a second commitment period are envisaged to start in 2005.

The first part of the paper sketches the negotiation process related to the introduction of LULUCF in the climate regime. In the second part, I examine possible factors influencing negotiating positions and the participation of Parties in the negotiation process by using regression analysis.

2.2. The history of LULUCF in the climate negotiations

2.2.1. LULUCF rules for Annex I Parties

For analyzing the negotiation process, it is necessary to look at the roots of the discussion on carbon sequestration in the climate regime. The first call for a global effort on sinks creation by afforestation took place at the 1989 Nordwijk conference, one of the first global policy meetings on climate change (Nordwijk Conference 1989). At the United Nations Conference on Environment and Development in 1992, the goal to negotiate a forest convention failed. Although, terrestrial carbon sinks and sources play a considerable role as

[5] This chapter is based on Jung (2004).

[6] In the following, sinks and LULUCF are used interchangeably, although in the strict sense LULUCF activities can encompass sinks as well as sources of emissions from the land use sector.

an obligatory element of national emission inventories, the (non-binding) targets of the UNFCCC only refer to emissions. The Convention defines the term sink, but does not give any details on how sinks should be accounted for.

The Berlin Mandate which was adopted in 1995 in order to strengthen the commitments of Annex I Parties under the Convention by the adoption of another protocol or legal instrument explicitly refers to ‘emissions by sources and removals by sinks’, thus taking on the language used in the UNFCCC.[7] The Ad Hoc Group (AGBM) installed under the Berlin Mandate met eight times before the third Conference of the Parties (COP 3) to work towards the development of targets and rules for what then was going to turn into the Kyoto Protocol. Many of the country proposals on quantitative reduction targets – by then labeled QUELROs[8] - brought up in the AGBM process included sources as well as removals by sinks. Referring to the submissions by Parties on reduction commitments, the report of the AGBM at its sixth meeting states that “the alternatives also reflect a range of views on the inclusion of removals by sinks. Some Parties prefer that sinks and sources be treated equally, while other Parties have proposed alternative approaches for taking sinks into account” (UNFCCC 1997a, p.28). Since most submissions of countries on QUELROs included sinks, the need for clarification on how to account for these lead to the establishment of an informal sinks consultation group. A questionnaire was introduced to clarify the main issues relating to sinks in establishing reduction commitments (UNFCCC 1997b). It was only few months before COP 3 that negotiators became aware of how important the sinks issue was for the negotiation of the quantitative emission targets. A compilation of the country submissions on the questionnaire was available at the second part of ABGM 8 held in Kyoto days prior to COP 3. Most of the Parties of the Umbrella Group[9] were the most active supporters of an introduction of LULUCF in the calculation of targets, while the EU and the Alliance of Small Island States (AOSIS) belonged to the most prominent opponents since Kyoto.[10]

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[7] See decision 1/CP.1 FCCC/CP/1995/7/Add.1, I. (f) Coverage of all greenhouse gases, their emissions by sources and removals by sinks and all relevant sectors”, II. 2. The process will, inter alia: (a) Aim, as the priority in the process of strengthening the commitments in Article 4.2(a) and (b) of the Convention, for developed country/other Parties included in Annex I, both - to elaborate policies and measures, as well as - to set quantified limitation and reduction objectives within specified time-frames, such as 2005, 2010 and 2020, for their anthropogenic emissions by sources and removals by sinks of greenhouse gases not controlled by the Montreal Protocol.

[8] Abbreviation for quantified emission limitiation and reduction obligations

[9] This group consists of the US, Canada, Japan, New Zealand and Australia, Iceland, Russia, Ukraine and Norway.

[10] For the submitted proposals of the pre-Kyoto process, see UNFCCC (1997c to 1997f). Submissions in favor of sinks included those of Australia, Canada, Denmark, Iceland, New Zealand and the European Union, while Japan, Kenya, Marshall Islands and Nauru wanted to see sinks to be excluded in the first commitment

The chairman of the informal sinks consultation group reported to AGBM 8 a few day before the start of the negotiations of COP 3 that all Parties present had agreed that sinks were "important and should be included in commitments, subject to concerns about definitions, timing and scope"(UNFCCC 1997b, p.3). However, the informal consultations did not lead to an agreement on the sink categories to be included. Since at COP 3, the numbers on QUELROs could not be fixed until this decision was taken, time pressured to finalize the negotiations as soon as possible. In the round-the-clock consultations in Kyoto, Parties could agree to include afforestation, reforestation and deforestation, leading to the wording in Article 3.3.[11] But due to the lack of scientific knowledge and data on further activities, it was laid down in Article 3.4 that these should be decided on by COP/MOP 1 and apply only in the second and subsequent commitment periods. During the final negotiations taking place in the night session of 11 December 1997, Japan managed to add to Article 3.4 a sentence allowing additional human-induced activities already in the first commitment period if a Party decided so (Fry 2002). This sentence should have significant consequences for the further negotiation process by leaving great uncertainties on the magnitude of the already fixed targets and opening a loophole which could be used by Parties in the following to renegotiate their targets. Since Article 3.7 stipulates that sinks will not be included in the base year emissions (gross-net approach), every ton of CO_2 accounted for by additional activities under Article 3.4 would be a factual decrease of the reduction target for those countries having a net sink in the commitment period.[12] Australia, however, managed to insert an exception into Article 3.7 which allows Annex I Parties with net emissions in 1990 from land-use change and forestry to use a net-net approach, by adding land use emissions to their base year emissions. The latter is a special gift to Australia which had considerable net emissions in the LULUCF sector in 1990. The EU which came to Kyoto to avoid the inclusion of LULUCF, slowly moved towards accepting certain LULUCF activities, partly for tactical reasons and partly due to internal opposition from France, Finland, Sweden and Italy (Oberthür and Ott 1999; Fry 2002).

Therefore, the text on LULUCF (Article 3) coming out of Kyoto, taken under the severe time pressure and lack of data, left many issues unclear and open to interpretation. The

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period. Interestingly, the position in favor of sinks expressed by the European Union and the rather sceptical position of Japan were the exact opposite of what both are pushing for since Kyoto.

[11] Article 3.3: "The net changes in greenhouse gas emissions by sources and removals by sinks resulting from direct human-induced land-use change and forestry activities, limited to afforestation, reforestation and deforestation since 1990, measured as verifiable changes in carbon stocks in each commitment period, shall be used to meet the commitments under this Article of each Party included in Annex I…."

[12] However, as described below, not all of the additional activities under Article 3.4 have been included based on a gross-net approach.

following negotiations – especially the ones on Article 3.4 - were then used by some countries to reopen the negotiation on the targets decided at COP 3 by reinterpreting the LULUCF decision. The session of the Subsidiary Bodies in June 1998 asked the Intergovernmental Panel on Climate Change (IPCC) to produce a Special Report on LULUCF. The negotiation on LULUCF came to a hold until the report was published in May 2000 (IPCC 2000) because it was expected to deliver the scientific background on LULUCF carbon sequestration relevant for the further decision-making under the Kyoto Protocol. The report was perceived as quite supportive of LULUCF. Seemingly technical issues, as for example how to define a forest and how to differentiate between deforestation and harvest, were as much a source of disagreement as the decisions on which additional LULUCF activities to include under Article 3.4. At the SBSTA meeting in Lyon, in September 2000, it became clear that uncertainties regarding Article 3.4 were still significant. Australia and Japan pushed for narrow definitions of additional activities (e.g. fire control, pest control) fearing that broad definitions (forest management, cropland management etc.), as favored by the US and Canada, would lead to a disproportionately large flow of LULUCF credits into the two latter countries. The EU which had initially opposed any inclusion of additional activities was a weak opponent due to internal differences. Finally, broad definitions were adopted (Fry 2002). The developing countries had hardly been heard regarding this issue. However, at SBSTA 13, Brazil, speaking on behalf of G77 and China introduced a set of principles addressing developing country concerns regarding LULUCF in the Kyoto framework. The additional activities under Article 3.4 became the crunch issues, and were one of the main reasons for the collapse of the negotiations in November 2000 in The Hague. A compromise paper elaborated by the President of COP 6, Jan Pronk, could not break the deadlock in the negotiations (Ott 2001; Grubb and Yamin 2001). The resumed session in July 2001, took place under politically different circumstances, since President Bush had announced the withdrawal of the US from the Kyoto Protocol, thus giving further power to the rest of the Umbrella group whose ratification was now needed to let the Kyoto Protocol enter into force. At the resumed COP 6bis (July 2001) in Bonn, countries tried to find a rule for how to account for additional activities. Parties were allowed to propose their own forest management caps which are now labeled 'Appendix Z'. The latter includes the maximum allowable amount of forest management that can be accounted for by each Party. As these caps represent a proportion of the forest management activities undertaken anyway, and are accounted for on a gross-net basis, they lower the factual reduction targets of Parties. Russia, not being able to propose a number, introduced a paragraph allowing to revise the figure on the forest management cap at a later stage. The final decisions on the negotiating text were therefore postponed until COP 7 where Russia managed to double the provisional figure given at COP 6bis.[13] The LULUCF text was finally adopted at COP 7 in Marrakech.[14] Eligible activities as stipulated by the Marrakech Accords are afforestation, reforestation and deforestation (Article 3.3), as well as forest management, revegetation, cropland management and grazing land management (Article 3.4). While all forest activities are accounted for on a gross-net basis and accounting for forest management is limited by a country specific cap[15], cropland and grazing land management as well as revegetation are included without any limits, but are based on a net-net approach. Parallel to the discussion on additional activities under Article 3.4, it was decided at COP 7 to include LULUCF into the CDM. The following paragraph will briefly summarize the process leading to this decision.

2.2.2. LULUCF in the Clean Development Mechanism

The draft text on Clean Development Mechanism (Article 12) contained a note that LULUCF might be included in the CDM depending on the resolution of the issue under Article 3 (Fry 2002; Depledge 2001). However, in the final version coming out of Kyoto, this footnote had been erased. Thus, the text on Article 12 only refers to emission reductions. It remained unclear if this wording meant that LULUCF was to be excluded from the CDM or not (Depledge 2001).

A number of countries have kept this debate alive since Kyoto and demanded that LULUCF should be eligible. The main supporters of LULUCF in the CDM were the US, Canada, Japan, and the coalition of Latin-American countries GRILA.[16] The European Union, Brazil, China and India, AOSIS and Russia belong to the countries having opposed the inclusion of LULUCF in the CDM. The decision on the issue was passed between the CDM and the LULUCF contact group until COP 6bis, with no group wanting to take the responsibility for the subject.

It was not only contentious whether to include LULUCF at all, but also which activities would be eligible in the case of such an inclusion. Some countries were aiming at an even

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[13] See also Fry (2002)
[14] See UNFCCC (2001a) and UNFCCC (2001b).
[15] Since no solution was found to factor out indirect and natural effects from directly-human induced ones, the cap is supposed to avoid to a great extent that residual uptake can be accounted for under forest management.
[16] The Latin-american group GRULAC has split up over the issue of sinks in the CDM. While Brazil and Peru wanted to see any sinks projects excluded, most of the resting Latin-American Parties formed the GRILA group which was actively pushing for sinks in the CDM.

wider inclusion of LULUCF than stipulated under Article 3. Opinions differed especially concerning the viability of avoided deforestation – emission avoidance through forest protection projects – in the CDM. The potential scale, leakage problems, socio-economic as well as sovereignty concerns have been brought up as arguments against its inclusion.

The final decision at COP 7 only includes afforestation and reforestation, while avoided deforestation is eligible under the Adaptation Fund of the Kyoto Protocol. The use of LULUCF credits for complying with the reduction targets was limited to 1% of base year emissions of each Annex I Parties per year. Nevertheless, concerns regarding non-permanence of carbon sequestration as well as social and environmental effects were still prevailing. At COP 9, expiring credits which are supposed to address the concerns regarding the reversibility of carbon sequestration in afforestation and reforestation projects were adopted.[17]

2.3. Country negotiating positions

In the following, I analyze the distribution of positions of countries in the negotiation process on LULUCF. I focus on the three most important negotiation issues regarding LULUCF: the inclusion of mandatory LULUCF activities in Article 3.3 as negotiated mainly at COP 3, the inclusion of additional LULUCF activities in Annex I under Article 3.4 as well as the inclusion of LULUCF in the CDM – both under negotiation until COP 7. The negotiating positions described here represent the position Parties have voiced during the greatest part of negotiation on the respective issue.[18] The position taken by a Party during the negotiations, however, does not necessarily reflect what it agreed to in the final decision. Since decisions in the international climate regime have to be taken by consensus, the text over which Parties are negotiating has to be adapted in a way that all Parties will be able to consent to it.[19]

It has to be emphasized that decisions in the framework of the international climate regime are not simple yes-versus-no options. Negotiations are the development of a legal text in which Parties and negotiating coalitions try to introduce as much of their own position as

[17] On temporary credits, see Dutschke et al. (2004).

[18] Voicing a position does not necessarily mean that a Party expressed this position in an official document, since informal meetings and conversation in the door halls are an important element of international climate change negotiations as well. Since we conduct a cross-sectional analysis, we cannot consider changes in country positions over time. This approach is justified, when assuming that the respective position is the one expressed during the biggest part of the negotiation process.

[19] However, no clear definition of consensus exists. The latter is necessary due to the lack of an agreement on a voting rule. Often it is defined negatively to mean that there are no stated or formal objections to a decision. A Party can reluctantly consent to a decision, but then ask for its concerns to be noted in the report after adoption. There is a great level of discretion of the presiding officer to decide whether the objection of a Party has to be formally considered or only represents some lesser level of discontent that will allow a decision to go forward after the adoption (Depledge 2001).

possible. The search for compromise consists of the change in parameters of the decision along different dimensions, trying to find the point that will make consensus possible. Graphically, this can be represented by a three-dimensional diagram as given in Figure 2-1 which plots in a very simplified manner the positions of the Umbrella group and the EU versus the final outcome. In reality, even more dimensions and areas outside of the LULUCF negotiations will have to be considered elucidating the complexity delegates are facing at international climate change negotiations.[20] The country positions this paper is referring to are the ones that a Party was pursuing in the negotiations (in our graph represented by the bowls 'EU' and 'Umbrella'), independently of what was the final outcome of the negotiations (bowl 'Result' in Figure 2-1).

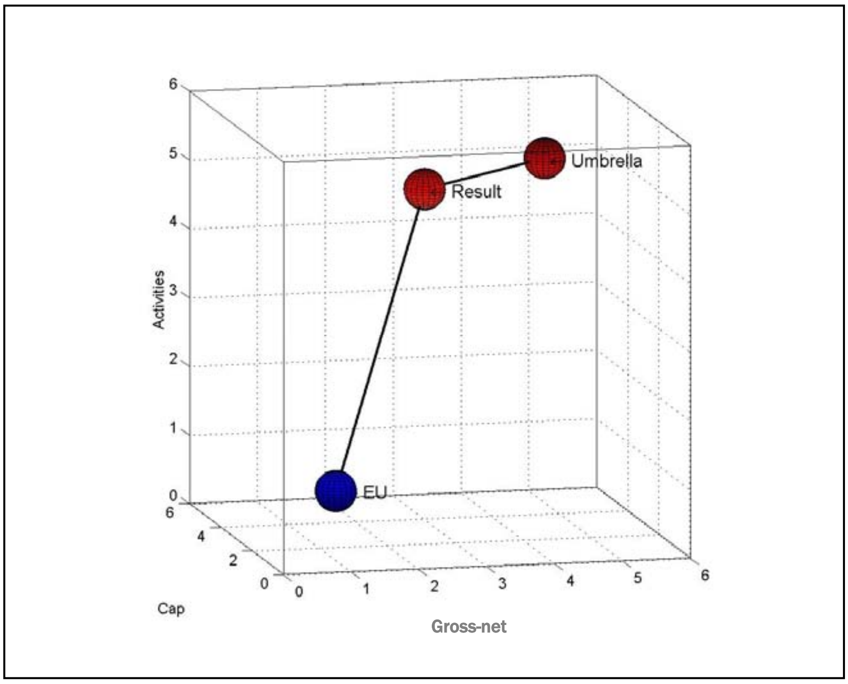

Figure 2-1: Country negotiating positions versus negotiation result

The following paragraphs describe the negotiating positions of 166 Parties[21], measured on a scale from 'strongly against', 'against ', 'neutral', 'in favor', and 'strongly in favor'.

[20] The most important parameters along which negotiatiors moved in the negotiations on LULUCF are the number and type of eligible LULUCF activities, the degree to which the use of these different activities was limited by a cap, the definition of forest, the reporting and verification procedures as well as the inclusion of LULUCF activities in the base year of the emission inventory (gross-net versus net-net calculation).
[21] The 166 countries encompass most of the Parties to the UNFCCC at COP 3. Literature review, interviews, and UNFCCC recordings were used for collecting this information.

2.3.1. LULUCF in Annex I countries

Figure 2-2 a) illustrates the distribution of negotiating positions of Parties regarding the debate held at COP 3 in Kyoto on whether to include LULUCF in the calculation of reduction commitments at all. The relatively big proportion of Parties taking a neutral stance in Kyoto can be explained by the above mentioned lack of knowledge on the subject. Only a small proportion of mainly Annex I countries has been pushing for the inclusion of LULUCF, while a significant coalition of Annex I and non-Annex I sinks opponents has voiced strong concerns. The group of strong opponents consisted mainly of AOSIS, India, Brazil, and the EU with the exception of Finland, France, Italy and Sweden, while the Umbrella group was actively pushing for the inclusion of LULUCF at Kyoto.

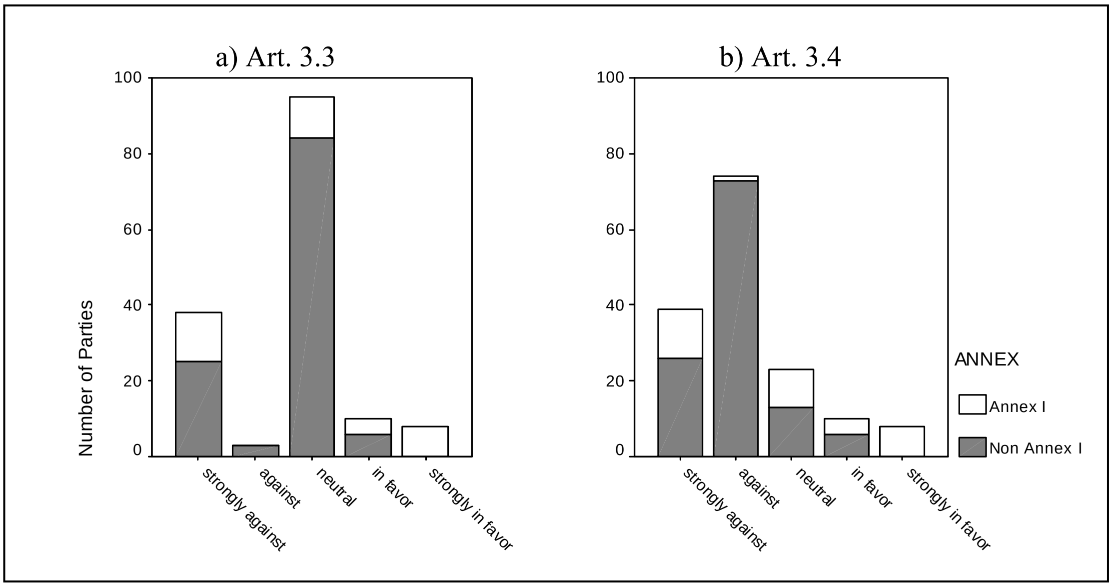

Figure 2-2: Distribution of Parties´ negotiating positions on Article 3.3 and 3.4

There was considerably more time for Parties to develop a position towards the inclusion of additional LULUCF activities under Article 3.4 after Kyoto. Figure 2-2 b) illustrates the changes in the distribution of positions in the post-Kyoto phase (Article 3.4) as compared to the ones on Article 3.3 at COP 3. Most of the neutral non-Annex I Parties on Article 3.3 had shifted to the group of opponents of the inclusion of additional activities, while the coalitions representing the supporters and strong opponents had remained unchanged. It can be seen that the division on LULUCF was not between Annex I and non-Annex I Parties, but caused by different criteria.

2.3.2. LULUCF in the CDM

The negotiating positions on the issues of whether to include LULUCF in the CDM, as shown in Figure 2-3, follow a different pattern than on Article 3[22]. The coalitions of Annex I Parties taking a strong position in favor and against LULUCF under Article 3 did so as well for LULUCF in the CDM. However, a relatively big proportion of Parties remained undecided on the issue, while the Annex I supporters have been joined by a significant coalition of non-Annex I Parties in favor of including LULUCF in the CDM. While Parties belonging to the African group, OPEC as well as the Environmental Integrity Group voiced some support for the issue, the Latin-American CDM sinks supporters (GRILA) strongly fought for the inclusion of forestry projects in the CDM.

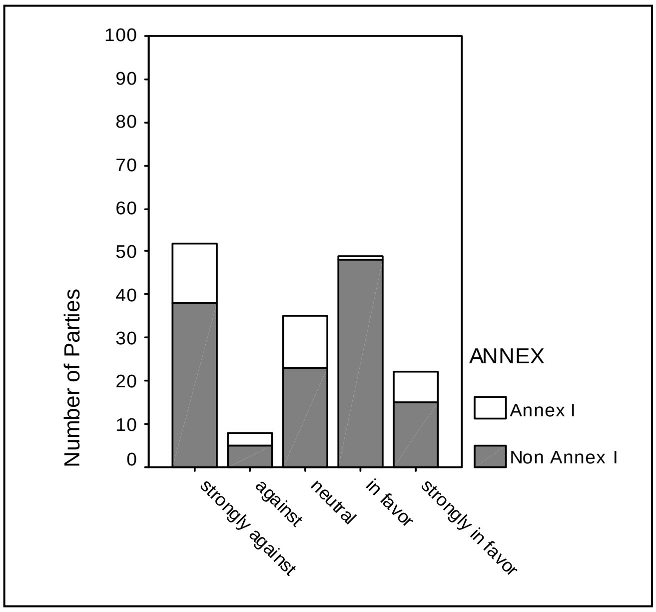

Figure 2-3: Distribution of Parties´ negotiating positions on LULUCF projects in the CDM

The inclusion of LULUCF in the CDM is often mentioned as the issue over which there has been a significant split of G77 and China. This is due to the fact that Non-Annex I Parties can be found in both extreme positions, strongly pushing for as well as strongly being against the inclusion of LULUCF. This split is mainly represented by the coalition of most Latin-American countries highly interested in forestry in the CDM facing the rather skeptical coalition of China, Brazil, AOSIS and many Asian countries.

2.4. Number of Parties versus power

The above description of the distribution of negotiating positions, however, does not tell much about why certain decisions were taken the way they were. The sheer number of

[22] In the following, Article 3 means only the two paragraphs of Article 3 analyzed here: Article 3.3 and 3.4.

Parties taking each position does not equal the negotiating power represented by the respective coalition. In reality, only a small number of Parties is actually influencing the outcome of the negotiations, while especially most non-Annex I Parties remain sidelined.

The main goal of this paper is, however, to find factors explaining Parties´ negotiating positions by conducting a statistical analysis, and not explaining the outcome of the negotiations.

2.5. Statistical analysis of country positions and participation in the negotiations

After having identified the negotiating positions of countries, I use two different regression models for categorical independent variables to analyze issues related to the negotiating positions. First, a multinomial logit model is applied to identify factors affecting the respective positions taken in the negotiations. Second, I examine factors influencing the participation of Parties in the submission process in the international climate negotiations by using a zero-inflated count model.

2.5.1. A multinomial logit model of negotiating positions

When using the negotiating position as the dependent variable, the outcome categories of 'strongly against' to 'strongly in favor' represent a Likert scale which is frequently interpreted as a continuous scale in order to be able to conduct a standard linear regression analysis. Long (1997), however, remarks that such an assumption often leads to distorted results and that an ordered logit/probit or a multinomial logit model are more appropriate for dependent variables with categorical outcomes. I use the multinomial logit model to avoid the parallel regression assumption of the ordered logit model.[23]

The multinomial logit model is used for estimating a regression model with nominal dependent variables. In the following, each of our country positions represents a nominal outcome.[24] However, the dependent variable is recoded to only three outcome categories by

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[23] The outcomes of negotiating positions can be seen as an ordered scale, which makes the ordered logit model the first choice. For using the latter, parallel regression assumption has to be fulfilled, though, which is not the case in this analysis. For details on the parallel regression assumption in ordered logit models see Long (1997), page 140-145.

[24] The model can be derived as a probability model as specified by the following equation:

$$\Pr(y_i = m|x_i) = \frac{\exp(x_i ß_m)}{1 + \sum_{j=2}^{J} \exp(x_i ß_j)}$$, for m>1

Let y be the dependent variable with J nominal outcome categories. Then $\Pr(y_i = m|x_i)$ is the probability of observing outcome m given the ith observation of the independent variable x. The ß´s represent the coefficients which are obtained by maximum likelihood estimation. The maximum likelihood estimator used for the estimation of the results based on the probability equation is:

joining the two categories 'against' and 'strongly against' as well as 'in favor' and 'strongly in favor'. Consequently, the resulting scale used in the multinomial logit analysis consists of 'against', 'neutral' and 'in favor'.[25]

The research questions guiding this analysis are based on different hypothesis which are supposed to be tested by the model. The *first hypothesis* assumes that there are certain domestic interests from a forestry lobby influencing the negotiating position towards LULUCF. Should this hypothesis hold, Parties with a bigger forestry lobby should have a higher probability to be in favor of including LULUCF in the climate regime. The size of the forestry lobby is captured by the variable export of forest products as % of GDP.

Table 2-1: Independent variables of the multinomial logit model (explaining negotiating positions)

hypo-theses	independent variables	concept	abbreviation	Source
1	Export of forest products (% of GDP)	Importance of forest industry	export_gdp	Calculated based on data from FAO (2003)
2	Distance to target with LULUCF (in % of 1990 emissions)	Stringency of Kyoto target with LULUCF in Article 3	gap_sinks90	Own calculations based on inventory data contained in UNFCCC (2003b) and (2004), BAU emissions from Meinshausen and Hare (2001)
	Distance to target without LULUCF (in % of 1990 emissions)	Stringency of Kyoto target without LULUCF	gap_nosinks90	
	Reduction in distance to target due to LULUCF in Article 3.3/3.4 (in % of 1990 emissions)	Decrease of Kyoto target due to introduction of LULUCF in Article 3	red_targ90	
	Number of Fossil of the Day Awards (COP 5-COP 9)	Destructive participation in the climate negotiations	awards	www.fossil-of-the-day.org
	Membership in G77+China	Developing country	g77	

The *second hypothesis* stipulates that the LULUCF issue was used by those Parties with a rather negative attitude towards international climate policy to reduce their Kyoto reduction targets or compliance costs through the backdoor. The part regarding the general attitude towards climate policy is operationalized by the independent variable 'number of the Fossil-of-the-Day Awards' representing the degree of destructive participation of a Party in

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$$L(\beta_2;.....,\beta_J \mid y; X) = \prod_{m=1}^{J} \prod_{y_i=m} \frac{\exp(x_i\beta_m)}{\sum_{j=1}^{J} \exp(x_i\beta_j)}$$

Taking the logs of L, we obtain the log likelihood equation which can be maximized by applying iterative numerical methods. For further details on the MNLM see Long (1997), Long and Freese (2003), Powers and Xi (2000), Menard (2001) and Agresti (2002).

[25] This is done to guarantee that each category at least comprises a minimum amount of observations. The other reason is to avoid any doubt about the independence of outcome categories.

the climate negotiations. The ‘Fossil of the Day Award’ is granted at a daily basis at the international climate change negotiations to those countries which are considered to have made the worst input to or to have blocked the progress of the negotiations. The problem that a certain number of awards has been granted for the support of LULUCF, which would make our model tautological, has been accounted for by not considering those awards granted for issues related to LULUCF.[26]

The independent variables representing the stringency of the respective Kyoto emissions target (distance to target) and the decrease in the Kyoto target due to the introduction of LULUCF under Article 3 (reduction in distance to target) are used to analyze the second part of the hypothesis referring to the motivation to renegotiate the target. Should this hypothesis hold, Parties with a high number of awards, a relatively stringent target and/or a relatively high decrease in the target due to the inclusion of LULUCF should be the ones favoring LULUCF and vice versa.

Furthermore, the membership of G77 and China is used as a dummy variable to examine if the negotiating position is influenced by the membership in the negotiation group of the developing countries. The independent variables included in the analysis are summarized in Table 2-1.

2.5.2. A count model of participation in the submission process

A second part of my analysis intents to examine a *third hypothesis* relating to factors influencing the participation of Parties in the negotiations on LULUCF. The hypothesis states that those Parties in favor of the inclusion of LULUCF in the climate regime have been participating more actively in the negotiations on the issue than the other Parties. Although, the number of submissions is only one of many possible indicators of active participation in the climate negotiations, it is the only one which can be measured quantitatively, thus giving some impression of the behavior of countries in the negotiations on LULUCF.

A *fourth hypothesis* stipulates that the delegation size influences the number of submissions a country contributed in the process. Since LULUCF is a highly technical issue, it can be expected that for participating in the submission process a country needs to possess the human resources and the technical know how on the issue. With smaller delegations, it is increasingly hard for delegates to follow and participate in the discussions on all the issues

[26] The award is an initiative of the Climate Action Network (CAN). A list of the number of awards per Party including the reasons for the respective awards can be found at www.fossil-of-the-day.org.

under negotiation. The dependent variable is the number of submissions on LULUCF until COP 7. The independent variables included in the model (Table 2-2) are the average delegation size as well the dummy variables on the positions ’against’ and ’neutral’ on additional activities in Article 3.4 and the CDM, with the category ’in favor’ serving as the reference category.[27]

Table 2-2: Independent variables of zero-inflated count model (explaining number of submissions)

hypoth-esis	independent variables	concept	abbreviation	source
3	Outcome categories of country positions ’against ’, ’in favor’ and ’neutral ’	Position taken on LULUCF	art4_a (Art.3.4 against) art4_n (Art.3.4 neutral) artcdm_a (CDM against) artcdm_n (CDM neutral)	See above
4	Average number of delegates (COP 3 to COP 7)	Delegation size	delegates	Michaelowa and Lehmkuhl (2004)

The positions on Article 3.3 were not considered here, as we have learnt from the analysis above that only after COP 3 Parties had a well founded position on the LULUCF issue. Since the number of submissions is a count variable, a model for count outcomes has to be applied. Models for count outcomes are the Poisson regression model, the negative binomial regression model and the zero-inflated count models.[28] The best fitting model to the distribution of the observed number of submissions is the zero-inflated poisson model which will be applied in the following. For details on the model selection, see Appendix B of this chapter. In the following, the results of the two models are presented.

[27] The categorical variables representing the country positions with the outcome categories standing for each position taken on sinks is included here as a set of dummies. For a variable with J categories, only J-1 dummy variables have to be included to prevent perfect collinearity. The excluded category is the reference category.

[28] Count models are specifically designed for outcome variables indicating how many times something happened. They are based on the Poisson distribution ($\Pr(y \mid \mu) = \frac{e^{-\mu}\mu^{y}}{y\,!}$, for y= 0, 1, 2,…) putting into relation the expected number of times an event occurred (μ) with the number of times an event did occur (y) given a certain value of the independent variable x.

$$\mu_i = E\left(y_i \middle| x_i\right) = \exp(x_i\,ß)$$

While the negative binomial accounts for the failure of the Poisson model to deal with overdisperion (greater variance than mean), the zero-inflated (zero-inflated Poisson, ZIP and zero-inflated negative binomial, ZINB) count models change the mean structure to allow zeros to be generated by two separate processes, thus increasing the probabilities of a zero-count. They exclude those zeros from the calculation which are considered not to be able to get a non-zero outcome due to structural reasons, e.g. in this case, those who will not participate in the submission process at all, independent of delegation size and negotiating positions. The ZIP model used in the following, calculates the probability for each count among those not always zero as:

$$\Pr(y_i \mid x_{i,} A_i = 0) = \frac{e^{-\mu_i}\mu_i^{\,y_i}}{y_i!}$$

For further details on count models see e.g. Long (1997) as well as Long and Freese (2001).

2.6. Results

2.6.1. Factors influencing negotiating positions

2.6.1.1. LULUCF in Article 3

After running the multinomial logit model for negotiating positions on Article 3.3 and Article 3.4, a set of variables can be identified as having a significant relation to the respective negotiating positions.[29] Tables 2-3 shows the Likelihood-ratio tests (LR test) for the positions on Article 3.3 and 3.4.[30] In both cases, a significant influence can be identified for the number of 'Fossil-of-the-Day Awards', the reduction in distance to target due to the introduction of LULUCF in Article 3 (gain_sinks) as well as the stringency of the Kyoto target (gap_nosink). For Article 3.4, additionally, being a member of G77 has a significant effect.

Table 2-3: Likelihood-ratio test for independent variables explaining positions on LULUCF in Art. 3

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**** Likelihood-ratio tests for independent variables

 Ho: All coefficients associated with given variable(s) are 0.

   a) Art.3.3|       chi2   df   P>chi2
-------------+-------------------------
      awards |     33.890    2    0.000
gap_nosin~90 |     15.270    2    0.000
  red_targ90 |      6.317    2    0.042
---------------------------------------
   b) Art.3.4|       chi2   df   P>chi2
-------------+-------------------------
      awards |     35.707    2    0.000
gap_nosin~90 |     12.415    2    0.002
  red_targ90 |      6.152    2    0.046
         g77 |     40.978    2    0.000
---------------------------------------
```

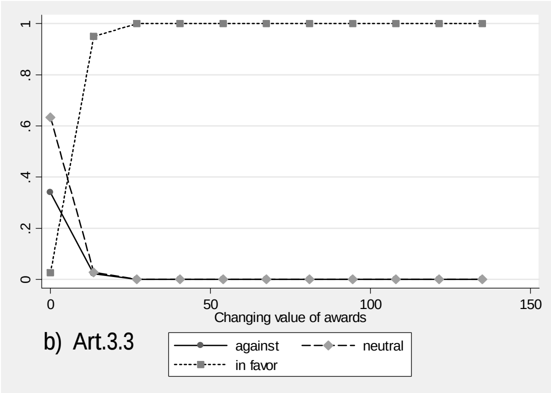
Regarding our first hypothesis, no significant relation between the variables representing the importance of the forest sector and the negotiating position can be identified. This suggests that the negotiating positions of Parties on Article 3 have not been influenced by a forest lobby, which does not mean that there might not be other domestic influences belonging to other sectors of the economy.

The significant variables are all relating to the second hypothesis. Graphical summaries provide the best tool for identifying basic patterns of (nonlinear) influence of these variables on the negotiating positions. The following graphs represent the effect of a change

[29] For the output of the regression analysis on Article 3, see part a) and b) of Appendix A.

[30] The likelihood-ratio test which compares the likelihood-ratio statistics of the restricted model with the one of the full model [G^2=-2 ($L^2_r - L^2_f$)] is used for obtaining sigificance levels of individual variables. In the following, we are refering to significant variables as those significant at the 5% level.

in the independent variables on the predicted probabilities of belonging to each group – measured on a scale from 0 to 1.



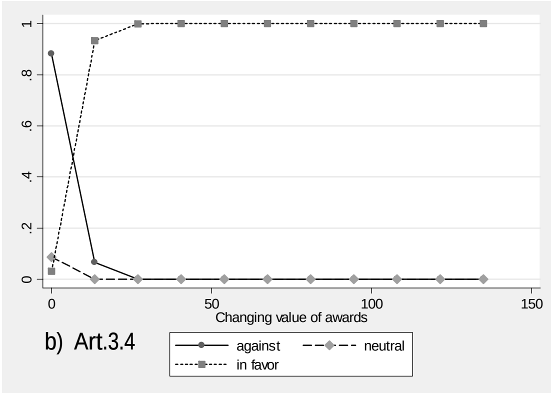


Figure 2-4: Predicted probability of negotiating positions on Art. 3.3/3.4 with varying 'Fossil of the Day Awards'

The results illustrated in Figure 2-4 support our hypothesis that both for Article 3.3 and Article 3.4 countries holding a higher number of 'Fossil-of-the-Day Awards' tend to belong to those countries being in favor of including LULUCF in Article 3. The countries which have never been granted any award are most probable of either having stayed neutral (Article 3.3 at COP3) or having fought against the inclusion of LULUCF (Article 3.4 in the post-Kyoto phase). Therefore, the countries pushing for the inclusion of LULUCF in the calculation of reduction targets seem to have been especially those countries usually inhibiting progress in the climate change negotiations and vice versa.

Further support for our second hypothesis is provided by the results represented in Figure 2-5. These indicate that Parties tended to have a supportive position towards LULUCF under Article 3, the more they could reduce their target due to the inclusion of sinks. This hardens the often heard suspicion that LULUCF was used by certain Annex I Parties as a tool to water down the commitments made under the Kyoto Protocol. Furthermore, Figure 2-5 provides some interesting insights regarding the influence of information available on the respective negotiation issue. As described above, there was hardly any information on how certain LULUCF options would change the reduction target of different countries at COP 3. Graph 5 a) suggests that it were mainly the LULUCF supporters who were aware of their possible benefits due to the introduction of LULUCF in Article 3, while the probability of the sink opponents is affected less strongly by the gains. On Article 3.4, though, Parties had more time to gather information on the effects of each option on their own target, and therefore their benefits and losses.

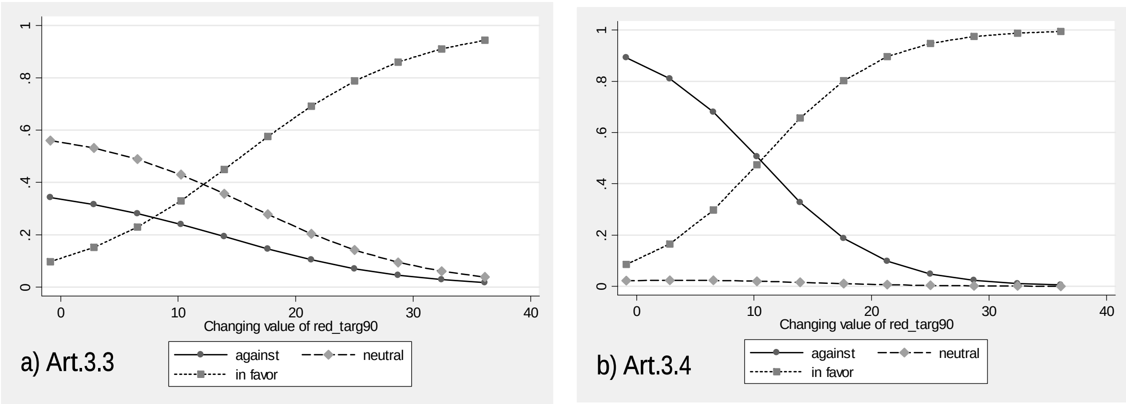


Figure 2-5: Predicted probability of negotiating positions on Art. 3.3/3.4 with varying reduction of target due to introduction of LULUCF in Article 3.3/3.4

Accordingly, Figure 2-5 b) shows that, in choosing their negotiating positions, Parties based their decision to a significant extent on the degree by which sinks would reduce their Kyoto target. Consequently, especially those countries supported additional sink activities which became aware that they would significantly benefit from sinks. The neutral positions on additional sink activities seem unaffected by the reduction of the target due to LULUCF. However, were those Parties speculating to reduce their target by including LULUCF also those Parties with the most stringent reduction targets? Reducing a target which implies almost no real reduction above the business as usual case or even a target granting hot air is different from trying to reduce a target which is very strict. Figure 2-6 plots the probabilities of belonging to each group with varying stringency of target. For Article 3.3, the tendency to belong to the LULUCF opponents and the LULUCF supporters is both increasing with a higher stringency of the target. Interestingly, this trend is stronger for the LULUCF opponents. Hot air holding countries are most likely to have stayed neutral. Regarding additional LULUCF activities (Art. 3.4), the picture is quite different. While there is a clear increase in the probability to belong to the sink supporters the stricter the target, the probability of opposing additional sink activities is highest for countries with a zero distance to target, and decreasing for the countries with a positive distance to target. As developing countries have no reduction target (value of zero), their dominance in the LULUCF opponents is probably the reason for the high probability of LULUCF opponents at zero distance to target. The following decrease of the probability of this group indicates a tendency that stringency of target became a more important factor in the determination of the negotiating positions on additional sink activities. Here, as well differences in the status of information and knowledge on the issue can explain the differences between the two figures to a some extent.

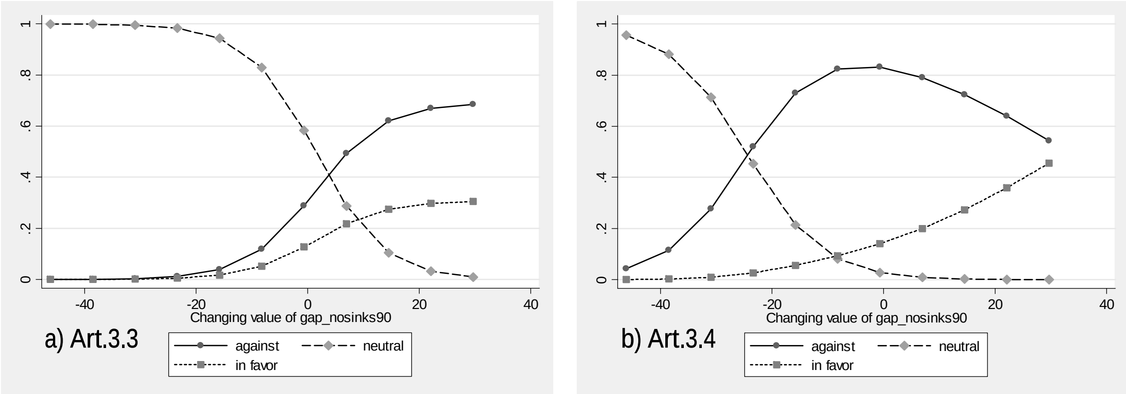


Figure 2-6: Predicted probability of negotiating positions on Art. 3.3/3.4 with varying stringency of target

However, as the probability of LULUCF opponents is greater than the one of the LULUCF supporters at all values, the fear to be unable to comply with the Kyoto target does not seem to have been the main driving force for the negotiating position of countries on LULUCF under Article 3.

In order to show the dynamics among negotiating positions, odds ratios can be calculated to illustrate, for example, how a change in expected reduction of distance to target affects the odds of a Party in choosing a pro-sinks relative to a neutral position.[31] To analyze such questions, I use odds ratio plots as the one represented in Figure 2-7.[32] The positive sign of, for example, the coefficient $\beta_{I|N}$ is expressed by a letter 'I' standing to the right of the letter 'A' representing the negotiating positions 'In favor' and 'Neutral'. The magnitude of the effects is expressed by the distance between the letters, with the scales representing the value of $\beta_{k,m|n}s$ at bottom and the $\exp(\beta_{k,m|n})$ s at the top.[33] Lines between the letters show insignificant coefficients. With this information, we are now able to identify patterns regarding negotiating positions on LULUCF under Article 3, starting with the factor changes in the odds of negotiating positions on Article 3.3 shown in Figure 2-7.

---

[31] An odds ratio is the ratio of the probabilities of outcome m versus outcome n as x_k increases by δ. The odds ratio is defined by:

$\frac{\Omega_{m|n}(X, x_k + \delta)}{\Omega_{m|n}(X, x_k)} = \exp(\beta_{k,m|n}\delta)$, with $\beta_{k,m|n}$ being the the coefficient representing the effect of x_k on the negotiating position m versus n. . For further details, see Long (1997).

[32] These can be generated by STATA and provide a relatively easy way to identify patterns which would otherwise be complicated to extract from a big number of coefficients.

[33] With s being the standard deviation. "Against" is used as basecategory.

With a standard deviation increase in the number of 'Fossil-of-the-Day Awards', the odds of taking a supportive position on LULUCF under Article 3.3 versus being against (or versus being neutral) increase significantly.

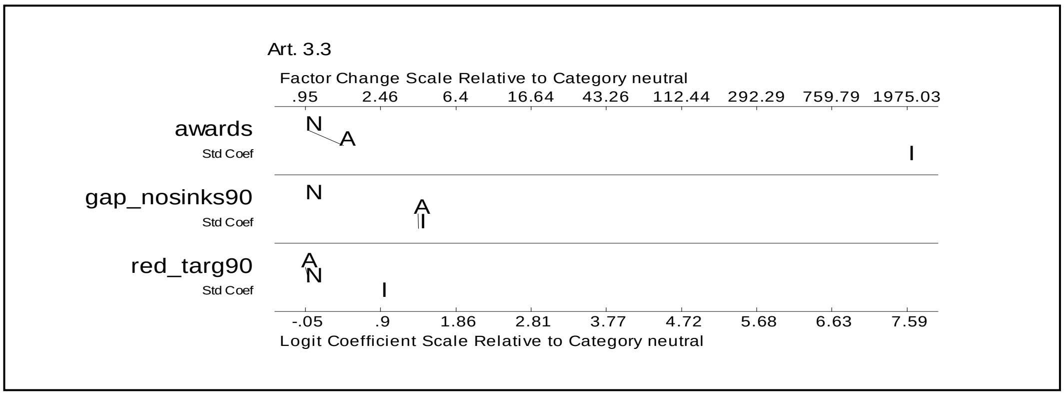


Figure 2-7: Factor changes in the odds of negotiating position on Article 3.3 due to change in the independent variables

The effect of a standard deviation increase in the 'reduction of the target due to LULUCF' (red_targ90) on the odds of being in favor (versus being against) follow the same pattern as the one just mentioned, but the magnitude of the effect is only a very small fraction of it. The effects of both variables on the odds of being neutral versus against are not significant. For positions on Article 3.4, shown in Figure 2-8, the pattern changes to some extent.

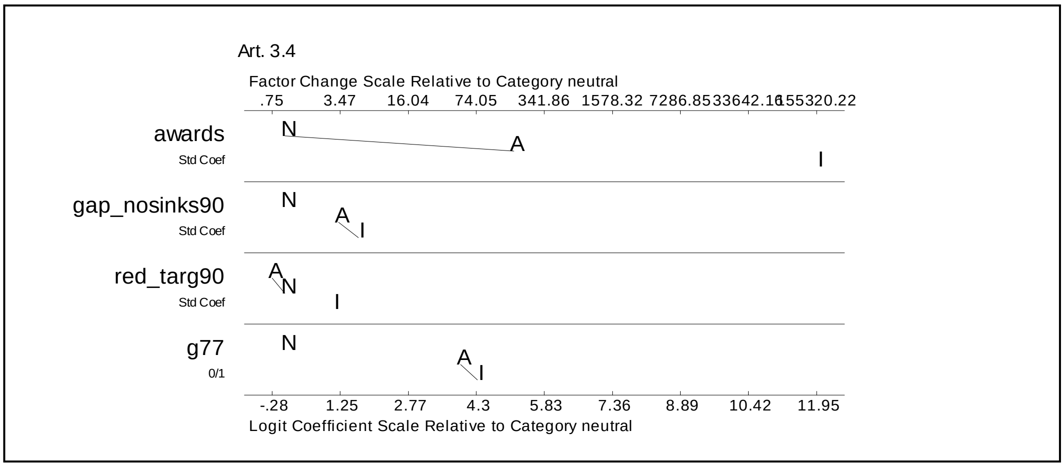


Figure 2-8: Factor changes in the odds of negotiating positions on Article 3.4 due to change in the independent variables

With increasing awards, the odds of being against versus taking a neutral position towards additional activities increase considerably. The effect of an increasing stringency of target decreases the odds of staying neutral relative to taking a position on the issue, but only to a small extent. The same can be said for membership of G77 and China.

The most interesting conclusion from the odds ratio plots is that the effect of the number of 'Fossil-of-the-Day Award' on the odds of being in favor versus being neutral or against, are dominating in terms of its magnitude, thus suggesting that the main driving force of Parties to push for the inclusion of LULUCF in the calculation of reduction targets has been a rather negative attitude towards international climate policy. The motivation to reduce the reduction target also influenced the group supporting additional LULUCF activities positively, but to a smaller extent. The stringency of the target does not deliver a clear explanation for why Parties supported LULUCF, since it seem to have been also Parties with a relatively strict target taking an opposing position on LULUCF under Article 3. For Article 3.4, being a member of G77 and China increases the odds of taking a position versus staying neutral.

In the following, I examine the results of the multinomial logit model for the negotiating positions on LULUCF in the CDM.

2.6.1.2. Forestry in the Clean Development Mechanism

While Annex I Parties were the ones most directly affected by the decisions on LULUCF under Article 3, the consequences of a decision on whether to include forestry in the CDM were especially relevant for developing countries. Rather than directly reducing the emission targets of Annex I Parties, forestry in the CDM was to influence the supply of emission certificates on the international market, thus influencing the price of emission reductions.[34] The incentives for Annex I Parties to include LULUCF are, therefore, linked to the possible reduction in compliance costs due to cheaper prices on the international market. On the other hand, developing countries had to consider their benefits from CDM including forestry projects as compared to a purely energy based CDM.[35] The variable 'reduction in distance to target due to Article 3' does only make sense for LULUCF regarding Article 3, and was therefore not included in the model analyzing positions on LULUCF in the CDM.

---

[34] It is, however, rather unlikely that the introduction of forestry projects in the CDM will have a significant effect on the international market price. For an analysis of the effects of CDM forestry decisions on the international market for emission permits, see chapter 3.

[35] Therefore, it would be promising to include the variable forestry CDM potential at this point. Unfortunately, there is no reliable data available for the all the developing countries included in our analysis. Therefore, we focus only on the interest of Annex I Parties. A comparision of negotiating positions on sinks in the CDM with the benefits and losses encountered by Annex I and Non-Annex I Parties can be found chapter 3.

During the negotiations on forestry in the CDM, it was clear that LULUCF under Article 3.3/3.4 would be included and some rough picture existed on what this would mean for the respective reduction targets. Therefore, the variable distance to target (gap_sinks90) used here accounts for this knowledge by representing the distance to target including the sinks options under Article 3.3 and 3.4. Table 2-4, summarizing the results of the LR tests, shows the significant variables which will be examined closer below. [36] Regarding the first hypothesis, no influence of the importance of the forest industry, measured as export of forest products in percent of GDP can be found, thus repeating the result obtained for Article 3.

Table 2-4: Likelihood-ratio test for independent variables explaining positions on forestry in the CDM

```
Ho: All coefficients associated with given variable(s) are 0.

      poscdm |       chi2   df   P>chi2
-------------+-------------------------
 gap_sinks90 |      9.917    2    0.007
      awards |     29.541    2    0.000
         g77 |     24.686    2    0.000
---------------------------------------
```

In the following, the results regarding the second hypothesis are described by first looking at the variation of predicted probabilities of belonging to each group with increasing number of ’Fossil-of-the-Day Awards’. Figure 2-9 a) shows that - as do the results for Article 3.3/3.4 - mostly the countries which have a tendency to inhibit progress in the climate change negotiations, have the highest probability of belonging to the supporters of forestry projects under the CDM.

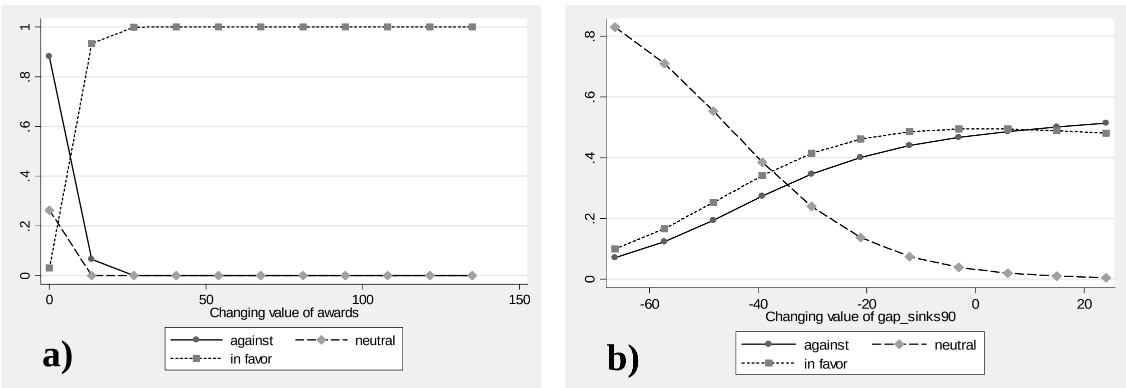


Figure 2-9: Predicted probabilities of negotiating positions regarding forestry in the CDM with varying ’Fossil-of-the-Day Awards’ and stringency of the target

[36] For the output of the regression analysis for sinks in the CDM see part c) of Appendix A.

The only difference to Article 3.3/3.4 is that now even countries without any awards have some probability of supporting LULUCF. Figure 2-9 b), representing the effects of the stringency of the target, shows almost identical curves for the sink supporters and opponents. The tendency to take a position increases the less hot air a country is holding. For the countries not holding hot air, an increase in the stringency of their target does not seem to have been a relevant factor influencing their negotiating position (relatively flat curve). While Parties with a lot of hot air are most probable neutral regarding LULUCF in the CDM, the countries with the relatively stringent targets are those taking a position (either against or in favor of LULUCF in the CDM). The odds-ratio plots can contribute some additional information regarding the effect of the independent variables.

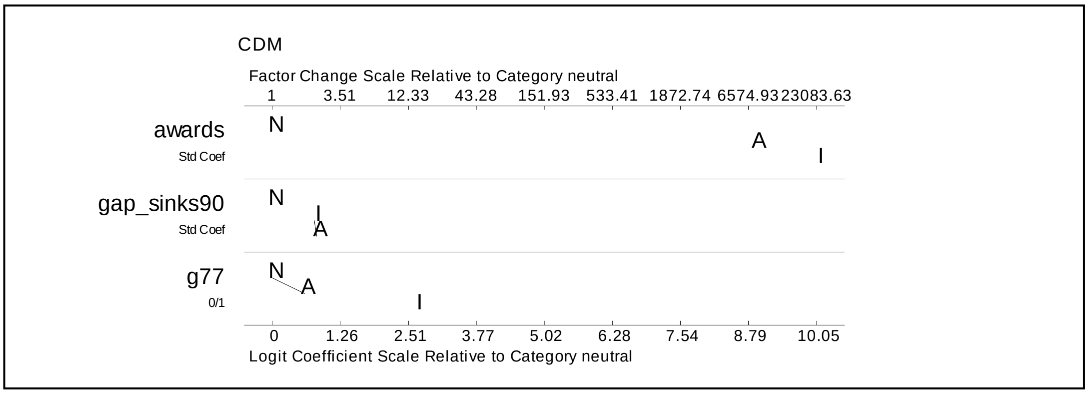


Figure 2-10: Factor changes in the odds of position on forestry in the CDM due to change in the independent variables

Figure 2-10 illustrates that an (standard deviation) increase in the number of 'Fossil-of-the-Day Awards', raises the odds of being in favor versus being against (neutral). However, the increase in the odds of being in favor relative to being against is only a fraction of the effects measured for Article 3.3/3.4. Now, the odds of being against versus being neutral increases significantly with the number of awards a country is holding, thus illustrating that positions on forestry in the CDM are less clearly attributable to those Parties normally blocking progress in the negotiations as it is for Article 3.3/3.4. With an increasing stringency of target, the probability of taking a position (no matter of against or in favor) augments slightly compared to the one of staying neutral.

The rising support of CDM forestry projects by certain developing nations is illustrated by the relatively strong increase in the odds of being in favor versus staying neutral (or against) caused by the membership in G77/China.

The following paragraph examines the third and fourth hypothesis, thus analyzing participation of Parties in the submission process on LULUCF.

2.6.2. Participation in the submission process

As mentioned above, a zero-inflated count model will be used to examine which factors influenced the number of submissions on LULUCF a Party provided in the negotiation process. Before interpreting the results of the model, I will briefly explain the two different groups of results which are created by the zero-inflated models. Zero-inflated models assume that there are two latent groups, the 'Not Always Zero' and the 'Always-Zero' group. A country belonging to the first group has a positive probability of a nonzero count, while the ones of the latter group will always have zero counts due to structural reasons. A country in the 'Always Zero group' for submissions in the climate negotiations can be thought of as a country which generally does not participate in the submission process, independently of their position and delegation size.

Table 2-5: Results of the ZIP model: factor changes in the expected counts

```
Count Equation: Percentage Change in Expected Count for Those Not Always 0
----------------------------------------------------------------------
  submission |      b         z     P>|z|      %      %StdX      SDofX
-------------+--------------------------------------------------------
     art4_a |  -0.43103   -2.705   0.007    -35.0    -17.4     0.4427
     art4_n |  -1.97339   -4.600   0.000    -86.1    -51.3     0.3645
   artcdm_a |   0.36930    2.955   0.003     44.7     19.5     0.4819
   artcdm_n |  -0.92443   -0.672   0.502    -60.3    -31.5     0.4091
  delegates |   0.01690    4.323   0.000      1.7     19.2    10.3794
----------------------------------------------------------------------
Binary Equation: Factor Change in Odds of Always 0
----------------------------------------------------------------------
     Always0 |      b         z     P>|z|      %      %StdX      SDofX
-------------+--------------------------------------------------------
     art4_a |  -0.40951   -0.395   0.693    -33.6    -16.6     0.4427
     art4_n | -16.37148   -0.019   0.985   -100.0    -99.7     0.3645
   artcdm_a |  -4.13318   -3.036   0.002    -98.4    -86.4     0.4819
   artcdm_n |  14.45751    0.017   0.986  1.9e+08  36961.7     0.4091
  delegates |  -0.14649   -1.474   0.140    -13.6    -78.1    10.3794
----------------------------------------------------------------------
  Vuong Test =  5.44 (p=0.000) favoring ZIP over PRM.
----------------------------------------------------------------------
    b = raw coefficient
    z = z-score for test of b=0
    P>|z| = p-value for z-test
    % = percent change in odds for unit increase in X
    %StdX = percent change in odds for SD increase in X
    SDofX = standard deviation of x
```

The 'Not Always Zero' group comprises those Parties which did not provide a submission to the LULUCF process, but generally belong to the Parties willing to provide submissions.

With this information, it is now possible to come to the interpretation of the results of the regression analysis, represented in Table 2-5.
For those Parties being able or willing to participate in the submission process at all, taking an opposing and neutral position (relative to a supporting position) on additional sink activities under Article 3.4 (art4_a, art4_n) as well as being against forestry projects in the CDM (artcdm_a) relative to supporting them, has a significant influence on the number of submission on LULUCF a Party provided in the negotiation process until COP 7. Furthermore, the delegation size affects how active a country participated in the submission process. Being against additional LULUCF activities decreases the number of submissions by 35% as compared to those being in favor. For the Parties having stayed neutral, the number of submission even decreases by 86%. Consequently, the Parties favoring the inclusion of additional sink activities have also been the most active ones in the submission process, a result supporting the third hypothesis. For the positions on forestry in the CDM, the opposite seemed to have been the case. Having taken a position against forestry in the CDM increases the number of submissions by 45% as compared to the sink supporters. The latter might be due to the sink opponents trying to inhibit a broad introduction of forestry in the CDM on a technical level.
Among the Parties generally being able to participate in the submission process, for every additional delegate, the number of submissions of a Party increases by 1.7%. Therefore, the hypothesis relating to the influence of delegation size on the number of submissions is supported. However, the delegation size seems to play a rather small role for the participation of Parties in the submission process on LULUCF. The latter finding shows that if a Party feels that an issue is important, it is able to contribute to the negotiations even if its delegation size is relatively small.[37]
Among those generally not submitting text proposals to the UNFCCC process (Always Zero group), the only significant influence is exerted by the variable being 'against' (as compared to being 'in favor') of forestry in the CDM. Consequently, opposing forestry in the CDM decreases the odds of belonging to the group normally not participating in the submission process by 98% relative to the LULUCF supporters.

2.7. Summary and conclusion

The negotiation on LULUCF in the Kyoto Protocol has been one of the most complicated and contentious issues in the history of climate change negotiations. Since most Parties

[37] Small countries join to negotiation coalitions like the one of AOSIS to take advantage of economies of scale. Some submissions in our data set are not individual submissions by one country, but proposals elaborated by a whole negotiation group.

were lacking knowledge on the issue when coming to COP 3 in Kyoto, a basis on which to take decisions regarding LULUCF was missing. Most of the Parties which had taken a strong position at Kyoto in 1997 remained with it in the negotiation on additional LULUCF activities afterwards, while the majority of developing countries, mostly unaware about the issue when coming to Kyoto, had moved to the group opposing additional sink activities afterwards. Regarding LULUCF in the CDM, however, the Annex I sink supporters were joined by a relatively big coalition of developing countries interested in attracting CDM forestry projects.

A multinomial logit regression is conducted to test two hypothesis regarding factors influencing Parties´ negotiation position on LULUCF. The results do not support that the importance of the forestry sector of a country has a significant influence on the countries´negotiating position on LULUCF. They, however, suggest that the LULUCF issue was used by those Parties with a rather negative attitude towards international climate policy to reduce their Kyoto reduction targets. The countries holding a higher number of 'Fossil-of-the-Day Awards', which is supposed to represent the general attitude towards international climate policy, have a strongly increasing probability to have supported the inclusion of LULUCF in the climate regime. In choosing their negotiating position regarding LULUCF under Article 3.3/3.4, Annex I Parties seem to have been motivated as well by the amount they were able to reduce their reduction target due to LULUCF. While the probability of belonging to the LULUCF supporters is increasing with the stringency of the target, rather those countries with stricter targets have the highest probability of opposing LULUCF under Article 3.3/3.4. The general attitude towards climate policy seems to have been a major driving force for the Parties pushing for LULUCF, while the rationale to reduce the reduction target played an important, but smaller role in determining the pro-sink positions.

Regarding the inclusion of forestry projects in the CDM, the stringency of the target does not explain whether a country belonged to the sink supporters or opponents. Furthermore, it is less clearly attributable to the number of the Fossil-of-the-day Awards (general attitude towards international climate policy), if a country has taken a favoring or opposing position on this issue. An important variable able to contribute more to the explanation of the main reasons for positions on LULUCF in the CDM might be the benefits or losses encountered by Parties due to the introduction of forestry in the CDM. Since no data on CDM potentials is available for all the Parties included in our analysis, it is out of the scope of this analysis to answer how much this factor contributed to the choice of negotiating position on the issue.

A second part of the paper analyzes two hypotheses relating to the participation of Parties in the submission process by applying a zero-inflated poisson model. For those Parties having taken a pro-sink position on Article 3.4, results suggest that LULUCF supporters have been more actively participating in the submission process, while the exact opposite seems to be the case for the Parties being 'in favor' of forestry projects in the CDM. The countries opposing LULUCF in the CDM maybe tried to inhibit a broad inclusion of LULUCF by influencing the negotiation outcome on a technical level.

The last hypothesis stipulating that Parties with bigger delegations tend to provide a higher number of submissions is supported by the results of the zero-inflated poisson model, although the influence of the delegation size on the number of submissions is found to be rather modest.

Although all the Parties have one vote in the climate change negotiations, in reality negotiation power is distributed quite unequally. Since the LULUCF issue touches the basic structure of the climate change regime, namely the size of reduction commitments (Article 3.3/3.4) and the compliance costs (CDM), our analysis of LULUCF positions can give a more or less representative picture of the constellation of countries in the climate regime.

If the negotiations on targets for a second commitment period start in 2005 as foreseen, then Parties should have learned their lessons from the negotiation on LULUCF. These lessons include the knowledge that agreeing on targets before the detailed rules are fixed will lead to a renegotiation of targets on the basis of bending the rules at later stages. Furthermore, all Parties should be well prepared on important issues to avoid having to take decisions without sufficient information, as happened at COP 3 in Kyoto. This way they will be able to negotiate on more equal grounds. If some Parties are given a first mover advantage, the others will not be able to react until they can gather some knowledge on the issue by themselves.

LULUCF has been said to have functioned as the valve of the climate regime which has kept certain countries on board. We have learnt that such valves are an integral part of the structure of a climate regime, and that their elaboration is essential for its overall effectiveness.

Appendix

Appendix A: Outputs of the multinomial logistic regression

a) LULUCF in Article 3.3

Table 2-6: Output of multinomial logit model (Article 3.3)

```
. mlogit  pos33 awards gap_nosinks90 red_targ90

Multinomial regression                            Number of obs   =        163
                                                  LR chi2(6)      =      78.22
                                                  Prob > chi2     =     0.0000
Log likelihood = -110.92369                       Pseudo R2       =     0.2607

------------------------------------------------------------------------------
       pos33 |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
2            |
      awards |   .0283202   .1187384     0.24   0.811    -.2044028    .2610432
gap_nosin~90 |   .1639362   .0619176     2.65   0.008       .04258    .2852925
  red_targ90 |  -.0081189   .0776731    -0.10   0.917    -.1603553    .1441175
       _cons |  -.6871775   .1962893    -3.50   0.000    -1.071897   -.3024574
-------------+----------------------------------------------------------------
4            |
      awards |   .4961655   .1255553     3.95   0.000     .2500816    .7422493
gap_nosin~90 |    .164317    .071724     2.29   0.022     .0237406    .3048934
  red_targ90 |   .1338851   .0626489     2.14   0.033     .0110955    .2566747
       _cons |  -3.549302     .60566    -5.86   0.000    -4.736373    -2.36223
------------------------------------------------------------------------------
(Outcome pos33==3 is the comparison group)
```

b) LULUCF in Article 3.4

Table 2-7: Output of multinomial logit model (Article 3.4)

```
mlogit  pos34 awards gap_nosinks90 red_targ90 g77

Multinomial regression                            Number of obs   =        163
                                                  LR chi2(8)      =     131.65
                                                  Prob > chi2     =     0.0000
Log likelihood = -55.867158                       Pseudo R2       =     0.5409

------------------------------------------------------------------------------
       pos34 |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
3            |
      awards |  -.3366333   .2430762    -1.38   0.166    -.8130539    .1397873
gap_nosin~90 |  -.1432592   .0588103    -2.44   0.015    -.2585253    -.027993
  red_targ90 |   .0427275   .0892802     0.48   0.632    -.1322584    .2177135
         g77 |  -3.958256   .7410227    -5.34   0.000    -5.410634   -2.505878
       _cons |   .4297046   .4546601     0.95   0.345    -.4614129    1.320822
-------------+----------------------------------------------------------------
4            |
      awards |   .4449329   .1324501     3.36   0.001     .1853354    .7045304
gap_nosin~90 |   .0527742   .0664767     0.79   0.427    -.0775178    .1830661
  red_targ90 |   .2057448   .1113612     1.85   0.065    -.0125192    .4240088
         g77 |   .3668091   1.335044     0.27   0.784    -2.249829    2.983447
       _cons |  -4.097869   1.408055    -2.91   0.004    -6.857605   -1.338132
------------------------------------------------------------------------------
(Outcome pos34==2 is the comparison group)
```

c) LULUCF in the CDM

Table 2-8: Output of multinomial logit model (CDM)

```
. mlogit poscdm  gap_sinks90  exportgdp  awards g77


Multinomial logistic regression                   Number of obs   =        163
                                                  LR chi2(8)      =      59.78
                                                  Prob > chi2     =     0.0000
Log likelihood = -141.94922                       Pseudo R2       =     0.1740

------------------------------------------------------------------------------
      poscdm |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
2            |
 gap_sinks90 |   .0086463   .0349504     0.25   0.805    -.0598552    .0771477
   exportgdp |   8.835747   14.89796     0.59   0.553    -20.36372    38.03521
      awards |  -.0731881   .0351681    -2.08   0.037    -.1421163   -.0042599
         g77 |  -2.010569   .5706114    -3.52   0.000    -3.128946   -.8921911
       _cons |   1.588483   .5505463     2.89   0.004     .5094317    2.667534
-------------+----------------------------------------------------------------
3            |
 gap_sinks90 |  -.0912166   .0436172    -2.09   0.037    -.1767048   -.0057284
   exportgdp |  -69.95262   52.05733    -1.34   0.179    -171.9831    32.07787
      awards |  -.5459367   .2453758    -2.22   0.026    -1.026864   -.0650089
         g77 |  -2.684624   .6666854    -4.03   0.000    -3.991304   -1.377945
       _cons |   1.655121   .6226762     2.66   0.008     .4346982    2.875544
------------------------------------------------------------------------------
(Outcome poscdm==4 is the comparison group)
```

Appendix B: Selection of count model

In searching for the model best fitting the observed distribution of counts of the dependent variable (number of submissions on LULUCF), following results were obtained:

1. The negative binomial (NBRM) is improving the fit as compared to the Poisson regression (PRM):

a) due to significant likelihood ratio test of alpha

Table 2-9: Test of alpha

```
Negative binomial regression                      Number of obs   =        166
                                                  LR chi2(5)      =     124.24
                                                  Prob > chi2     =     0.0000
Log likelihood = -268.14357                       Pseudo R2       =     0.1881

------------------------------------------------------------------------------
  submission |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
      art4_a |   -.619316   .2665798    -2.32   0.020    -1.141803   -.0968292
      art4_n |  -1.329155   .4806714    -2.77   0.006    -2.271254   -.3870569
    artcdm_a |   1.331145   .1732532     7.68   0.000     .9915746    1.670715
    artcdm_n |  -2.089603   .6238856    -3.35   0.001    -3.312396   -.8668094
   delegates |   .0329865   .0074908     4.40   0.000     .0183048    .0476683
       _cons |    .465179   .2763312     1.68   0.092    -.0764202    1.006778
-------------+----------------------------------------------------------------
    /lnalpha |  -1.012437     .34038                     -1.679569   -.3453042
-------------+----------------------------------------------------------------
       alpha |   .3633326   .1236711                      .1864543    .7080049
------------------------------------------------------------------------------
Likelihood-ratio test of alpha=0:  chibar2(01) =   27.56 Prob>=chibar2 = 0.000
```

2. The zero-inflated poisson (ZIP) model is improving the fit over the PRM and the NBRM (improves prediction of zeros and values below 3)

a) Vuong test of non-nested models tests if ZIP model reduced to the PRM (H0 = ψ_i = 0), with ψ_i = Probability of being in the Always-zero group

Table 2-10: Vuong test

```
Zero-inflated poisson regression                  Number of obs   =        166
                                                  Nonzero obs     =         84
                                                  Zero obs        =         82
Inflation model = logit                           LR chi2(5)      =      86.84
Log likelihood  = -227.3408                       Prob > chi2     =     0.0000
------------------------------------------------------------------------------
  submission |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
submission   |
      art4_a |  -.4310257   .1593487    -2.70   0.007    -.7433435   -.1187079
      art4_n |  -1.973386   .4290423    -4.60   0.000    -2.814294   -1.132479
    artcdm_a |   .3693047   .1249779     2.95   0.003     .1243526    .6142569
    artcdm_n |  -.9244265   1.375518    -0.67   0.502    -3.620392    1.771539
   delegates |   .0169008   .0039091     4.32   0.000     .0092391    .0245624
       _cons |   1.458952   .1826816     7.99   0.000     1.100903    1.817002
-------------+----------------------------------------------------------------
inflate      |
      art4_a |  -.4095072   1.036309    -0.40   0.693    -2.440636    1.621622
      art4_n |  -16.37148   847.3344    -0.02   0.985    -1677.116    1644.373
    artcdm_a |  -4.133179   1.361336    -3.04   0.002    -6.801349    -1.46501
    artcdm_n |   14.45751   847.3263     0.02   0.986    -1646.272    1675.187
   delegates |  -.1464866   .0993528    -1.47   0.140    -.3412144    .0482413
       _cons |   1.850835    1.34625     1.37   0.169    -.7877661    4.489436
------------------------------------------------------------------------------
Vuong test of zip vs. standard Poisson:            z =     5.44  Pr>z = 0.0000
```

b. The improved fit can be easily shown by plotting the predicted versus the observed counts of the respective models

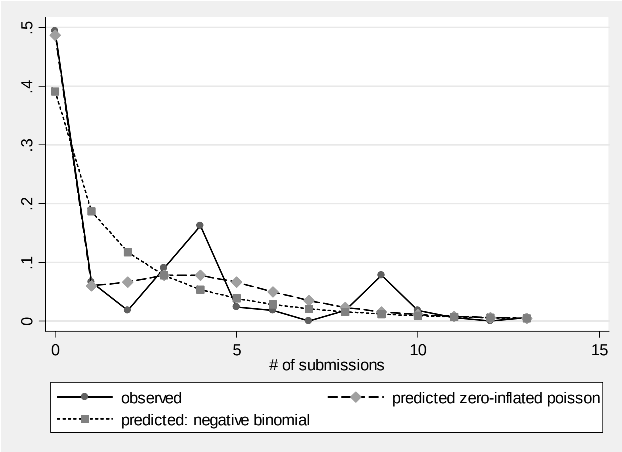


Figure 2-11: Fit of predicted counts of NBRM and ZIP to observed data

3. The zero-inflated negative binomial (ZINB) is not improving the fit as compared to the ZIP model.

(The likelihood ratio test of α tests whether ZINB reduces to the nested ZIP (or NBRM reduces to the nested PRM) by testing the H_0: $\alpha = 0$ (no overdispersion), with α = parameter reflecting unobserved heterogeneity among observations.

```
Likelihood-ratio test comparing ZIP to ZINB:    0.000Prob>=0.449
```

Consequently, the ZIP model is the best model, and is thus, used for our analysis regarding participation of Parties in the submission process on LULUCF

Chapter 3

Market Effects of Including Forestry in the Clean Development Mechanism

3. Market Effects of Including Forestry in the Clean Development Mechanism[38]

3.1. Introduction

The negotiation process on LULUCF has been dealt with in detail in Chapter 2. In the following, I am analyzing the market effects of the decisions taken in these negotiations, focusing only on the decisions on LULUCF in the CDM.

After it was clear that LULUCF projects could earn credits under the Clean Development Mechanism as well, it had to be decided which forestry activities would be eligible. A controversial debate evolved around the question whether to include avoided deforestation under the CDM. In the negotiating process, some were emphasizing the multiple benefits of avoiding deforestation in the first place instead of having to incur time and effort for afforestation or reforestation, while others brought up the argument that the inclusion of avoided deforestation would lead to a flooding of the permit market and thus the crowding out of emission reduction projects in the energy sector. The final decision laid down in the Marrakech Accords limits LULUCF activities in the CDM to afforestation and reforestation (A/R) only.

To account for the concerns that the use of credits generated through A/R would undermine the main goal of the Kyoto Protocol, namely emission reductions at the source, a demand-side cap was introduced. This cap limits the use of greenhouse gas removals from such projects to 1% of a Party´s baseline year emissions for each year of the commitment period. The rules and procedures for the implementation of forestry projects in the CDM were among the last implementation issues of the Kyoto Protocol and were finalized at COP 9 in December 2003.[39] The decisions taken concerning LULUCF affect the options available to Parties in fulfilling their emission targets and, therefore, influence their compliance costs.

Most of the economic models of the international market for emission offsets are only based on the marginal abatement cost curves of the energy sector and do not consider the sink enhancement options included in the framework of the Kyoto Protocol. Some studies account for LULUCF activities in a very simple manner by modifying the marginal energy cost curve through the inclusion of a horizontal segment with a constant marginal cost for the amount of carbon sequestration assumed to be available.[40] Others assume LULUCF options to be at zero cost and represent the LULUCF potential by shifting the energy cost

[38] This chapter is based on Jung (2005b)

[39] Rules and modalities under negotiation had to address definitions for forest, afforestation and reforestation, the stringency of project baselines, leakage, impermanence as well as socio-economic and environmental impacts. Some questions regarding small-scale projects were only finalized at COP 10.

[40] See for example Missfeldt and Haites (2001); Jotzo and Michaelowa (2002).

curve to the right by the sequestration potential.[41] Almost all of the models including sinks do not specify at all which LULUCF activities they considered for the calculation of the sequestration potentials and costs or only focus on one forestry activity, e.g. afforestation. This leads to an unsatisfactory representation of the reductions potentials and costs which countries encounter in the climate regime. Furthermore, it neglects the influence of policy decisions on sinks potentials and costs and, therefore, on the carbon sequestration cost curves.

Many of the arguments in favor of LULUCF have been based on the assumption that carbon sequestration activities are relatively cheap as compared to emissions reductions in the energy sector and that this is especially true for activities in developing countries. By conducting a literature review, I try to shed some light on what is really known about the costs of carbon sequestration. On the basis of the main conclusions from this literature review, I analyze the role of forestry in the CDM[42] by developing marginal carbon sequestration cost curves[43] which are then implemented into a partial equilibrium model of the carbon market called CERT.[44] I do not only include sinks as a fixed-amount-fixed-cost option, but put emphasis on the hitherto neglected fact that potentials and costs of forestry projects depend on the policy decisions taken on LULUCF in the Kyoto framework. Therefore, I differentiate four different forestry project types to simulate the consequences of different policy decisions concerning project eligibility. This differentiation allows me to examine some of the arguments broad up for and against the inclusion of forestry in the CDM in general as well as the inclusion of different project types. Last but not least, I describe the redistribution of benefits and losses between countries due to an introduction of forestry in the CDM, and try to analyze if such benefits and losses can explain country positions concerning forestry in the CDM in the negotiation process under the framework of the UNFCCC.

[41] See for example Kappel et al. (2002); Löschel and Zhang (2002).

[42] LULUCF activities in Annex B countries will, of course, also have an effect on the demand and supply of emissions certificates. Here we are only focusing on LULUCF in the CDM. For an analysis of different scenarios of eligible LULUCF categories under Art. 3.3 and Art. 3.4 see Missfeldt and Haites (2001).

[43] The term carbon sequestration cost curve is misleading when referring to conservation of forest or avoiding/slowing deforestation, since these lead to emission reductions. However, for reasons of simplicity, it will be used here for all marginal cost curves of forestry projects.

[44] CERT 1.3.1 is a publicly available spreadsheet model from Grütter Consulting, financed by the World Bank for the use in National Strategy Studies. The model can be downloaded at: www.ghgmarket.info.

3.2. Carbon sequestration costs in the literature

The research on carbon sequestration is relatively young.[45] Starting in the late 80s, mainly US-American researchers began studying potentials and costs of afforestation activities to sequester carbon. Several studies on the cost-effectiveness and the potentials of carbon sequestration have been conducted.[46]

Table 3-1: Estimates of forestry carbon sequestration potentials and costs

Author	*Country/region*	*Project types covered*	*Potentials (land/ carbon)*	*Costs*	*Marginal cost curve*
Global/Non-Annex B					
Benitez (2003)	South America	Plantations	x	x	x
Dixon et al. (1991)	Boreal, temperate, tropical	Natural regeneration, afforestation, reforestation, agroforestry, forest management	x	x	x
Dixon et al. (1994)	South America, Africa, South Asia, North America	Agroforestry	x		
Fearnside (1995)	Brazil	Reduced deforestation, plantations, sustainable timber management	x	x	
Fearnside (2001)	Brazil	Silvicultural plantations, forest management, avoided deforestation	x		
Houghton et al. (1993, 2001)	Latin America, Africa, Asia	Plantations, Agroforestry, Forest Management	x		
IPCC (2000)	Global	Plantations, regeneration, agroforestry, protection, forest management	x	x	x
Ismail (1995)	Malaysia	Forest protection, plantations, forest management	x	x	
de Jong et al. (2000)	Mexico	Forest Management, agroforestry	x	x	x
Kerr et al. (2001)	Costa Rica	Forest management	x	x	
Makundi and Okiting'ati (1995)	Tanzania	Conservation, agroforestry	x	x	
Masera et al. (1995)	Mexico	Conservation/protection, forest management, plantations, agroforestry	x	x	
Niles et al. (2002)	48 developing countries	Forest restoration, avoided deforestation	x		
Nordhaus (1991)	Global	Plantations	x	x	
Ravindranath et al. (2001)	India	Forest protection, plantations, regeneration	x	x	
Ravindranath and Somashekhar (1995)	India	Natural regeneration, agroforestry, community forestry	x	x	
Sedjo (1999)	Argentina	Plantations	x	x	
Sedjo and Solomon (1989)	Global	Plantations		x	x
Sedjo et al. (2001)	Global	50 different timber and forest management types	x	x	x
Trexler and Haugen (1995)	Tropics	Slowed Deforestation, regeneration, agroforestry, plantations	x		
Wangwacharakul and Bowonwiwat (1995)	Thailand	Forest protection, plantations, agroforestry	x	x	x
Winjum and Schroeder (1997)	Global	Plantations	x		
Xu (1995)	China	Plantations, agroforestry, forest management	x	x	x
Xu et al. (2001)	China	Forest protection, plantations, regeneration, agroforestry	x	x	
Annex B					
Adams et al. (1993)	USA	Plantations	x	x	x
Adams et al (1999)	USA	Plantations	x	x	x
Alig et al. (1997)	USA	Plantations	x	x	
Barson and Gifford (1990)	Australia	Plantations	x		
Callaway and McCarl (1996)	USA	Plantations	x	x	x
Cannel (2003)	Europe, UK	Art. 3.3/Art.3.4 activities and biomass	x		
Dudek and LeBlanc(1990)	USA	Plantations	x	x	

[45] Here, I am only analyzing carbon sequestration options due to forestry activities. Other options, like carbon sequestration in agricultural lands, are not considered in this chapter, since they are not part of the CDM.
[46] For a detailed analysis of past studies see Richards and Stokes (2004)

Golub (2000)	Russia	Forest management, plantations and regeneration	x	x	x
Gurney and Neff (2000)	Canada, Russia, USA	Art. 3.4 activities	x	x	
van Kooten et al. (1992)	Canada	Forest management, plantations	x	x	x
van Kooten et al. (2000)	British Columbia, Alberta (Canada)	Plantations	x	x	
Lewis et al. (1996)	USA	Plantations	x	x	
Moulton and Richards (1990)	USA	Forest management, plantations	x	x	x
Newell and Stavins (2000)	Delta States	Plantations	x	x	x
New York State (1991)	New York State	Forest management, plantations	x	x	
Parks and Hardie (1995)	USA	Plantations	x	x	x
Petroula (2002)	Europe	Art. 3.3/3.4 activities	x		
Plantinga et al. (1999)	Maine, South Carolina, Wisconsin	Plantations	x	x	x
Plantinga and Mauldin (2000)	Maine, South Carolina, Wisconsin	Plantations	x	x	
Richards (1993)	USA	Plantations	x	x	x
Richards (1997)	USA	Plantations	x	x	
Slangen and van Kooten (1996)	Netherlands	Plantations	x	x	
Sohngen et al. (1998)	North America, Europe, subtropical	Plantations	x		
Stavins (1999)	USA	Plantations	x	x	x
Based on Richards and Stokes (2004), expanded and modified by the author					

Bottom-up approaches focus on individual processes of abatement technologies or sequestration options.[47] Different methods for constructing bottom-up marginal carbon sequestration cost curves can be used. The simplest and mostly used method is to order the cumulative sequestration potentials of different LULUCF activities from the lowest to the highest cost option. Other methods apply sector or sub-sector models, e.g. timber market models, cost-benefit approaches and econometric techniques.

Table 3-1 gives a broad overview of the existing studies on LULUCF costs and potentials and the respective marginal cost curves developed. Most of the studies concentrate on the US, single US states or US regions. Some global studies exist, mainly looking at the carbon sequestration potentials and costs differentiated by continents or climatic zones. Studies which focus on the potentials and costs of forestry carbon sequestration in developing countries, especially the tropics, started only in the mid-nineties. The estimates of potentials of comparable geographic zones vary widely between studies. The same applies to the cost estimates. The latter could be due to the fact that many cost studies neglect a substantial part of costs (e.g. land costs, monitoring costs) as well as the benefits[48] generated by the projects (Kauppi et al. 2001). This, of course, will change the cost estimates dramatically and result in a distorted structure of estimates when comparing different project types. For example, fast growing plantations may have higher implementation costs than avoided deforestation projects, but they also generate marketable benefits which can make them

[47] Of course, there is also the option of constructing marginal sequestration cost curves by a top-town approach. In our study we are just looking at bottom-up cost curves since the development of top down costs curves for LULUCF is still in its infancy.
[48] Here I am referring only to the direct, marketable benefits.

even profitable. Other factors influencing the carbon sequestration cost can be the discount rate used for the costs as well as the carbon benefits, the carbon accounting method applied, the model used to estimate the opportunity cost of land, the baseline assumed, the physical characteristic of the project area, the biomass pools included, and the silvicultural species used.[49] Due to the above mentioned differences, the result is a whole variety of types of cost curves which are not directly comparable to each other (Kauppi et al. 2001; Richards and Stokes 2004). This makes it impossible to take marginal sequestration cost curves for the implementation into a global carbon market model from the existing literature. Therefore, in this study, I rely on a simple method to estimate consistent marginal carbon sequestration cost curves which can be implemented into a global carbon market model.

3.3. Development of marginal carbon sequestration cost curves

To analyze in detail possible policy scenarios concerning forestry in the CDM, it is necessary to define which activities I consider to be eligible LULUCF activities. The four categories of sink enhancement project types included in the study are plantations, regeneration, agroforestry and avoided deforestation. The first three are ’direct human-induced conversion of non-forest to forested land’, thus falling under the definitions of A/R under the Kyoto Protocol.[50] The term ’regeneration ’ as used here, refers to reforestation of degraded lands to secondary forests, while the category ’plantations’ covers fast-growing commercial plantations. Under the category ’agroforestry’, I subsume all projects of natural resource management integrating trees in farmland and rangeland. Projects falling under the category ’avoided deforestation’ result in the conservation of forest which otherwise would have been deforested.

Necessary data for the development of the cost curves is data on land availability potentials for each project type in hectares (ha) per year, carbon uptake factors in t CO_2/ha and year and costs for possible forestry activities in US$/t$CO_2$.[51] By multiplying the land availability and carbon uptake factors, one receives the carbon sequestration and storage potential for each project type and country.[52] However, the use of the word ’potential ’ in the literature

[49] For some approaches to identify factors influencing the cost of carbon sequestration see Newell and Stavins (2000), van Kooten et al. (2004) as well as Richard and Stokes (2004).
[50] For the definitions of forest, afforestation and reforestation, see UNFCCC (2001a) and Decision 19/CP.9 in UNFCCC (2003c).
[51] Although we are often using the term carbon, the measurement unit used in the international permit market is carbon dioxide (CO2). This makes sense, because in the frame of the Intergovernmental Panel on Climate Change (IPCC), CO2 was chosen as the reference gas to for the Global Warming Potentials. However, many studies and models and especially the literature in the US employ carbon (C) as the main measurement unit.
[52] For obtaining potentials for the first commitment period, the annual values are multiplied by five.

on carbon sequestration is often unclear and misleading. Cannel (2003) distinguishes between three different interpretations of the term potential, first the 'theoretical potential capacity' (physical potential without consideration of practical, e.g. institutional or financial constraints), second the 'realistic potential capacity' (physical potential with consideration of most constraints, but optimistic assumptions) and finally the 'conservative, achievable capacity' (cautious prognosis, based on current trends, with few optimistic assumptions).

I base the land availability potentials on the data from Trexler and Haugen (1995), who considered qualitative constraints [53] for 52 tropical countries [54] when estimating land availability potentials for the above four project types. For the land availability potentials, I further assume that the implementation of LULUCF projects in the CDM will not start before 2005. Although CDM projects in the first commitment period may accumulate credits starting from 2000, basic implementation issues have not be solved until the end of 2003, which makes the implementation of projects before the year 2005 unlikely. In spite of these additional restrictions, the Trexler and Haugen data might be optimistic in the sense that the estimates of regrowth project potentials do not exclude land having been deforested after December 1989.[55] This land is not eligible for LULUCF projects because policy makers wanted to prevent deforestation aiming at clearing land for afforestation projects. According to Cannel´s categorization, I consider my land availability estimates to represent a conservative, achievable potential capacity, since it takes into account the most important constraints and few optimistic assumptions.

Carbon uptake factors are estimated on the basis of the IPCC Special Report on Land use, Land-use change and Forestry (Cerri et al. 2001) weighted by the percentage of the forest area type in each region from the Global Forest Resources Assessment 2000 (FAO 2001). In the present study, the amount of carbon from LULUCF projects on the market does not represent the real carbon uptake, but the one accounted for the generation of carbon credits under the Kyoto Protocol. For plantations the carbon uptake factors vary between 5.5 and 22 tCO_2/ha and year; for agroforestry between 1.8 and 4.2 tCO_2/ha; and for regeneration between 1.8 and 14.7 tCO_2/ha without considering belowground biomass and carbon

[53] Variables considered are: existing land use and projected land-use change, population growth rates and urbanisation trends, institutional and economic sources of deforestation, governmental and non-governmental forestry experience and infrastructures, current forestry-concessions, agricultural and energy policies, land-tenure systems and land-titling requirements, political and economic structures and stability, infrastructural development plans and potential environmental, economic or social crisis facing the country.

[54] These 52 countries, plus China and Chile, which we included additionally, cover the most important countries for forestry projects under the CDM. Estimates for China are taken from Xu et al. (2001). For a country list see Appendix B.

[55] Reforestation as defined under the Kyoto Protocol in FCCC/CP/2001/13/Add.1"will be limited to reforestation occurring on those lands that did not contain forest on 31 December 1989."

storage in wood products.[56] The carbon emissions saved through avoided deforestation were calculated on the basis of data from Trexler and Haugen (1995) and the FRA 2000 (FAO 2001) on the standing biomass per hectare, assuming an immediate loss of 80% of the carbon stored in the biomass to the atmosphere. Additionally, 10% of carbon was subtracted from the biomass estimates. This is supposed to account for revegetation occurring in the baseline after forest clearing, which reduces the amount of carbon credits that can be generated by the project.

Table 3-2: Estimates of global potential for carbon uptake/storage in t CO_2 per year

Project types considered	Low uptake/storage	High uptake/storage
Plantations	3,936,000	6,316,700
Plantations and Regeneration	6,953,500	13,386,200
Plantations, Regeneration and Agroforestry	7,324,853	14,240,311
Only avoided deforestation	93,215,250	159,367,750
All LULUCF	100,540,103	173,608,061

On the basis of the described land availability estimates and carbon uptake and storage factors, I calculate the potential carbon sequestration and storage for the different project types as summarized in Table 3-2.

The potentials for each country are listed in Appendix A. Due to the given uncertainties, I consider two different sets of carbon uptake factors, one with low and one with high estimates.

Although, the literature is unclear about the level of carbon sequestration costs, it provides a rough picture on the order of costs of different project types. For my study, I therefore assume a certain order of net cost estimates with avoided deforestation being the cheapest of the four project types. The literature is divided over the costs of avoided deforestation, though. While many studies find it to be the most cost-efficient sinks project type (e.g. Newell and Stavins 2000) others studies argue that costs are higher than in other projects because costs for addressing the causes of deforestation will have to be taken into account as well (e.g. Sathaye et al. 2001). In this assumed order of costs, plantations and agroforestry follow as the second and third cheapest project type. Although, they involve implementation costs, they generate income through marketable benefits. Regeneration

[56] The exclusion of soil carbon can be justified by the uncertainties in soil carbon measurement as well as the high costs that will prevent most of the project developers from including soil carbon uptake in their carbon accounting. For details on this see Ellis (2000). Procedures for the accounting of carbon sequestration in wood products are in development, but will not be applicable for the first commitment period.

projects are assumed to involve higher net costs than all the other project types, since less marketable benefits accrue and regrowth is slower.

Table 3-3: Cost differences between countries

A/R costs	Cost ($/tCO_2$) = D * X/C	D = calibration parameter[20], X = GDP/capita (PPP) in current international US$, C = carbon uptake factor for respective project type
Cost of avoided deforestation	Cost ($/tCO_2$) = D * 1/(0.07*C*L)	D = calibration parameter[20], C = carbon storage for respective project type, L = ha of arable land per capita in 1999

Cost differences of regrowth projects between countries are calculated considering differences in GDP per capita and the carbon uptake factors, while costs for avoided deforestation are assumed to be determined by scarcity of arable land and the carbon uptake factors of the project activity in the respective country (see Table 3-3).[57] The cost estimates used for the development of the marginal sequestration cost curves are presented in Appendix C. The cost estimates in my standard analysis range mostly in the very low end of the cost estimates, but do not include negative costs which are often found in bottom-up studies. Since it is not very probable that the whole LULUCF potential will be available at such low costs, a sensitivity analysis with higher cost estimates is conducted.[58] The bottom-up marginal sink cost curves are developed by ordering the cumulative carbon sequestration/storage potentials, starting with the lowest cost option to the highest cost option. Then, steady marginal cost curves are obtained through an Ordinary Least Square (OLS) regression.

3.4. Model and policy scenarios

For the analysis of the different LULUCF policy scenarios, I use the CERT model, which is a partial equilibrium model of the international greenhouse gas trading market. It is based on energy sector marginal abatement cost curves (MACs) and Business As Usual (BAU)

[57] With the calibration parameter D, we are able to change the level of costs. The value of 0.07 in the calculation of avoided deforestation cost is part of the (assumed) function used to describe the relationship between the variables influencing the cost estimates.

[58] Calibration parameter D is set to 0.0005 for plantations, 0.0002 for agroforestry, 0.0009 for regeneration, and 0.14 for avoided deforestation in the low cost case. For receiving the high cost estimates, we multiply D by 25.

data from the equilibrium models EPPA and GTEM.[59] The CERT model comprises 6 Annex B (USA, Japan, EU15, remaining OECD, Eastern Europe and the FSU) and 6 Non-Annex B regions (Energy Exporting Countries, China, India, Dynamic Asian Economies, Brazil, Rest of the world) which are summarized in Table 3-4. [60]

Table 3-4: Country grouping of the CERT model

USA	**JPN** (Japan)	**EEC** (EU-15)	**OOE** (other OECD)	**EET** (Eastern Europe)	**FSU** (Former Soviet Union
EEX (energy exporting countries)	**CHN** (China)	**IND** (India)	**DAE** (Dynamic Asian Economies)	**BRA** (Brazil)	**ROW** (Rest of the world)
For the countries in each group, see Appendix C.					

Here, I use the GTEM MACs and BAU paths and only consider CO_2. LULUCF options for Annex B Parties are included by deducting the Appendix Z sinks agreed upon at COP 7 in Marrakech from the reduction requirement, thus lowering demand of emissions certificates by this amount. Transaction costs associated with the generation of emissions certificates are set to 0.55 \$/tCO_2 for CDM projects and 0.27 \$/tCO_2 for Joint Implementation projects. In the reference scenario, the United States participate to some small extent in the international carbon market.[61] I assume, Russia and eastern European countries to restrict supply of emissions permits by banking an amount of 722.3 MtCO_2. This represents almost 60% of their total hot air. [62]

Table 3-5 summarizes the four basic policy scenarios constructed for my analysis, each of them reflecting different decisions concerning project eligibility under the CDM. Scenario 1 includes all four project types, and thus represents the policy debate before COP 7. Furthermore, I examine the effect of the 1% cap on the use of forestry CERs, by assuming the maximum amount of available forestry CERs to be equal to the maximum allowed amount of the 1% cap. [63] This is only applicable to scenarios where the carbon sequestration/storage potential is greater than the one defined by the 1 % cap. In the present study, this is only valid for the scenarios including avoided deforestation.

[59] EPPA stands for MIT´s “Emissions Prediction and Policy Analysis model, and GTEM for “Global Trade and Environment Model” of ABARE Australia.
[60] For the countries contained in each group, see Appendix C.
[61] Despite the repudiation of Kyoto Protocol on the national level, there is a considerable interest from the state and company level in the US.
[62] For studies on banking and market power see e.g. Böhringer and Löschel (2003) as well as Löschel and Zhang (2002).
[63] Forner and Jotzo (2002) point out that a binding cap on demand might create a parallel market for forestry CER with different permit prices, because – contrary to our assumption here – an excess supply would drive forestry CER prices down. However, a further analysis of this is beyond of the scope of this paper.

Table 3-5: Policy scenarios

No.	Scenario	Project types included	1% cap
0	No LULUCF*	--	--
1a	AD	P, AF, R, AD	No
1b			Yes
2	A/R all	P, AF, R	**
3	A/R I	P, R	**
4	A/R II	AF, R	**

* CDM implementation rate 100 %, participation rate USA 25 %, transaction costs CDM 0.55 $/tCO2, transaction cost Annex B 0.27 $/tCO2, 722.3 MtCO2 hot air banked
* * 1% cap not binding,
P : Plantations, AF: Agroforestry, R: Regeneration, AD: Avoided Deforestation

Since avoided deforestation was excluded at COP 7, Scenario 2 to 4 include only the regrowth project types and refer to the discussion whether to explicitly exclude either agroforestry (scenario 3) or plantations (scenario 4) from the Kyoto definitions of forest for the CDM. Since no such exclusion was decided at COP 9 in Milan, scenario 2 represents the *status quo* of policy decisions concerning forestry in the CDM.

When looking at the amount of potential forestry CERs that could be generated in the different scenarios, it becomes clear that the avoided deforestation potential of 3605.5 million tCO_2 could fulfill 223 % of reduction requirements of the Kyoto Protocol.[64] As mentioned above, the 1% cap gets binding at these levels (scenario 1b), which would limit the amount of forestry CERs to 724.7 million tCO_2, representing 44.8 % of total reduction requirements. For the scenarios 2 to 4, the potential of forestry CERs lies between 300.4 $MtCO_2$ and 155.0 $MtCO_2$, representing between 18.6 % and 9.6 % of the total reduction requirements.

3.5. Results

3.5.1. Effect of including LULUCF in the CDM

For analyzing the role of forestry in the CDM, I will examine the effects of an introduction of forestry in the CDM on the market price. The market price of emissions permits under my reference scenario without forestry in the CDM is 3.08 US$/$tCO_2$.

[64] The assumed reduction of USA is included in calculation of reduction requirements, although it is not based on Kyoto target (Total reduction requirement = 1617 Mio tCO2). Therefore, the percentage values of the LULUCF potentials of purely Kyoto based reduction requirements will be slightly bigger. Due to the hot air, FSU and Eastern Europe are not considered to have reduction requirements.

Figure 3-1 shows by how much the permit price is reduced due to an introduction of forestry in the CDM in the respective scenarios. The highest reduction of the permit price on the international market is shown in the scenarios including all four project types (1a and 1b), leading to a price 0.9 $/tCO_2$.

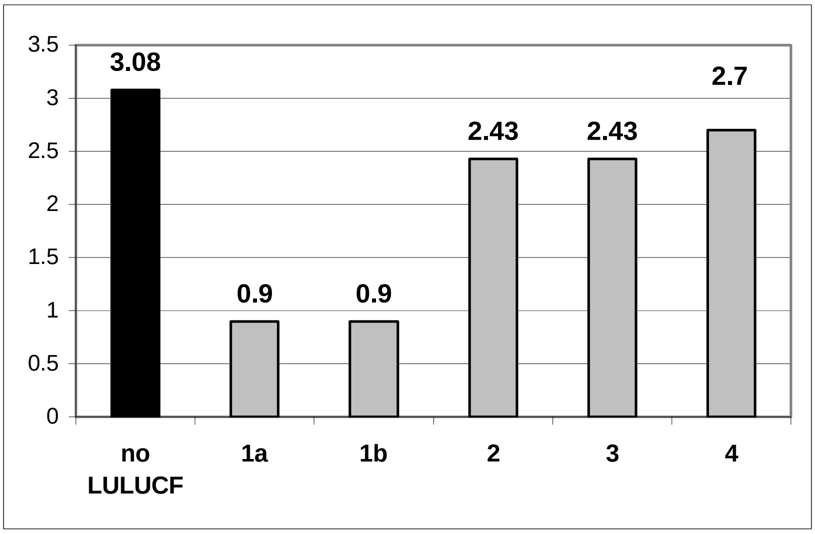


Figure 3-1: Permit price in scenarios including forestry as compared to scenario without forestry in CDM (in $/tCO_2$)

The 1% cap in scenario 1b does not have any effect on the market price in this case. When excluding avoided deforestation, the reduction in the permit price is considerably lower, leading to a market price of 2.43 $/tCO_2$ in both scenario 2 and 3. The exclusion of agroforestry (scenario 3) does not have any effect on the market price under the assumed settings. When additionally excluding plantations (scenario 4), the resulting market price is 2.7 $/tCO_2$, thus representing a relatively small reduction of 0.38 $/tCO_2$.

These price reductions seem to be considerable at first sight. But one has to put them in the context of market conditions in the reference scenario which are characterized by a very low market price as a result of the withdrawal of the US from the Kyoto Protocol and the hot air available in the market. When comparing the effects of an introduction of forestry in the CDM with the ones exerted by the US withdrawal or the hot air, one can conclude that the first two are the main factors determining the market price, while forestry in the CDM - even when including avoided deforestation - plays a minor role.

3.5.2. Distributional aspects

The introduction of forestry in the CDM has implications for the distribution of costs and benefits between different countries. As shown in Table 3-6, Annex B countries incur a total of 2353 million $ to fulfill their Kyoto obligations in the reference scenario without forestry in the CDM. However, Eastern Europe and the FSU make a profit from hot air sales of 417 million $ and 2136 million $, respectively. For Non-Annex B countries, the CDM without forestry projects gives the opportunity to gain 708.6 million $, with China getting the biggest (506.5 million $) and Brazil the smallest slice (4.9 million $) of the cake.

Table 3-6: Redistribution of benefits and losses due to the inclusion of LULUCF in the CDM

Annex B							
Scenario	**USA**	**Japan**	**Europe**	**Other OECD**	**Eastern Europe**	**FSU**	**Total Annex B**
0	costs in million $						
	1552	*463*	*1927*	*963*	*-417*	*-2136*	***2353***
Profits (- = Losses) compared to scenario 0 in %							
1a	70.6	70.2	70.3	70.0	-76.7	-75.8	**63.8**
1b	70.4	70.6	70.6	70.3	-77.2	-76.1	**64.2**
2	21.2	21.4	21.4	21.2	-26.1	-25.3	**16.8**
3	21.1	21.4	21.3	21.1	-26.1	-25.2	**16.7**
4	12.2	12.3	12.3	12.1	-15.3	-14.7	**9.4**
Non-Annex B							
Scenario	**EEX**	**China**	**India**	**DAE**	**Brazil**	**ROW**	**Total Non-Annex B**
0	profits in million $						
	56,1	*506,5*	*56,4*	*25*	*4,9*	*59,6*	***708,6***
Profits (- = Losses) compared to scenario 0 in %							
1a	-62.7	-95.6	-61.7	-71.2	277.6	13.8	**-77.6**
1b	-74.0	-98.0	-71.3	-68.0	1055.1	-23.0	**-78.6**
2	-4.5	-23.7	31.0	-24.0	198.0	18.5	**-12.8**
3	1.8	-24.0	33.7	-21.6	228.6	18.6	**-12.0**
4	31.0	-24.5	-12.9	-8.4	230.6	57.2	**-10.0**

In general, the more forestry offsets are offered on the market, the more FSU and Eastern Europe lose their benefits from hot air trading, with percentage losses of more than three quarters in the scenarios including avoided deforestation. The opposite is true for the other Annex B countries. Their gain grows the more forestry project types are eligible and lies between ca. 12 % in scenario 4 and 70% in scenario 1a.[65] Annex B as a whole profit considerably from an introduction of LULUCF in the CDM because the overall compliance costs decrease 9.4% in the lowest (scenario 4) and 64.2 % in the highest case (scenario 1b).
Although the amount of CERs exported from non-Annex B rises with the inclusion of forestry in the CDM the non-Annex B Parties still lose as a whole compared to the standard scenarios because this quantity effect is overcompensated by the price effect induced by the shrinking permit price. In the case with no policy restrictions on LULUCF (scenario 1a),

[65] The profits of countries in percentage terms are very similar due to the fact that at the very low level of 3.08 $/tCO2, the marginal abatement cost curves do not differ a lot neither in slope nor in level.

this loss reaches around 78 % of profits in the reference scenario. The loss decreases due the exclusion of avoided deforestation to around 13 %, being smallest in scenario 4 with 10%. Consequently, the introduction of LULUCF in the CDM causes a redistribution from non-Annex B to Annex B countries. Furthermore, profits and losses are shifted inside the non-Annex B group. China belongs to the biggest loser in spite of its relatively big forestry potential, with losses reaching from around 24 % to 98 % of profits gained in a purely energy based CDM. The explanation for this is that its huge CDM potential from substitution of coal based electricity generation has still greater dimensions than its forestry potential.

The DAE group is the second biggest loser, while the distribution of losses and profits for the Energy Exporting countries (EEX) and India depend on the project eligibility criteria applied. The country with the biggest gain is Brazil which can increase its rather small profits in the purely energy based CDM by 198 % (scenario 2) to 1055 % (scenario 1b). But also the ROW group representing the other Latin-American and all African countries gain from A/R in the CDM. This is due to the combination of a relatively low energy with a relatively high forestry CDM potential of most Latin-American and African countries. Especially promising for ROW would be a CDM without avoided deforestation and plantations as eligible forestry projects.

3.5.3. Sensitivity analysis

The carbon sequestration cost curves used for the scenario analysis are subject to various uncertainties. Therefore, a sensitivity analysis is conducted in order to examine the effects of a variation in the cost assumptions as well as the carbon uptake and storage factors.

3.5.3.1. Costs

Since the costs used for the above analysis are rather lower bound estimates, and the whole potential for LULUCF activities is probably not available at such low costs, I first develop another set of carbon sequestration cost curves on the basis of higher cost estimates for each of the four scenarios. The cost estimates are based on the same assumptions as the lower bound estimates, but the parameter D used for their calculation is multiplied by 25. The resulting costs are shown in Appendix C.

Furthermore, the assumed order of costs might have an influence on the results. So is the widely used assumption that avoided deforestation is very cheap questionable because protecting a forest area would have to address the causes of deforestation and be far more than just putting a fence around the forest. Since the literature is not clear about the costs of avoided deforestation, I also vary the used order of costs by assuming that avoided deforestation is now the most expensive project type.[66]

3.5.3.1.1. Effect on the market price

When assuming rather higher price levels (with avoided deforestation still being the cheapest project type), the already small effects of forestry sinks in the CDM is reduced even further. Figure 3-2 presents the market prices for the higher cost level for each scenario shaded in grey, and the values for the low cost estimates as used in the standard scenarios in white.

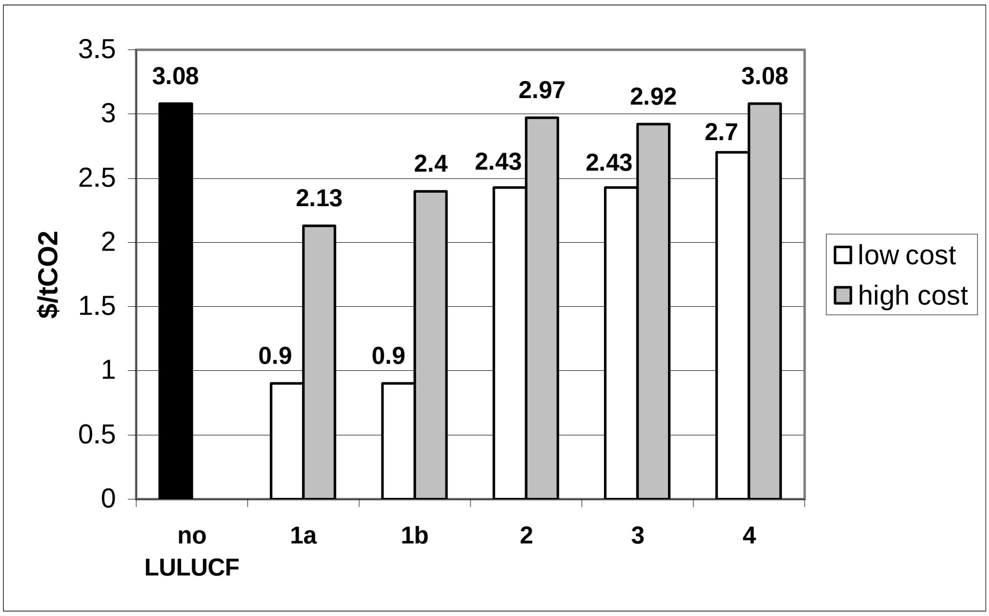


Figure 3-2: Permit price in forestry scenarios when varying the cost level (in $/tCO_2$)

The reduction of the market price of carbon dioxide is small even in the scenarios including avoided deforestation, and insignificant (scenarios 2 and 3) or even zero (scenario 4) in the ones only including A/R.

Results for the described variation in the order of costs are represented in Figure 3-3 for low as well as high cost levels. The relatively high effect of scenario 1 on the market price in the standard scenarios is significantly reduced when avoided deforestation is assumed to be the most expensive instead of the cheapest project type. This counts even more for the high cost scenario (dotted black plot) in which even the inclusion of avoided deforestation would not lead to any effect on the market price.

[66] The default value D in the formula for the calculation of avoided deforestation cost is set to 6 for the low cost and multiplied by 25 for high cost levels.

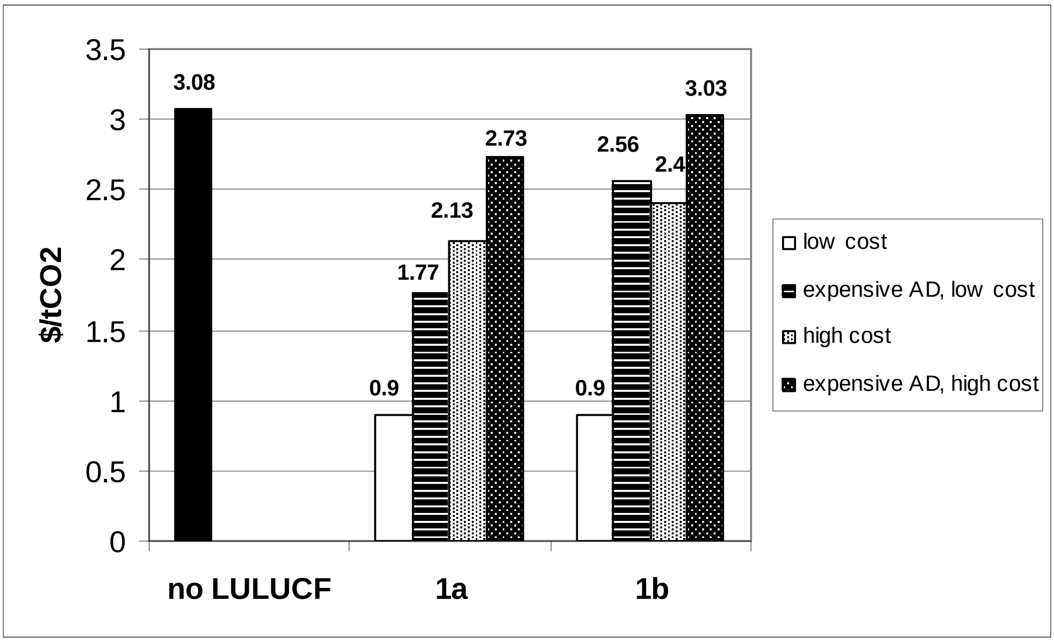


Figure 3-3: Permit price with varying cost order, avoided deforestation least vs. most expensive at low and high cost levels (in $/tCO_2$)

Therefore, I can conclude that most of the arguments broad up against the inclusion of avoided deforestation in the CDM have been based on the assumption that costs of this project type are very low. If avoided deforestation is considerably more expensive than widely thought, its inclusion would have a negligible effect on the market.[67]

3.5.3.1.2. Distributional aspects

If assuming a higher cost level (but not changing the cost order), it is obvious that Annex B countries would profit less of an introduction of forestry in the CDM. The changed redistribution of profits and losses is presented in Table 3-7. The pattern of redistribution remains more or less unchanged, while the level of profits and losses decreases.

Under the assumption of higher costs, Annex B countries as a whole could shift profits of only 17% (scenario 1b) away from non-Annex B countries, while the actual outcome of negotiations represented by scenario 2 shows only a small redistribution towards Annex B. When looking at the redistribution inside the non-Annex B group, the pattern changes slightly as compared to the scenarios using low cost levels. China and DAE lose, while Brazil is the only clear winner of any kind of introduction of forestry in the CDM.

[67] It has to be mentioned, though, that projects including conservation aspects are subject to difficulties in the baseline construction. There would always be a perverse incentive to drive national deforestation rates up to earn more credits from avoiding deforestation or conservation. This has been one of the major concern brought up against deforestation as well.

Table 3-7: Redistribution of benefits and losses due to the inclusion of LULUCF in the CDM, high cost estimates

Annex B							
Scenario	**USA**	**Japan**	**Europe**	**Other OECD**	**Eastern Europe**	**FSU**	**Total Annex B**
Profits (- = Losses) compared to scenario 0 in %							
1a	30.6	30.9	30.8	30.5	-36.9	-35.9	**24.8**
1b	21.8	22.0	22.1	21.8	-26.9	-26.1	**17.3**
2	3.9	4.1	4.0	3.9	-11.5	-4.9	**2.9**
3	5.4	5.4	5.4	5.4	-7.0	-6.6	**4.0**
4	0.6	0.6	0.6	0.5	-0.7	-0.7	**0.4**
Non-Annex B							
Scenario	**EEX**	**China**	**India**	**DAE**	**Brazil**	**ROW**	**Total Non-Annex B**
Profits (- = Losses) compared to scenario 0 in %							
1a	-3.9	-57.0	-12.1	-10.4	744.9	122.1	**-27.0**
1b	-10.3	-45.7	-9.8	-0.8	1451.0	69.5	**-18.4**
2	5.0	-4.8	11.7	-8.0	6.1	-5.2	**-2.8**
3	18.0	-7.4	39.2	-11.2	6.1	-8.7	**-1.8**
4	2.1	-1.2	-0.5	-0.4	14.3	2.9	**-0.4**

Benefits and losses in the scenarios without avoided deforestation follow a less clear pattern for all the other countries and groups. For the ROW group, profits in the scenarios with avoided deforestation are lost if the 1 % cap is considered, while benefits in all the other scenarios increase, especially in the scenario which only includes regeneration and agroforestry.

3.5.3.2. Carbon uptake and storage factors

Since the carbon uptake and storage factors used in the standard scenarios are rather optimistic, I conduct the scenario analysis for a set of lower estimates of per hectare carbon sequestration and storage. It has to be reminded that, based on my assumptions, not only LULUCF potentials but also the costs are affected by a variation in carbon sequestration and storage factors.

3.5.3.2.1. Effect on the market price

The effects of lower carbon sequestration and storage estimates are shown in Figure 3-4. Lower uptake and storage factors lead to slightly higher market prices. In general, price reductions are rather small, especially for scenario 2 to 4.

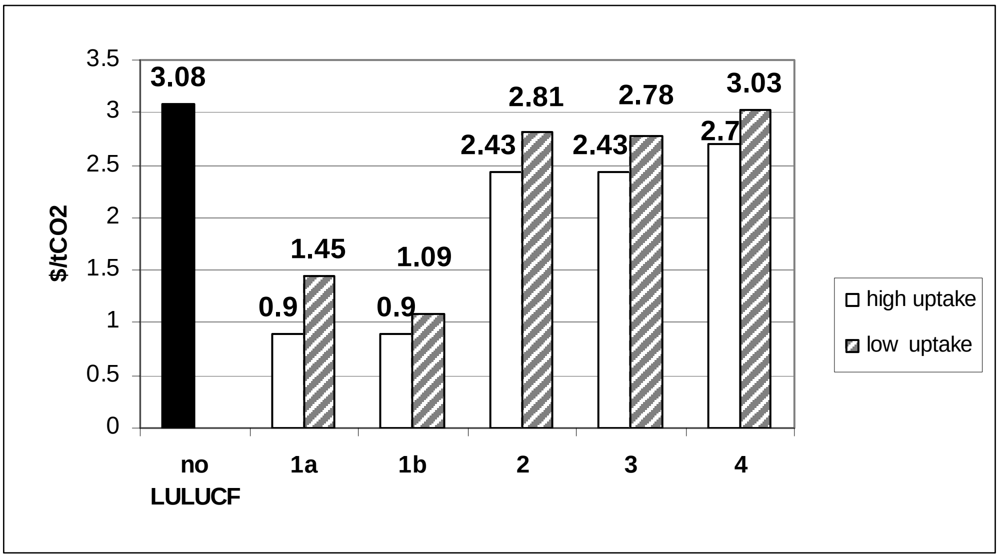


Figure 3-4: Permit price with varying carbon uptake/storage factors (in \$/tCO_2)

3.5.3.2.2. Distributional aspects

For Annex B countries, benefits and losses decrease in the case of lower uptake and storage to some extent (see Table 3-8), but follow the same pattern of redistribution as in the standard scenario.

Table 3-8: Redistribution of benefits and losses due to the inclusion of LULUCF in the CDM, low carbon uptake/storage

Annex B							
Scenario	**USA**	**Japan**	**Europe**	**Other OECD**	**Eastern Europe**	**FSU**	**Total Annex B**
Profits (- = Losses) compared to scenario 0 in %							
1a	52.7	52.9	52.9	52.6	-60.4	-59.3	**45.6**
1b	64.0	64.4	64.3	64.1	-71.5	-70.3	**57.3**
2	9.1	9.3	9.2	9.1	-11.5	-11.1	**7.0**
3	9.8	9.9	9.9	9.8	-12.5	-11.9	**7.5**
4	1.9	1.9	1.9	1.9	-2.6	-2.4	**1.4**
Non-Annex B							
Scenario	**EEX**	**China**	**India**	**DAE**	**Brazil**	**ROW**	**Total Non-Annex B**
Profits (- = Losses) compared to scenario 0 in %							
1a	-15.0	-79.9	-52.3	-38.4	677.6	93.6	**-51.2**
1b	-55.3	-95.1	-85.6	-56.0	1722.4	12.9	**-68.2**
2	8.0	-4.3	36.2	-12.8	77.6	-5.0	**0.1**
3	14.1	-5.2	47.3	-8.8	149.0	-3.0	**1.7**
4	-3.2	-3.9	0.2	2.4	81.6	12.6	**-1.3**

The group of Annex B countries can gain up to 57 % in the scenario including avoided deforestation and the 1 % cap on LULUCF. In the more realistic scenario 2, these benefits are reduced to 7 %, while in scenario 4 almost no benefits remain. Non-Annex B countries as a whole lose up to almost 70 % in scenario 1b, but are more or less unaffected in the other three scenarios. Of all non-Annex B countries, Brazil is the biggest winner again. Brazil and ROW can even increase their benefits in the avoided deforestation scenarios (as compared to the standard scenarios), while all the other countries are still encountering significant losses. China remains the country losing the most, although the size of the losses decreases especially for the scenarios without avoided deforestation.

The pattern of redistribution for the scenarios only including A/R is as unclear as before, especially for the energy exporting countries (EEX), DAE and ROW. The latter two again profit most if only agroforestry and regeneration are eligible CDM activities.

3.6. Country positions in climate negotiations

As described in Chapter 2, the negotiation on Art. 3.3 and 3.4 can be seen as a renegotiation of emissions targets, which was only possible due to the fact that the targets were negotiated before the rules and modalities of the Kyoto Protocol were agreed on. It can only be suspected that the negotiations on the inclusion of LULUCF in the CDM, and on its rules and modalities were driven by a similar interest. Some Annex B countries might have been hoping to decrease their compliance cost while non-Annex B countries with low energy CDM potential, and especially the ones that had invested in forestry projects in the AIJ phase, wanted LULUCF to be included in the CDM in a way as broad as possible (Scholz 2002).

In the following, it is examined how far the results of the scenario analysis concerning the redistribution of benefits and losses due to the introduction of LULUCF in the CDM can explain the respective country positions on the subject in the climate negotiations. Table 3-9 summarizes the results obtained from the scenario analysis, showing which countries win or lose due to an introduction of LULUCF in the CDM. These benefits and losses are differentiated for an introduction of LULUCF with avoided deforestation and with A/R only. Additionally, the respective country positions are included in the table showing if a country has been in favor of accounting for LULUCF in Annex B inventories (Art. 3.3/3.4), and if it has been in favor of avoided deforestation and/or A/R as eligible CDM activities.

It becomes obvious that country positions concerning LULUCF are not defined along the lines of the negotiating coalitions formed in the frame of the climate regime. Can the benefits and losses of an introduction of LULUCF in the CDM account for this?

Table 3-9: Winners and losers of an inclusion of LULUCF in the CDM as compared to country positions

Annex B								
		USA	**Japan**	**Europe**	**Other OECD**	**Eastern Europe**	**FSU**	**Total Annex B**
Profits (- = Losses) compared to scenario 0 in %								
With avoided deforestation (scenario 1a,b)		+++	+++	+++	+++	**---**	**---**	**+++**
A/R only (scenarios 2)		+++	+++	+++	+++	**---**	**---**	**+++**
In favor of …. in negotiations								
LULUCF Art. 3.3/3.4		ŏ	ŏ	-	ŏ	-	ŏ	**?**
CDM	Avoided deforestation	ŏ	ŏ	-	ŏ	-	-	**?**
	A/R	ŏ	ŏ	-	ŏ	-	-	**?**
Non-Annex B								
		EEX	**China**	**India**	**DAE**	**Brazil**	**ROW**	**Total Non-Annex B**
Profits (- = Losses) compared to scenario 0 in %								
With avoided deforestation (scenario 1a,b)		**---**	**---**	**---**	**---**	+++	+	**---**
A/R only (scenarios 2)		+	**---**	+++	**---**	+++	+	**--**
In favor of …. in negotiations								
LULUCF Art. 3.3/3.4		ŏ	-	-	?	-	?	**?**
CDM	Avoided deforestation	ŏ	-	-	?	-	ŏ	**?**
	A/R	ŏ	-	-	?	ŏ	ŏ	**?**

Based on the results of table 3-6, 3-7 and 3-8:
+++ clear winner, --- clear loser, + probably some profits, - probably some losses
ŏ in favor, - opposing, ? no common group position
Country positions based on Michaelowa and Greiner (2001) and Jung et al. (2005)

In quite a number of cases, the country positions coincide with respective profits and losses. The USA, Japan and the group including other OECD countries like Australia, Canada, New Zealand and Norway were the main forces pushing towards a broad inclusion of LULUCF ever since the beginning (Anderson et al. 2001; Jung et al. 2005).

The results confirm partly that an active pro-sinks position might have been driven by the interest of lowering the own compliance cost. The European Union, however, has been opposing LULUCF in the CDM, in spite of being able to gain from its inclusion. This situation could be explained by the leadership role which the European Union has been trying to take over in the climate regime as well as the weak influence of interest groups in the EU pushing for the subject. The Eastern European countries and Russia have been rejecting LULUCF in the CDM as well, but due to different reasons. A broad inclusion of LULUCF in the CDM would probably lead to a devaluation of the hot air held by these countries. In spite of this, Russia used the negotiation on country specific forest management caps - known as Appendix Z - to double its own amount of forest management activities (Michaelowa and Greiner 2001).

For non-Annex B countries the picture is even more complex. In the negotiations, the group of Non-Annex B countries represented in the Group 77 and China has been divided over the question whether to include LULUCF in the CDM - with most of the Latin American countries having been in favor and most of the Asian countries having been against it (Anderson et al. 2001). Here, the economic gains and losses seem to explain some of the country positions as well. Especially China, but also India has been the greatest opponents of the inclusion of LULUCF in the CDM. While the position of China derives from the clear losses from any kind of introduction of LULULCF in the CDM, results for India show at least some profits if only A/R is eligible under the CDM. However, the most interesting case in the Group 77 and China is Brazil which was rejecting the inclusion of avoided deforestation in the CDM although belonging to the countries which could gain considerably. This position and the active role Brazil took in the negotiations to prevent avoided deforestation from being included may be explained by political reasons, like the strong position of Brazil in the G77 group as well as sovereignty concerns about the amount of foreign investment in the Amazon region (Fearnside 2001; Michaelowa and Greiner 2001).[68]

3.7. Uncertainties and limits of the analysis

The basis of my analysis is the development of carbon sequestration costs curves which are subject to uncertainties about the potentials and costs they are based on. The literature review shows that the comparison of studies of carbon sequestration costs and potentials is rather problematic. Furthermore, other important cost elements, e.g. land cost, benefits, transaction costs[69] are neglected widely, leading to a wide range of estimates for costs and carbon sequestration potentials. Due to the lack of a solid cost data set for the development of my carbon sequestration cost curves, I had to rely on a number of assumptions rather than empirical results.

Additionally, the calculation of demand for emissions permits in the CERT model does not consider political preferences toward non- CDM and non-sinks permits. The European Union, with the exception of some individual countries[70], rejects forestry CERs for the fulfillment of its own compliance and has excluded LULUCF from the European Emissions Trading Scheme (Commission of the European Community 2003). The remaining buyer

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68 For a detailed analysis of negotiating positions, see Chapter 2.

69 At such low market prices as resulting from our study, transaction costs become a really important subject, because they might turn into a decisive factor for projects implementation. However, little is known on transaction costs of CDM projects still. Some examples of transaction cost studies for forestry projects are van Kooten et al. (2002) and Milne (1999)

70 The Netherlands, Austria and Denmark

countries Canada, Japan, New Zealand, Norway and Switzerland may put emphasis on domestic sinks under Art. 3 of the Kyoto Protocol. Therefore, the countries actually demanding forestry CERs might be limited to Japan, Austria, Denmark, The Netherlands and Canada (Bernoux et al. 2002). Consequently, due to political preferences the demand for forestry CERs might be smaller than assumed by the model, which additionally decreases the role of LULUCF in the CDM in the first commitment period. On the other hand, the total demand for emissions permits in the CERT model might be underestimated, because it is assumed that Annex B countries will use all of the emissions permits they own or buy to fulfill their obligations in the first commitment period. The CERT model is a static partial equilibrium model considering the first commitment period only, and is not able to account for banking of emissions permits. The analysis suggests that the permit prices in the first commitment period will probably be very low. One strategy that Annex B countries might follow is the banking of all bankable[71] emissions permit while using a greater amount of forestry CERs for complying with their first commitment period target. This way, they could take advantage of the relatively cheap emissions reductions in the first commitment period and carry some of them over to the second commitment period.

3.8. Conclusion

The goal of my analysis is to examine the consequences of policy decisions on the inclusion of LULUCF in the CDM on the international market of emissions permits. Although, a vast literature on carbon sequestration costs has developed in the last two decades, it does not provide us with data for an analysis at global level. I, therefore, develop a set of carbon sequestration cost curves based on the knowledge available, and conduct a scenario analysis by running the partial equilibrium model CERT with different assumptions on the eligibility of forestry projects in the CDM. By doing so, I try to shed some light on which effects policy decisions regarding the inclusion of forestry in the CDM will have on the market price, as well as on the redistribution of losses and benefits between countries. Since the negotiation on the inclusion of LULUCF in the CDM has been a heavily debated issue in the climate regime, furthermore I investigate if such economic incentives can explain the negotiating position of countries in the climate regime.

In general, the greater reduction in permit price occur in the scenarios including avoided deforestation, leading to a market price of 0.9 $/tCO_2$ as compared to the 3.08 $/tCO_2$ in the reference scenario without LULUCF. The scenarios including only A/R lead to significantly lower reductions which range from 0.76 $/tCO_2$ to 0.38 $/tCO_2$. Compared to

[71] While LULUCF credits are not bankable, all other emissions permits are.

the effects exerted by the withdrawal of the US from the Kyoto Protocol and the hot air in the system, the reductions due to the inclusion of LULUCF in the CDM are rather small. Since the above results are based on relatively optimistic assumptions, the already small effects on the market price shrink even further if higher cost levels and lower carbon uptake factors are considered. Furthermore, the great reduction in permit price and, therefore, in compliance cost expected from an inclusion of avoided deforestation are mainly based on the assumptions of very low costs for this project type. If, however, avoided deforestation is assumed to be more expensive than widely thought, the relatively big effects of avoided deforestation on the carbon market disappear almost entirely.

The LULUCF issue has been a very controversial one ever since the beginning of the Kyoto Protocol. The rules, modalities and procedures adopted at COP 9 are the result of an intense negotiating process driven by the different interest of countries. Since emissions reduction targets were agreed upon before the concrete rules and modalities of the Kyoto Protocol had been adopted, the rules for the inclusion on forestry in the CDM had some implications for the compliance cost of Annex B countries, as well as the respective benefits from CDM projects for non-Annex B countries. Redistribution of benefits and losses due to the introduction of forestry in the CDM takes place along three lines running between Annex B and non-Annex B countries, and inside the group of Annex B as well as the group of non-Annex B Parties. The analysis shows that Annex B countries as a whole profit from forestry in the CDM, while non-Annex B countries lose or remain unaffected. The greatest profits for Annex B can be expected if LULUCF is not restricted to A/R only. In spite of these profits for Annex B, Russia and the eastern European countries lose from such an introduction of LULUCF because their hot air is devaluated. Inside the non-Annex B group, profits are shifted away from China and the Dynamic Asian Economies, while Brazil is profiting most, especially if avoided deforestation is an eligible activity in the CDM. While, at least in most cases, the African and the other Latin-American can expect some considerable profits, for India and the energy exporting countries there are only profits if avoided deforestation is excluded from the CDM. This basic pattern of redistribution seems to be relatively robust to a variation in cost level as well as carbon uptake and storage factors.

The benefits and losses countries encounter due to the introduction of LULUCF in the CDM seem to explain some country negotiating positions concerning LULUCF in the CDM. In general, countries with clear losses have been opposing forestry in the CDM, while some countries with clear profits have been in favor. The latter does not count for

Brazil and the EU who could profit economically from a policy they have been rejecting in the negotiations.

The huge effort made for the negotiation of rules and modalities for LULUCF in the climate regime and the small role it will probably play in the fulfillment of reduction requirements of the first commitment period lead to the question whether the first is in any way proportional to the latter. However, the success of LULUCF cannot only be measured in tons of CO_2, but in its contribution to keeping certain countries on board of the climate regime. In spite of this rather small role in the first commitment period, LULUCF might turn into an important element of the negotiation of reduction targets of future commitment periods. The practical experience, the progress in reducing uncertainties in carbon measurement and the credibility of forestry projects implemented in the first commitment period will be decisive for decisions to be taken on the inclusion of LULUCF in a possible second commitment period.

Appendix

Appendix A

Table 3-10: LULUCF potentials of considered Non-Annex B countries – first commitment period (in tCO_2)

Project type	**Plantations**		**Avoided deforestation**		**Agroforestry**		**Regeneration**		**Total carbon**	
Uptake factors	Low	high	low	high	low	high	low	High	low	high
EEX	**9,900,000**	**14,850,000**	**247,500,000**	**392,333,333**	**48,125**	**110,689**	**1,191,667**	**2,383,333**	**258,639,792**	**409,677,356**
Indonesia	9,166,667	13,750,000	165,000,000	297,000,000	45,833	105,417	275,000	550,000	174,487,500	311,405,417
Venezuela	733,333	1,100,000	82,500,000	95,333,333	2,292	5,273	916,667	1,833,333	84,152,292	98,271,939
CHN	**46,530,000**	**76,774,500**	**10,807,500**	**16,211,250**	**4,766,667**	**10,963,333**	**10,500,417**	**31,501,250**	**72,604,583**	**135,450,333**
IND	**18,333**	**27,500**	**24,750,000**	**41,250,000**	**22,917**	**52,708**	**916,667**	**1,833,333**	**25,707,917**	**43,163,542**
DAE	**1,549,167**	**2,328,333**	**49,500,000**	**86,625,000**	**128,333**	**295,167**	**2,429,167**	**4,904,167**	**53,606,667**	**94,152,667**
Malaysia	55,000	82,500	0	0	9,167	21,083	550,000	1,100,000	614,167	1,203,583
Philippines	1,466,667	2,200,000	30,937,500	55,687,500	114,583	263,542	1,833,333	3,666,667	34,352,083	61,817,708
Thailand	27,500	45,833	18,562,500	30,937,500	4,583	10,542	45,833	137,500	18,640,417	31,131,375
BRA	**9,166,667**	**13,750,000**	**464,062,500**	**773,437,500**	**45,833**	**105,417**	**13,750,000**	**27,500,000**	**487,025,000**	**814,792,917**
ROW	**4,995,833**	**8,075,833**	**912,326,250**	**1,611,885,000**	**1,796,256**	**4,131,384**	**26,532,917**	**61,485,417**	**945,651,256**	**1,685,577,634**
Bolivia	27,500	45,833	18,562,500	30,937,500	4,583	10,542	45,833	137,500	18,640,417	31,131,375
Chile	275,000	550,000	0	0	1,833	4,217	18,333	55,000	295,167	609,217
Colombia	183,333	275,000	222,750,000	371,250,000	45,833	105,417	1,833,333	3,666,667	224,812,500	375,297,083
Costa Rica	110,000	165,000	6,187,500	12,375,000	22,917	52,708	183,333	366,667	6,503,750	12,959,375
Ecuador	82,500	137,500	148,500,000	247,500,000	45,833	105,417	458,333	1,375,000	149,086,667	249,117,917
Guatemala	73,333	110,000	16,706,250	27,843,750	45,833	105,417	458,333	916,667	17,283,750	28,975,833
Guyana	0	0	0	0	0	0	183,333	366,667	183,333	366,667
Honduras	18,333	27,500	24,750,000	41,250,000	22,917	52,708	916,667	1,833,333	25,707,917	43,163,542
Mexico	550,000	825,000	57,750,000	123,750,000	458,333	1,054,167	9,166,667	18,333,333	67,925,000	143,962,500
Nicaragua	55,000	82,500	0	0	9,167	21,083	550,000	1,100,000	614,167	1,203,583
Panama	18,333	27,500	33,000,000	49,500,000	18,333	42,167	183,333	366,667	33,220,000	49,936,333
Paraguay	82,500	137,500	23,100,000	49,500,000	32,083	73,792	183,333	550,000	23,397,917	50,261,292
Peru	137,500	229,167	0	0	22,917	52,708	916,667	2,750,000	1,077,083	3,031,875
Suriname	0	0	0	0	48	106	146,667	293,333	146,714	293,440
ROW, Latin America	*1,613,333*	*2,612,500*	*551,306,250*	*953,906,250*	*730,631*	*1,680,448*	*15,244,167*	*32,110,833*	*568,894,381*	*990,310,031*
Bangladesh	366,667	550,000	0	0	114,583	263,542	0	0	481,250	813,542
Myanmar	366,667	550,000	0	0	22,917	52,708	2,200,000	4,400,000	2,589,583	5,002,708
Lao	275,000	412,500	0	0	0	0	458,333	916,667	733,333	1,329,167

Project type	**Plantations**		**Avoided deforestation**		**Agroforestry**		**Regeneration**		**Total carbon**	
Uptake factors	Low	high	low	high	low	high	low	high	low	high
Papua New Guinea	36,667	55,000	0	0	9,167	21,083	1,833,333	3,666,667	1,879,167	3,742,750
Vietnam	275,000	412,500	0	0	0	0	458,333	916,667	733,333	1,329,167
ROW, Asia	*1,320,000*	*1,980,000*	*0*	*0*	*146,667*	*337,333*	*4,950,000*	*9,900,000*	*6,416,667*	*12,217,333*
Angola	137,500	229,167	0	0	4,583	10,542	183,333	550,000	325,417	789,708
Benin	27,500	45,833	7,218,750	15,468,750	11,458	26,356	183,333	550,000	7,441,042	16,090,939
Botswana	0	0	3,465,000	7,425,000	9,167	21,083	22,917	68,750	3,497,083	7,514,833
Burkina Faso	68,750	114,583	4,331,250	6,187,500	45,833	105,417	458,333	1,375,000	4,904,167	7,782,500
Cameroon	27,500	45,833	41,250,000	74,250,000	114,583	263,542	275,000	825,000	41,667,083	75,384,375
Central African R.	13,750	22,917	11,343,750	20,418,750	34,375	79,064	18,333	55,000	11,410,208	20,575,731
Chad	13,750	22,917	4,620,000	6,600,000	13,750	31,625	18,333	55,000	4,665,833	6,709,542
Congo	137,500	229,167	0	0	4,583	10,542	183,333	550,000	325,417	789,708
Congo D. Rep	68,750	114,583	0	0	45,833	105,417	916,667	2,750,000	1,031,250	2,970,000
Cote d´Ivoire	137,500	229,167	103,125,000	185,625,000	45,833	105,417	458,333	1,375,000	103,766,667	187,334,583
Ethiopia	412,500	687,500	618,750	1,031,250	91,667	210,833	183,333	550,000	1,306,250	2,479,583
Gabon	55,000	91,667	0	0	0	0	0	0	55,000	91,667
Ghana	55,000	91,667	0	0	11,458	26,356	91,667	275,000	158,125	393,023
Guinea	68,750	114,583	10,395,000	22,275,000	22,917	52,708	183,333	550,000	10,670,000	22,992,292
Kenya	137,500	229,167	0	0	68,750	158,125	0	0	206,250	387,292
Madagascar	27,500	45,833	24,750,000	41,250,000	2,292	5,273	91,667	275,000	24,871,458	41,576,106
Mali	13,750	22,917	0	0	9,167	21,083	45,833	137,500	68,750	181,500
Mozambique	55,000	91,667	0	0	11,458	26,356	550,000	1,650,000	616,458	1,768,023
Niger	27,500	45,833	3,465,000	4,950,000	22,917	52,708	45,833	137,500	3,561,250	5,186,042
Nigeria	412,500	687,500	24,750,000	41,250,000	68,750	158,125	91,667	275,000	25,322,917	42,370,625
Senegal	27,500	45,833	11,550,000	24,750,000	91,667	210,833	229,167	687,500	11,898,333	25,694,167
Somalia	27,500	45,833	2,887,500	6,187,500	22,917	52,708	137,500	412,500	3,075,417	6,698,542
Sudan	137,500	229,167	46,200,000	99,000,000	22,917	52,708	916,667	2,750,000	47,277,083	102,031,875
Tanzania	82,500	137,500	33,000,000	66,000,000	68,750	158,125	916,667	2,750,000	34,067,917	69,045,625
Uganda	82,500	137,500	14,850,000	24,750,000	45,833	105,417	91,667	275,000	15,070,000	25,267,917
Zambia	27,500	45,833	6,600,000	6,893,333	4,583	10,542	45,833	137,500	6,677,917	7,087,208
Zimbabwe	55,000	91,667	6,600,000	3,666,667	22,917	52,708	458,333	1,375,000	7,136,250	5,186,042
Africa	*2,337,500*	*3,895,833*	*361,020,000*	*657,978,750*	*918,958*	*2,113,606*	*6,797,083*	*20,391,250*	*371,073,542*	*684,379,439*

Bold values: regions in the CERT model; italics: other regional aggregates

Appendix B

Table 3-11: Annex B countries in the grouping of the CERT model

GTEM name	Countries in GTEM
USA	United States of America
JPN	Japan
EEC	15 EU members: includes Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, Sweden, UK
OOE	Rest OECD; Includes: Australia, Canada, Iceland, New Zealand, Norway, Switzerland
EET	Economies in Transition of Eastern Europe; Includes: Bulgaria, Croatia, Czech Rep., Hungary, Poland, Romania, Slovakia, Slovenia
FSU	Soviet Union; Includes: Estonia, Latvia, Lithuania, Russia, Ukraine

Table 3-12: Non-Annex B countries in the grouping of the CERT model

	GTEM	LULUCF cost curves
EEX	Energy Exporting Countries; Includes: Algeria, Bahrain, Botswana, Swaziland, Egypt, Indonesia, Iran, Iraq, Israel, Jordan, Kuwait, Lebanon, Lesotho, Libya, Namibia, Oman, Qatar, Saudi Arabia, Syria, South Africa, Tunisia, United Arab Emirates, Venezuela, Yemen.	Indonesia, Venezuela
CHN	Includes China and Chinese Taipei	China
IND	India	India
DAE	Dynamic Asian Economies; Includes: Philippines, Malaysia, Singapore, South Korea, Thailand	Malaysia, Philippines, Thailand
BRA	Brazil	Brazil
ROW	Rest of the World (all other Non-Annex B countries)	Bolivia, Chile, Colombia, Costa Rica, Ecuador, Guatemala, Guyana, Honduras, Mexico, Nicaragua, Panama, Paraguay, Peru, Suriname, Bangladesh, Myanmar, Lao, Papua New Guinea, Vietnam, Angola, Benin, Botswana, Burkina Faso, Cameroon, Central African Republic, Chad, Congo, Congo D. Rep., Cote d´Ivoire, Ethiopia, Gabon, Ghana, Guinea, Kenya, Madagascar, Mali, Mozambique, Niger, Senegal, Somalia, Sudan, Tanzania, Uganda, Zambia, Zimbabwe

Appendix C

Table 3-13: Average cost estimates in $/tCO_2$ for each project type and country/region, low cost scenario

Low costs ($/tCO_2$)	EEX*	China	India	DAE*	Brazil	ROW*
Low uptake						
Plantations	0.11	0.27	0.08	0.19	0.26	0.15
Agroforestry	0.35	0.43	0.26	0.62	0.83	0.34
Regeneration	0.40	1.95	0.29	0.70	0.94	0.73
Avoided deforestation (cheap)	0.05	0.12	0.07	0.06	0.02	0.07
Avoided deforestation (expensive)	2.39	5.24	3.20	2.54	1.10	3.08
high uptake						
Plantations	0.07	0.16	0.05	0.13	0.17	0.09
Agroforestry	0.15	0.19	0.11	0.27	0.36	0.15
Regeneration	0.20	0.65	0.14	0.35	0.47	0.28
Avoided deforestation (cheapest)	0.03	0.08	0.02	0.03	0.02	0.04
Avoided deforestation (most expensive)	1.38	3.50	0.92	1.37	0.66	1.79

*For the country grouping used, see Appendix B. The potentials for which these average costs are estimated are shown in Appendix A.

Table 3-14: Average cost estimates in $/tCO_2$ for each project type and country/region, high cost scenario

High costs ($/tCO_2$)	EEX*	China	India	DAE*	Brazil	ROW*
Low uptake						
Plantations	10.15	24.90	7.40	17.77	23.80	14.10
Agroforestry	32.47	39.80	23.60	56.86	76.30	31.53
Regeneration	36.53	178.90	26.50	63.97	85.80	66.80
Avoided deforestation (cheap)	5.10	11.20	6.90	5.40	2.30	6.60
Avoided deforestation (expensive)	219.35	480.9	293.7	232.87	100.40	282.50
high uptake						
Plantations	6.80	15.10	4.90	11.90	15.90	8.30
Agroforestry	14.10	17.30	10.30	24.70	33.20	13.70
Regeneration	18.30	59.60	13.30	32.00	42.90	25.40
Avoided deforestation (cheapest)	3.00	7.50	2.00	2.90	1.40	3.80
Avoided deforestation (most expensive)	126.80	320.60	83.90	126.00	60.20	164.00

*For the country grouping used, see Appendix B. The potentials for which these average costs are estimated are shown in Appendix A.

Chapter 4

Host country attractiveness for CDM projects

4. Host country attractiveness for CDM projects[72]

4.1. Introduction

While the analysis in Chapter 4 is based on the underlying assumption that the amount of forestry projects taking place in non-Annex I countries is purely determined by the respective potential for forestry projects and their related costs, other factors might play a role for CDM investment flows as well. Therefore, in the following I investigate the attractiveness of CDM host countries, taking further aspects influencing CDM investments into account.

Annex I countries can provide financing for CDM projects either via equity investment (co-)financing the emission reduction project, via forward purchases or by buying the already produced 'certified emission reduction' (CER) on the secondary market.[73] According to a recent decision of the Executive Board, CERs can also be created by unilateral CDM projects.[74] After the main rules governing the CDM were decided at the Seventh Session of the Conference of the Parties (COP 7) in 2001, a process of refinement of implementation modalities and the development of the necessary infrastructure for the complex CDM project cycle began. While the overall contribution of CDM in the compliance of Annex I countries will depend on a variety of different factors outside the influence of host countries, the distribution of the CDM investment does and will depend mainly on the attractiveness of host countries for the CDM.[75] Against the background of the entering into force of the Kyoto Protocol in February 2005 and the kick-off of the CDM market, the question arises how CDM investment flows will be distributed between the potential host countries. This is especially relevant, since Decision 17/CP.7 of the Marrakech Accords emphasizes the importance of an equitable geographic distribution of clean development mechanism project activities at regional and sub regional levels (UNFCCC 2001b).

Often the simplistic assumption is used that CDM flows mainly follow the pattern of foreign direct investment (FDI) flows. Arquit Niederberger and Saner (2005) criticize this assumption and clarify CDM-related determinants of FDI flows. Fankhauser and Lavric (2003) study the attractiveness of JI host countries, and identify three factors determining the attractiveness of a JI host country:

[72] This chapter is based on Jung (2005a)
[73] See also Arquit Niederberger and Saner (2005)
[74] For a detailed study on unilateral CDM , see Jahn et al. (2004)
[75] This is true for almost all of the forms of CDM investment, however, not for the unilateral CDM. While forward purchase agreements allow buyers to reduce the risks involved in a concrete CDM project, the risk of CER accrual remains. Here country risks play an important role.

- the scope for cheap emission reductions,
- the institutional capacity of a host country to process JI deals, and
- the general investment climate.

These factors apply to CDM investment as well as for JI[76] and are used in the following as a basis for defining the attractiveness of CDM host countries for CDM projects. The analysis is, however, limited to non-sink projects, since data on the potentials for CDM forestry projects is not available for such a big set of countries as the one included in the present study.[77]

Instead of relying on the assumption that CDM flows follow the same pattern as FDI flows or are only determined by the mitigation potential, I use the explorative tool of cluster analysis to take into account all three factors identified by Fankhauser and Lavric (2003) in the classification of CDM host countries. Cluster analysis is a multivariate statistical procedure that identifies relatively homogenous groups of elements in a given data set. It has to be emphasized, though, that cluster analysis is an explorative tool, based on different plausible algorithms.[78] It is therefore useful for developing a first classification or investigating a conceptual scheme for grouping elements, which can help to improve the understanding of the respective issue (Aldenderfer and Blashfeld 1984, Bacher 2002, Mucha 1992).

The host country classification based on the attractiveness of countries for CDM non-sink projects provides a first picture of what the distribution of CDM flows might look like in a mature CDM market. While the present study is concerned with a more general picture, host country ratings (for example the one by Point Carbon[79]) are much more detailed, but focused on a smaller set of countries. Therefore, both can be seen as complementary approaches in analyzing CDM host country attractiveness.

4.2. Indicators for host country attractiveness

For using the three factors emission reduction potential, institutional CDM capacity and general investment climate in the cluster analysis, appropriate indicators have to be identified. 114 host countries for which the respective data was available are included in the analysis. The indicators used in this analysis are summarized in Table 4-1 below.

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[76] This is supported by a survey conducted by Point Carbon (2002) which identifies a supportive CDM approval system as well as the investment climate as the most important factors influencing CDM investment.

[77] The only comprehensive estimation of potentials for CDM forestry is the one of Trexler and Haugen (1995), which, however, only includes around 50 developing countries.

[78] The software package CLUSTAN is used for the analysis.

[79] For details see: http://www.pointcarbon.com/category.php?categoryID=723

While Fankhauser and Lavric (2003) use expected carbon emissions per GDP as a measure of a countries´ emission reduction potential, I argue that the expected absolute greenhouse gas emissions are a better indicator. First, the absolute value of emissions is more appropriate because the indicator emission intensity (e.g. CO_2 emissions/GDP) is not comparable due to its complex formation and the different factors influencing the level of this indicator (Sun 2000). Secondly, only focusing on CO_2 is not sufficient to reflect the wide range of greenhouse gas emission reduction options eligible under the CDM; currently most of the CDM projects actually reduce non-CO_2 gases.[80] The data on greenhouse gas emissions[81] in 2001, taken from the Climate Analysis Indicators Tool - CAIT - (WRI 2003) are used in the following as an indicator for emission reduction potential in CDM host countries.

Table 4-1: Indicators of host country attractiveness for non-sink CDM projects

Dimension	Variable
Emission reduction potential (in the non-sink sector)	Expected greenhouse gas emissions in 2010 (Gg CO_2)
Institutional CDM capacity	Index (0-4) based on: - Kyoto ratification, - AIJ experience, - CDM authority (DNA) installed timely, - National Strategy Study (NSS) completed
General investment climate	Index based on averages (1994-2003) of three dimensions of World Bank World Governance Research Indicators Dataset

Until emission reduction credits can be generated by a CDM project, projects have to pass a relatively complex project cycle. As prerequisites for a CDM project to be submitted to the Executive Board, the country has to have ratified the Kyoto Protocol and is obliged to have a Designated National Authority (DNA) operating. The latter has to approve the CDM project activity and confirm that it is complying with the national definition of sustainability. For setting-up a well-functioning and efficient DNA, there is a need for expert knowledge inside the government on rules and modalities governing

[80] Of the projects available for validation comments on the UNFCCC CDM website by Feb. 10 2005, 84% of estimated CERs come from non-CO_2 gases.
[81] It has to be mentioned, though, that there may be large uncertainties concerning the non-fossil fuel-related greenhouse gas emissions of developing countries.

the CDM.[82] It can be assumed that those countries which participated in the AIJ pilot phase (Activities Implemented Jointly), and completed a National Strategy Study analyzing their CDM potential will be able to profit from the experiences and knowledge gained. Therefore, the indicators ratification of the Kyoto Protocol[83], participation in the AIJ pilot phase, timely establishment of a Designed National Authority (DNA)[84] as well as completion of a National Strategy Study (NSS)[85] form an index representing the institutional CDM capacity of a CDM host country[86].

As an indicator for the general investment climate, I create an index based on the World Governance Research Indicators Dataset[87], using the dimensions of political stability, regulatory quality and rule of law.[88]

The data exploration shows that those host countries with higher greenhouse gas emissions tend to have built up a better institutional CDM capacity. While there is no significant correlation of the mitigation potential of a country with its investment climate, an improvement in the latter seems to be favoring a better institutional CDM capacity. However, none of the correlations is very strong.[89]

4.3. Classification of host countries by cluster analysis

As the data used in this analysis is measured on different scales, it is standardized using z-scores. In the first step of the analysis, I use the Single-linkage algorithm[90] to identify outliers. China, India and Brazil – countries with an exceptionally high mitigation potential and relatively good CDM capacity as well as investment climate - are identified as such and are excluded from the data set. In a second step, the Ward-

[82] Michaelowa (2003) deals with the tasks of host countries in the CDM project cycle, and highlights the importance of effective host country institutions for reaping benefits from the CDM market. Willems (2004) deals with the role of the institutional capacity in selecting climate actions in general.

[83] As of 5 October 2004 (www.unfccc.int)

[84] Defined as DNA operating by 4 November 2004.

[85] As of November 2004.

[86] Countries for which none of these criteria apply, will therefore have a minimum value of zero, the ones for which all of them apply a maximum value of 4.

[87] For details on the Governance Indicators see Kaufmann et al. (1999a), Kaufmann et al. (1999b), Kaufmann et al. (2003) as well as the website at: http://www.worldbank.org/wbi/governance/govdata2002/index.html. Kearney (2004) conducted a survey on the most critical risks to firm operation. Government regulation/legal decisions, country financial risk as well political and social disturbances are below the most important risks mentioned by more than 60% of total respondents.

[88] The range of the indicator is from -7.5 to 7.5, with higher values indicating a better investment climate.

[89]Pearson correlation coefficient of 0.29 and 0.31, respectively.

[90] The Single-linkage algorithm is the simplest of all algorithms and is able to identify outlier well by joining them in the last clustering step(s).

algorithm[91], which minimizes the variance within the clusters, is applied. The variance is defined as:

$$V_g = \sum_{k=1}^{K_g} \sum_{j=1}^{J} (x_{kjg} - \bar{x}_{jg})^2$$

where x_{kjg} is the value of the variable j for object k in group g, and $\bar{x}_{jg}$ is the average of the values of variable j in group g. The Ward method joins those groups or elements that result in the smallest increase of V_g.

Table 4-2: Cluster membership of host countries

Cluster	Ward	k-means
Cluster 1	Albania, Suriname, Central African Rep., Ivory Coast, Mozambique, Gabon, Macedonia, Sao Tome and Principe, Bosnia and Herzeg., Chad, <u>Guinea-Bissau</u>, Ethiopia, Kenya, Benin, Lesotho, Seychelles, Dominican Rep., Ghana, Gambia, Guyana, Malawi, Lebanon, Mauritania, Zambia, Burkina Faso, Senegal, Kyrgyzstan, Nepal, Syrian Arab Rep., Tanzania, Cameroon, Guinea, Papua New Guinea, Togo, Rwanda	Albania, Suriname, Central African Rep., Ivory Coast, Mozambique, Gabon, Macedonia, Sao Tome and Principe, Bosnia and Herzeg., Chad, , Ethiopia, Kenya, Benin, Lesotho, Seychelles, Dominican Rep., Ghana, Gambia, Guyana, Malawi, Lebanon, Mauritania, Zambia, Burkina Faso, Senegal, Kyrgyzstan, Nepal, Syrian Arab Rep., Tanzania, Cameroon, Guinea, Papua New Guinea, Togo, Rwanda
Cluster 2	Bahamas, Botswana, Qatar, Tunisia, Bahrain, Cape Verde, Kuwait, Brunei Darussalam, Oman, United Arab Emirates	Bahamas, Botswana, Qatar, Tunisia, Bahrain, Cape Verde, Kuwait, Brunei Darussalam, Oman, United Arab Emirates
Cluster 3	Algeria, Sudan, Turkmenistan, Congo, Sierra Leone, Haiti, Libyan Arab Yam., Tajikistan, Dem. Rep. Congo (Zaire), Iraq, Liberia	<u>Guinea-Bissau</u>, Algeria, Sudan, Turkmenistan, Congo, Sierra Leone, Haiti, Libyan Arab Yam., Tajikistan, Dem. Rep. Congo (Zaire), Iraq, Liberia
Cluster 4	Antigua and Barbuda, Belize, Mongolia, Maldives, Trinidad and Tobago, Chile, Costa Rica, Mauritius, Uruguay, El Salvador, Jordan, Panama	Antigua and Barbuda, Belize, Mongolia, Maldives, Trinidad and Tobago, Chile, Costa Rica, Mauritius, Uruguay, El Salvador, Jordan, Panama, <u>Malaysia, Bolivia, Morocco</u>
Cluster 5	Armenia, Moldova, Guatemala, Madagascar, Jamaica, Azerbaijan, Cuba, Laos, Niger, Paraguay, Uganda, Equatorial Guinea, Georgia, Yemen, Zimbabwe, Bangladesh, Israel, Philippines, <u>Kazakhstan</u>, <u>Malaysia</u>, Colombia, Egypt, <u>Bolivia</u>, Vietnam, Ecuador, Honduras, Nicaragua, Sri Lanka, Mali, <u>Morocco</u>, Peru	Armenia, Moldova, Guatemala, Madagascar, Jamaica, Azerbaijan, Cuba, Laos, Niger, Paraguay, Uganda, Equatorial Guinea, Georgia, Yemen, Zimbabwe, Bangladesh, Israel, Philippines, Colombia, Egypt, Vietnam, Ecuador, Honduras, Nicaragua, Sri Lanka, Mali, Peru
Cluster 6	Argentina, Thailand, Indonesia, Mexico, South Africa	Argentina, Thailand, Indonesia, Mexico, South Africa
Cluster 7	North Korea, Venezuela, Nigeria, Uzbekistan, Pakistan, Iran, Saudi Arabia	<u>Kazakhstan</u>, North Korea, Venezuela, Nigeria, Uzbekistan, Pakistan, Iran, Saudi Arabia

Host countries which were moved to other clusters by the k-means method are underlined.

Ward is chosen, because it is considered to result in a very good cluster structure if the expected clusters are relatively equivalent in size and outliers are excluded from the data (Backhaus et al. 2003).

[91] The Ward-algorithm is sometimes also labelled „Increase in sum of squares“, “Within-group sum of squares” or “Error sum of squares”. It requires a proximity matrix of squared euclidian distances.

By applying a bootstrapping method, in a third step it will be checked which tree partitions are significantly different from random.[92] The 7 and 8 cluster solution are the only ones deviating significantly from randomness. The 7 cluster solution of the Ward method[93] is used as the starting partition for a cluster analysis using the k-means method.[94] Contrary to hierarchical clustering methods as Ward, k-means belongs to the partitioning cluster methods which sort the cases in a series of iterations until converging to a stable partition of k clusters. The comparison of cases in the k-means method is based on the squared euclidian distance of the case to the cluster centers. If a case is found to be nearer to a cluster it is not part of, it will be moved to this cluster until all the cases are in their nearest cluster. As k-means is able to identify a very good cluster structure if a good starting partition and the cluster number are known, it can be used to 'calibrate' the results of the Ward method.

Table 4-2 summarizes the cluster memberships of host countries for the Ward and the k-means method. Host countries which were moved to another clusters by the k-means method are underlined.

The last step of the cluster analysis is the most challenging one, namely the interpretation of the clusters found. In the following, I will only look at the results obtained by the k-means method. Analyzing cluster centers, shown in Table 4-3, gives a first impression of the main characteristics of each group.

Table 4-3: Cluster means (k-means) and exemplars

	CDM capacity	Mitigation potential	Investment climate	Exemplar
Cluster 1	-0,650	-0,452	-0,128	Senegal
Cluster 2	-0,856	-0,319	1,494	Bahrain
Cluster 3	-0,982	-0,216	-1,749	Libyan Arab.Yam.
Cluster 4	1,096	-0,314	1,202	Panama
Cluster 5	0,823	-0,159	-0,203	Cuba
Cluster 6	1,654	3,169	0,421	South Africa
Cluster 7	-0,564	1,789	-0,533	Venezuela

As the data was standardized for the cluster analysis, the mean over all countries is zero. Therefore, negative values show that a variable in the respective cluster has a significant lower mean than in the total population and vice versa. Now, each cluster can be broadly described in a qualitative manner, as done in Table 4-4, with the first term indicating a

[92] This is a standard procedure included in CLUSTAN. For details see Wishart (2004).

[93] The 7 cluster solution is selected because it is characterized by a clear increase in the fusion coefficient which can be illustrated by an "elbow" in the inverse scree plot.

[94] For more details, see Bacher (2002), Mucha (1992), Aldenderfer and Blashfield (1984)

group´s characteristic as compared to the mean over the whole data set (based on Table 4-3), and the term in brackets expressing the absolute range given in each cluster. The ranges included in Table 4-4 show that there can be a considerable variance in each cluster which is important regarding the homogeneity of the clusters obtained. For the interpretation of the clusters, not only the mean but also the variance will have to be taken into account.

Table 4-4: Cluster characteristics

	CDM capacity		**Mitigation potential**		**Investment climate**	
	Mean compared to average	Range in cluster	Mean compared to average	Range in cluster	Mean compared to average	Range in cluster
Cluster 1	Low	No - low	Low	Very low - low	Bad	Very bad - bad
Cluster 2	Low	No - low	Low	Very low - low	Very good	Good - very good
Cluster 3	Low	No - low	Low	Very low - low	Extremely bad	Extremely bad
Cluster 4	High	Medium - very high	Low	Very low - high	Very good	Good - very good
Cluster 5	High	Medium - very high	Low	Very low - high	Bad	Very bad - medium
Cluster 6	Very high	High - very high	Extremely high	Very high– extremely high	Good	Very bad – good
Cluster 7	Low	No – medium	Very high	High – extremely high	Bad	Very bad - good

In order to test the homogeneity of the clusters, F-values are calculated for each variable and each cluster based on the following formula:

$$F = \frac{V(J,G)}{V(J)}$$

with V(J,G) representing the variance of variable J in group g, and V(J) the variance of variable J over all cases. Values smaller than 1 indicate that the cluster can be considered to be homogenous (Backhaus et al. 2003). Table 4-5, which includes the respective F-values, shows that only in cluster 6 there is a doubt about cluster homogeneity regarding the mitigation potential.

Table 4-5: F-values for each cluster and variable

	CDM capacity	Mitigation potential	Investment climate
Cluster 1	0.16456583	0.0317284	0.17425392
Cluster 2	0.18697479	0.10517629	0.13606474
Cluster 3	0.14355742	0.17311233	0.42185129
Cluster 4	0.34663866	0.17472665	0.24127466
Cluster 5	0.22969188	0.23779605	0.17298938
Cluster 6	0.21008403	1.21960878	0.41401113
Cluster 7	0.55042017	0.87168136	0.47824987

In the following, I will analyze and interpret each cluster separately with the aim to classify countries regarding their attractiveness for future CDM non-sink investment.

Cluster 1 is characterized by rather low institutional CDM capacity, low mitigation potential and a relatively bad investment climate. Consequently, it is to be expected that the countries in cluster 1 will not be able to attract any significant CDM (non-sink)[95] investment flows. Therefore, this group can be labelled as *very unattractive for (non-sink) CDM*. The majority of the countries belonging to this group are located in Africa (e.g. Mauritania, Ivory Coast, Ethiopia, Kenya, Tanzania). Some Eastern European countries (e.g. Albania, Macedonia), as well as Syria, Nepal, Papua New Guinea and Kyrgyzstan are part of this group as well.

Cluster 2 includes those countries which are characterized by low institutional CDM capacity and mitigation potential, but which – contrary to cluster 1 – have a very good investment climate. Of the 10 countries in this group, half belongs to the Arabian oil exporting countries (e.g. Bahrain, Kuwait, Qatar, United Arab Emirates), while the others are spread over the whole globe (Bahamas, Tunisia, Botswana, Cape Verde, Brunei). In spite of their good investment climate, these countries can be considered not very promising CDM host countries, since no climate project related conditions are given. As OPEC is not supporting the international climate regime in general, the OPEC member states[96] will probably not play a significant role in the CDM at all. This, however, may change if OPEC countries realize that significant revenues can be generated through CDM projects; a first indication is the rapid ratification of the Kyoto Protocol by a number of OPEC countries after Russian ratification ensured its entry into

[95] Countries with bad investment climate and a low institutional CDM capacity are likely to attract as little investment in LULUCF as in non-sink projects, since these two criteria will count for the investment in LULUCF projects as well.
[96] United Arab Emirates, Kuwait and Qatar

force. From the above, it can be concluded that cluster 2 will as well join the coalition of host countries which are *very unattractive for (non-sink) CDM* investments, but that some of these countries may move into Cluster 4 in the near future.

The 12 countries forming Cluster 3 are characterized by a low institutional CDM capacity, low mitigation potential, and an extremely bad investment climate. This group comprises countries of Northern, Western and Central Africa (e.g. Algeria, Liberia, Congo, Sudan) as well as countries like Haiti, Tajikistan and Turkmenistan. There are few chances that any of the countries in this group will play a significant role in the CDM market, although, some of the countries would offer some mitigation potential (e.g. Algeria, Iraq). Therefore, countries in cluster 3 can be considered to belong to the *very unattractive (non-sink) CDM* host countries as well.

Cluster 4 includes countries with a medium to very high CDM capacity, and a (very) good general investment climate. However, the majority of the countries have a rather small mitigation potential, although the cluster includes as well some countries which are characterized by higher greenhouse gas emissions (Chile, Malaysia and Morocco). The small mitigation potential of most of the countries in this cluster can be explained by the fact that most of them are very small (e.g. Belize, Antigua and Barbuda, Uruguay, Panama, Costa Rica, Trinidad and Tobago, Jordan, Mauritius, Maldives). In general, host countries in cluster 4 can be rated as *attractive for CDM* (non-sink) investors. As front-runner, they are likely to attract a considerable share of the early CDM investment, as it has been the case for Costa Rica in the Activities Implemented Jointly (AIJ) phase. Due to their size, however, they will not be able to provide a big portion of CDM credits in the world-wide market in the long run.

Cluster 5 is very similar to cluster 4 regarding institutional CDM capacity and mitigation potential, with the difference that most of the host countries in this group offer a worse investment climate than countries in cluster 4. Egypt is an exception and cannot be clearly distinguished from cluster 4. Members of this group are located in Latin America (e.g. Colombia, Guatemala, Ecuador, Peru, Nicaragua, Paraguay), in Africa (e.g. Mali, Niger, Uganda), and South East Asia (Laos, Philippines, Vietnam). Furthermore, countries like Yemen, Jamaica, Israel, Armenia, Azerbaijan, and Georgia are part of cluster 5 as well. Only a *limited attractiveness for non-sink CDM projects* can be assigned to this group, although some individual countries might offer a greater potential than others. Vietnam and Egypt, for example, appear to be the most promising CDM (non-sinks) countries in this group.

The relatively small cluster 6 comprises the 5 countries Argentina, Indonesia, Mexico, South Africa, and Thailand. Based on the cluster means, these countries are 'CDM-stars', with extremely high CDM capacity, exceptionally high mitigation potential and a good investment climate. When looking at the data for each country, the doubt about the homogeneity of the cluster regarding the mitigation potential can be ruled out. The exceptionally high values for Indonesia, Mexico and South Africa can explain the problematic F-value. Therefore, the values allow a consistent interpretation of the cluster regarding the mitigation potential. Nevertheless, regarding the investment climate, Indonesia is clearly identified as a negative outlier in the group. In summary, the countries in this group can be described as *very promising CDM (non-sink) countries,* keeping in mind, though, that Indonesia's attractiveness might be hampered to some extent by its relatively bad investment climate.

The common feature of host countries in cluster 7 is mainly their extremely high mitigation potential, while values for the institutional CDM capacity and the investment climate vary considerably. Although investors might find a good potential for CDM (non-sink) projects in these countries, they will probably be deterred either by a very bad investment climate or a very low CDM capacity. Due to the latter, host countries in cluster 7 are considered *unattractive for CDM (non-sink) projects*.

Last but not least, the three countries (China, India, and Brazil) which had been excluded from the data set as outliers are mentioned as well. These three countries are characterized by an exceptionally high mitigation potential, a good institutional CDM capacity and a good investment climate, and are known to be the *most promising CDM (non-sink) host countries*.

Resulting from the above, four main groups of host countries for CDM non-sink projects can be identified: countries which are very unattractive, countries which are attractive to a limited extent, attractive countries, as well as very attractive countries. The attractiveness of CDM host countries as represented by the respective clusters is summarized in Table 4-6.

Table 4-6: Clusters regarding their attractiveness as CDM (non-sink) host countries

	Very unattractive	**Attractive to a limited extent**	**Attractive**	**Very attractive**
Clusters	Cluster 1 Cluster 2 Cluster 3 Cluster 7	Cluster 5	Cluster 4	Cluster 6, China, India, Brazil

In the interpretation of clusters, I already mentioned the case of Egypt which would fit as well to cluster 4, but has been included in cluster 5 by the cluster analysis. In real world data, there always exist cases which cannot be clearly attributed to one group. It is, therefore, an essential part of the interpretation of the cluster analysis to point out which of the elements are not clearly attributable to one cluster only.

Table 4-7 shows the cases which are very similar to another cluster[97] and denotes if this 'instability' has consequences for the above host country attractiveness classification (as illustrated in Table 4-6). 19 cases could be identified as being very close to the mean of another cluster.

Table 4-7: Countries not clearly attributable to one cluster and effect on their classification

Country	Member of cluster	Not clearly distinguished from cluster	Affects classification of attractiveness
Benin	1	2	No
Bolivia	4	5	Yes
Bosnia and Herzeg.	1	3	No
Cape Verde	2	1	No
Chad	1	3	No
Egypt	5	4	Yes
Guinea-Bissau	3	1	No
Israel	5	4	Yes
Jamaica	5	4	Yes
Kazakhstan	7	1	No
Kenya	1	3	No
Lesotho	1	2	No
Morocco	4	5	Yes
Philippines	5	4	Yes
Rwanda	1	3	No
Seychelles	1	2	No
Turkmenistan	3	1	No
Uzbekistan	7	5	Yes
Vietnam	5	4	Yes

The countries Benin, Lesotho and Seychelles, and Cape Verde appear to lie somewhere between cluster 1 and cluster 2. As both clusters include very unattractive CDM host countries, this instability does, however, not change our host country classification. The latter applies as well to the border cases between cluster 1 and 3 (Bosnia and

[97] Defined as the distance to its nearest cluster being smaller 0.25 than the distance to any of the other clusters.

Herzegovina, Chad, Guinea-Bissau, Kenya, Rwanda, and Turkmenistan) and cluster 7 and 1 (Kazakhstan). Nevertheless, in some of the cases host country attractiveness might be estimated wrongly if only relying on the cluster membership as given by the k-means method. As already noted above, ranges in cluster 4 and 5 are relatively big, which hinders the interpretation of the CDM attractiveness of host countries in these clusters. The 7 countries that could belong as much to cluster 4 as to cluster 5 are either the less attractive cases of cluster 4 (Bolivia, Morocco) or the rather promising cases of cluster 5 (Egypt, Israel, Jamaica, Philippines, Vietnam). Uzbekistan, although being a member of the very unattractive group 7, seems to stick out from this group due to its tendency to belong to the countries which are attractive to a limited extent.

Figure 4-1 illustrates the classification of host countries by mapping countries according to their attractiveness for CDM non-sink investment. Thus, it provides a first picture of a likely geographical distribution of future CDM (non-sink) investment flows. The darker the color, the more attractive a country can be considered for non-sink CDM investment. The unstable cases, whose classification is affected by their instability, are presented separately (striped grey). [98]

The fact that relatively big countries belong to the category of the very attractive non-sink CDM host countries can be explained by the use of absolute greenhouse gas emissions as an indicator for mitigation potential. However, it is to be expected that a range of smaller countries (e.g. Costa Rica, Chile, Trinidad and Tobago) will be quite attractive for CDM non-sink investments as well. As mentioned above, they will probably be able to reap a significant benefit from the CDM especially in the early phase of the market.

Furthermore, it has to be noted, that all the very attractive host countries, with the exception of South Africa, are located either in Latin America or Asia (mainly Central, East, South and South East Asia). Most of the host countries in Western Asia, and especially in Africa, do not seem to be very promising CDM candidates.

Assuming that future CDM (non-sink) investment flows will be directed mostly towards the host countries which have been classified as attractive and very attractive, it is likely that a relatively small proportion of all potential host countries will receive most of the CDM investment in the market. Furthermore, it can be expected that the geographical distribution of CDM flows will be concentrated in certain regions or even countries.

[98] Results of the classification for each country are also presented in the Appendix.

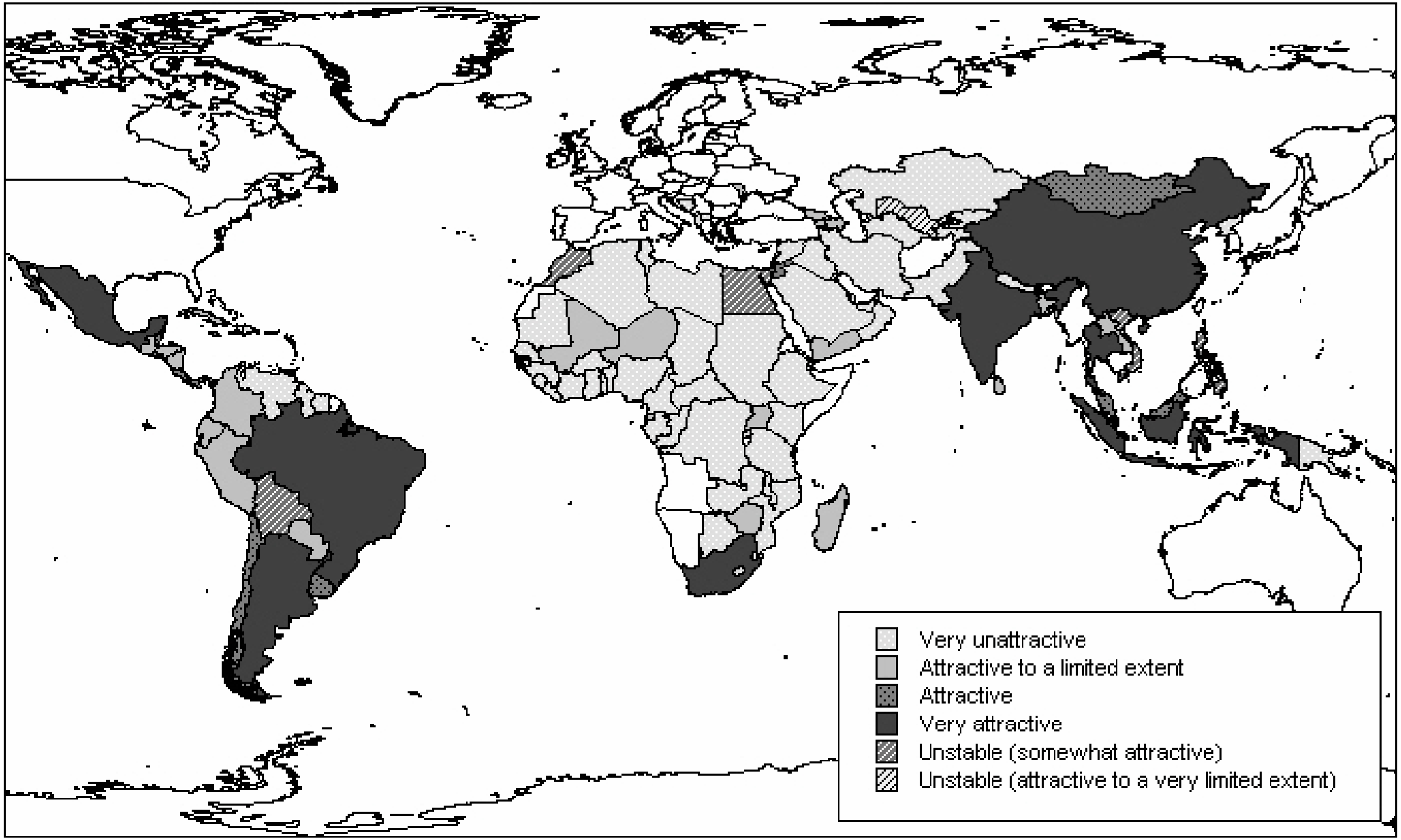

Figure 4-1: Map of the resulting host country classification

Moreover, the results suggest that the simplistic assumption of CDM following the same paths as traditional FDI flows, is a relatively good approximation - at least for those countries with the highest FDI attractiveness. From the countries included in the present analysis, China, India, Malaysia, Brazil, Thailand, Mexico and Indonesia are the developing countries with the highest FDI confidence index in 2004 (Kearney 2004). With the exception of Malaysia, all of these countries are as well classified as the most attractive CDM host countries.

4.4. Current CDM project status

Being aware that the current distribution of CDM investment cannot be considered representative of the one in a mature market, it is still worth having a look at the current status of CDM projects with the CDM Executive Board. Figure 4-2 shows the expected amount of CERs generated from CDM projects by 2012 available for validation comments[99] on the UNFCCC CDM website by 10 February 2005. Assuming that the amount of CERs is positively correlated to the amount of investment in the respective project, Figure 4-2 can give an indication to which extent early CDM (non-sink) investment are compatible with my classification of host countries.

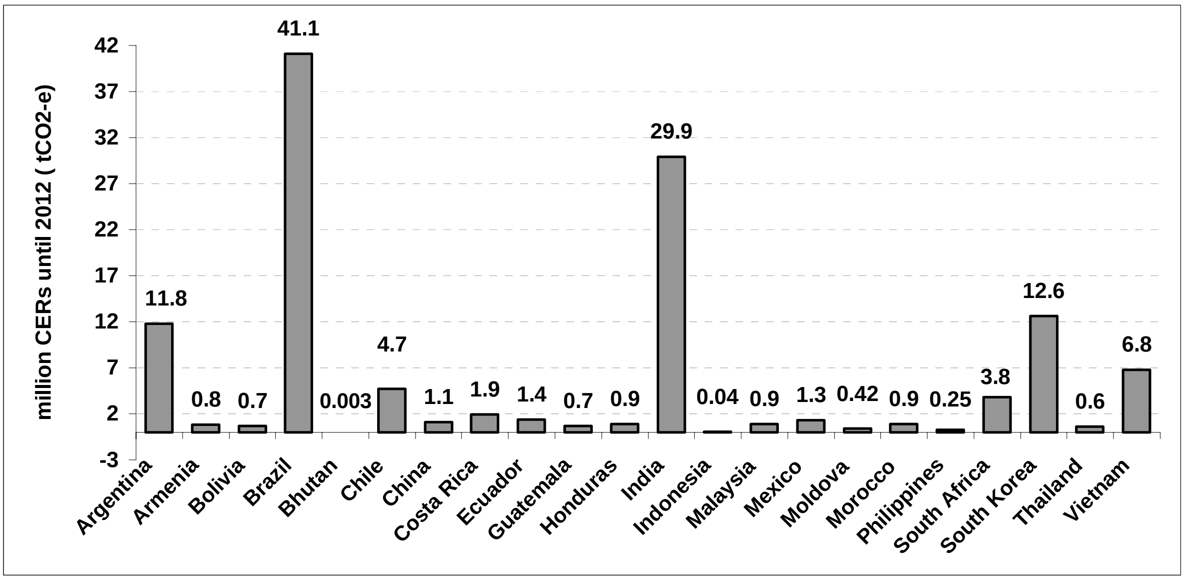

Figure 4-2: Expected amount of CERs generated from CDM projects by 2012 available for validation comments on the UNFCCC CDM website (10 Feb. 2005)

The countries with the biggest amount of CERs from non-sink CDM projects in the first commitment period are Brazil, India, South Korea and Argentina. While South Korea - a

[99] Includes submitted projects, those under review as well as registered ones.

potentially very important host country - was not included in the present analysis, the other three have all been classified as very attractive host countries. China, Mexico, South Africa, Thailand and Indonesia are lagging behind as compared to their 'CDM host country attractiveness'. However, only the fact that they belong to the first 22 countries with CDM projects at the current stage, is an indication that their attractiveness for CDM non-sink projects is considerable.

Three of the smaller countries classified as 'attractive' (Chile, Costa Rica, Malaysia), as well as four of the 'somehow attractive countries' (Bolivia, Morocco, Philippines, Vietnam) are also participating in the first phase of CDM project proposals. The remaining countries Armenia, Bhutan, Ecuador, Guatemala, Honduras and Moldova are all classified as countries 'attractive to a limited extent', with the exception of Bhutan which was not included in the present analysis. This very first CDM project data shows quite some correspondence with the cluster analysis results. It has to be kept in mind, though, that we are in a very early phase of the CDM market. The few projects submitted so far can just give an indication, but cannot necessarily be considered representative of what a future distribution of CDM projects might look like.

4.5. Policy implications

The expectation that it might only be relatively few host countries receiving most of the CDM (non-sink) investment flows is not compatible with the above mentioned claim for an equitable geographical distribution of CDM project activities in the Marrakech Accords.[100]

Rules and modalities of the Kyoto Protocol like the exemption of CDM projects in least developed countries (LDCs) from the adaptation levy as well as the rules for small scale CDM projects aim at rendering CDM projects in less attractive host countries more attractive. However, it cannot be expected that they will considerably change the distribution of CDM investment flows. Measures like the improvement of the general investment climate are more long-term measures and more a development than a climate policy issue.

Consequently, of the three variables included in the cluster analysis only the improvement of the CDM institutions and capacity by capacity building will be an appropriate measure available to climate policy for promoting a more equal distribution

[100] I am neglecting here, that my results are only valid for non-sink projects. Nevertheless, the overall distribution of CDM projects is unlikely to be distributed in a more equal manner than the results suggest for non-sink CDM projects.

of CDM activities.[101] It has to be questioned, though, whether CDM capacity building makes sense in all cases. For host countries with a considerable mitigation potential and an acceptable investment climate, CDM capacity building will be promising in order to make these countries more attractive for private CDM investment. Countries whose mitigation potential is very small will, however, not necessarily turn into attractive host countries if they build up a good institutional CDM capacity.[102]

When focusing only on the general investment climate, an increase in the CER price[103] appears to be another appropriate 'tool' to achieve a more equitable distribution, since it will be able to compensate the higher risk of countries with rather bad investment climate, thus increasing investment into less attractive countries. However, this argument might not be as straightforward as it seems at first sight. With higher prices investors might as well prefer more costly options in already experienced and less risky host countries which could lead to a further geographical concentration of CDM investment.

The above discussion leads to the conclusion that it is rather against the general principle of a market-based tool like the CDM to result in an equal geographical distribution of projects. Measures taken will probably be able to decrease the concentration of projects in certain countries and regions to a small extent, but will not solve the problem entirely. Considering that the CDM is a market-based tool, it might be more appropriate to ask for an equal distribution of CDM opportunities, rather than CDM project activities.

4.6. Advantages and limits of the approach chosen

Finally, I would like to discuss the strengths and weaknesses of the approach I have chosen for the present analysis. As it was the goal to include as many host countries in the analysis as possible, relatively few and rough indicators had to be used. So is for example non- CO_2 emission data for developing countries subject to relatively great uncertainties. Moreover, the indicator for CDM capacity is only capable to a limited extent of measuring the quality of institutions. More details on the quality of CDM institutions can only be investigated by country case studies which are, however, currently available for few countries only.

Furthermore, relatively little is known on the relative importance of factors influencing CDM investment. In the present study, therefore, an equal weight of the three

[101] For details on the capacity building activities having taken place so far, see Michaelowa (2004).

[102] There might be even cases, where the costs of such capacity and institution building will by far outgrow any future CDM inflows.

[103] For example due to strict targets in a second commitment period.

dimensions is assumed. Additionally, further factors, e.g. host country climate project experience, might play a role for investors' decisions in the future as well. However, the three selected indicators cover the most important dimensions of host country attractiveness. Host country ratings include similar dimensions, but are limited on the most promising host countries so far. An advantage of cluster analysis over rankings is as well that it uses a known concept for classifying host countries, thus making the classification rule explicit. It has to be emphasized, though, that it is not free of subjectivity, as the researcher´s choice on the variables to be included and the fusion algorithm to be used will influence the results. Therefore, host country ratings and a classification approach as the one chosen in the present analysis can be considered complementary tools, both with their own strengths and weaknesses.

4.7. Summary and conclusion

The present study uses cluster analysis for the classification of 114 potential CDM host countries based on their attractiveness for CDM non-sink projects. The three dimensions of host country attractiveness considered are the mitigation potential, the institutional CDM capacity and the general investment climate. Based on the combination of the three latter factors four levels of attractiveness are identified, and countries are classified according to their cluster memberships. Those cases which are very close to two clusters are classified separately as unstable cases.

The results suggest that the CDM investment in non-sink projects will be concentrated in rather few countries. The CDM (non-sink) stars are China, India, Brazil, Argentina, Mexico, South Africa, Indonesia and Thailand.[104] They are followed by a number of smaller attractive countries like Costa Rica, Trinidad and Tobago, Mongolia, Panama, and Chile. These smaller countries are likely to reap a significant benefit from the CDM especially in the early phases of the market. Costa Rica´s role as a front-runner in the AIJ phase can be seen as an analogy to their potential importance in the early CDM market. The big countries (e.g. China) will probably take over at later stages if they succeed in shaping their institutional CDM structures well. It will be, therefore, vital for the smaller attractive countries to build flexible CDM institutions which avoid high long-term fixed costs.

While most of the promising CDM host countries are located in Latin America and Asia, the general attractiveness of African host countries is relatively low (with the exception of South Africa). It is not expected, that the inclusion of forestry projects in the CDM

[104] South Korea, not included in this analysis, is very likely to also belong to this group.

will improve this inequitable geographical distribution.[105] Therefore, policy implications of these results are addressed. One measure available to climate policy for the promotion of a more equal geographical distribution of CDM project activities - as asked for by the Marrakech Accords - is a well coordinated and planned CDM capacity building in host countries. In the short run, capacity building might contribute to mitigating the problem, without being able to solve it entirely. However, since the CDM is a market-based tool, it is more appropriate to ask for an equal distribution of CDM opportunities rather than CDM project activities.

[105] However, the inclusion of CDM forestry projects will increase CDM investment in the Latin American countries.

Appendix

Table 4-8: Host country classification

<table>
<tr><th>Very attractive</th><th>Attractive</th><th>Attractive to a limited extent</th><th>Very unattractive</th></tr>
<tr><td>Argentina</td><td>Antigua and Barb.</td><td>Azerbaijan</td><td>Algeria, Albania</td></tr>
<tr><td>Brazil</td><td>Belize</td><td>Armenia</td><td>Bahrain, Botswana</td></tr>
<tr><td>India</td><td>Chile</td><td>Bangladesh</td><td>Bahamas</td></tr>
<tr><td>Mexico</td><td>Costa Rica</td><td>Sri Lanka</td><td>Bosnia and Herzegovina</td></tr>
<tr><td>South Africa</td><td>El Salvador</td><td>Colombia</td><td>Benin, Brunei</td></tr>
<tr><td>Thailand</td><td>Jordan</td><td>Cuba</td><td>Chad, Congo</td></tr>
<tr><td>China</td><td>Mongolia</td><td>Ecuador</td><td>Dem. Congo (Zaire)</td></tr>
<tr><td>Indonesia</td><td>Mauritius</td><td>Equatorial Guinea</td><td>Cameroon</td></tr>
<tr><td></td><td>Maldives</td><td>Georgia</td><td>Central African Republic</td></tr>
<tr><td></td><td>Malaysia</td><td>Guatemala</td><td>Cape Verde</td></tr>
<tr><td></td><td>Panama</td><td>Honduras</td><td>Dominican Republic Ethiopia</td></tr>
<tr><td></td><td>Trinidad and Tobago</td><td>Laos</td><td>Gambia, Gabon, Ghana</td></tr>
<tr><td></td><td>Uruguay</td><td>Madagascar</td><td>Guinea, Guyana</td></tr>
<tr><td></td><td></td><td>Moldova</td><td>Haiti, Iran</td></tr>
<tr><td></td><td></td><td>Mali</td><td>Ivory Coast</td></tr>
<tr><td></td><td></td><td>Niger</td><td>Iraq, Kenya</td></tr>
<tr><td></td><td></td><td>Nicaragua</td><td>Kyrgyzstan, North Korea</td></tr>
<tr><td></td><td></td><td>Paraguay</td><td>Kuwait, Kazakhstan</td></tr>
<tr><td></td><td></td><td>Peru</td><td>Lebanon, Liberia, Lesotho</td></tr>
<tr><td></td><td></td><td>Uganda</td><td>Libyan Arab.Yam., Malawi</td></tr>
<tr><td></td><td></td><td>Yemen</td><td>Macedonia, Mauritania</td></tr>
<tr><td></td><td></td><td>Zimbabwe</td><td>Oman, Mozambique</td></tr>
<tr><td></td><td colspan="2">Bolivia*</td><td>Nigeria, Nepal</td></tr>
<tr><td></td><td colspan="2">Egypt*</td><td>Suriname, Pakistan</td></tr>
<tr><td></td><td colspan="2">Israel*</td><td>Papua New Guinea</td></tr>
<tr><td></td><td colspan="2">Jamaica*</td><td>Guinea-Bissau</td></tr>
<tr><td></td><td colspan="2">Morocco*</td><td>Qatar, Rwanda</td></tr>
<tr><td></td><td colspan="2">Philippines*</td><td>Saudi Arabia, Seychelles</td></tr>
<tr><td></td><td colspan="2">Vietnam*</td><td>Senegal, Sierra Leone</td></tr>
<tr><td></td><td></td><td></td><td>Sudan, Syria</td></tr>
<tr><td></td><td></td><td></td><td>United Arab Emirates</td></tr>
<tr><td></td><td></td><td></td><td>Tajikistan, Togo</td></tr>
<tr><td></td><td></td><td></td><td>Sao Tome and Principe</td></tr>
<tr><td></td><td></td><td></td><td>Tunisia, Turkmenistan</td></tr>
<tr><td></td><td></td><td></td><td>Tanzania, Burkina Faso</td></tr>
<tr><td></td><td></td><td></td><td>Venezuela, Zambia</td></tr>
<tr><td></td><td></td><td colspan="2">Uzbekistan**</td></tr>
<tr><td colspan="4">* somewhat attractive, **attractive to a very limited extent</td></tr>
</table>

Chapter 5

On the Integration of Carbon Dioxide Capture and Storage into the International Climate Regime

5. On the Integration of Carbon Dioxide Capture and Storage into the International Climate Regime[106]

5.1. Introduction

The debate on the integration of carbon sequestration options into the climate regime has so far mainly focused on LULUCF. However, recently capture of carbon dioxide at large point sources and its subsequent storage in reservoirs - carbon capture and storage (CCS) - entered the political discussion. As CCS is unique in the sense that it does not avoid the formation but the emission of CO_2 into the atmosphere, the question arises if CCS is more similar to an emission reduction (at the source) or a removal activity (sink enhancement).

Moreover, if CCS is supposed to be implemented into the international climate regime, two issues have to be addressed: the possible non-permanence of storage as well as potential cross-border cases due to a geographical separation of capture and storage. The first part of this chapter discusses their implications for inventory and accounting practices. The second part addresses economic aspects of considering non-permanence of storage of CO_2 in geological reservoirs.

5.2. Carbon Dioxide Capture and Storage

The term 'Carbon Dioxide Capture and Storage' refers to the capture of CO_2, and its subsequent storage in reservoirs. CCS can be separated into three elements:

1. capture (including compression)
2. transport
3. storage

The most suitable sources for CO_2 capture are large point sources[107] such as industrial facilities or power plants.[108] In some industrial processes, CO_2 is separated from gas flows (hydrogen production, natural gas sweetening) in order to be able to continue downstream operations. Most of the separated CO_2 is vented into the atmosphere and only a small fraction is used in, for example, the food industry.[109]

[106] This chapter is based on Bode and Jung (2005).
[107] Ha-Duong and Keith (2002) and Lackner et al. (no year) have also proposed to capture CO_2 directly from the air, showing that this might become a feasible option in the future.
[108] OECD/IEA (2004) mentions the fuel extraction and transformation sector as an additional important emissions source where capture might be applied.
[109] Storage of CO2 due to utilization in the food and fertilizer industry results in very low retention times, though, and is therefore, not an important option for CCS.

The bulk potential for CO_2 capture, however, can be found in the power sector. Three processes are available for the capture of CO_2 from such large point sources (Thambimuthu et al. 2002, VGB 2004):

a. *Post-combustion capture*, in which the CO_2 is scrubbed from the flue gas.
b. *Pre-combustion capture*, in which the $CO_2$is removed prior to combustion by producing a hydrogen-rich fuel gas mixed with CO_2. The CO_2 is separated from the latter by physical absorption, while the hydrogen is used for combustion.
c. *Oxyfuel combustion* uses oxygen instead of air for combustion, resulting in a flue gas consisting mainly of water vapour and CO_2.

Additional energy use caused by the capture processes is referred to as the energy penalty, which can range from 15 – 40 percent of energy output (Haefeli et al. 2004). Prior to transportation, compression is generally required, resulting in additional energy use that is, however, much smaller than the penalty for capture.

Transport of CO_2 is a mature technology, as the technical requirements are similar to transporting other gases. Experience with CO_2 transport via pipelines already exists, especially in the USA where around 2800 km of pipelines are currently in place (Gale and Davison 2004). The alternative is to transport carbon dioxide by ship[110], especially if transport distances are longer or if the capture and storage site are separated by water (Wildenborg and van Meer, 2002).

After transportation, the CO_2 is injected into the storage reservoir, which can be either a geological reservoir or the ocean. Presently, only storage in geological reservoirs is seriously considered as a climate mitigation option (OECD/IEA 2004), and as such will form the focus of this paper. Three main groups of geological reservoirs can be identified:

a. Oil and gas reservoirs (depleted, or in combination with Enhanced Oil Recovery, EOR or Enhanced Gas Recovery, EGR)[111]
b. Saline aquifers
c. Unminable coal seams (possibly in combination with Enhanced Coal Bed Methane Recovery, ECBM)

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[110] Trucks and trains are also possible media of transport.

[111] While little experience exists with ECBM, EOR has already been applied for some decades to enhance oil production. Depending on the location, EOR is profitable today, especially when oil prices are high. Contrary to EOR, Enhanced Gas Recovery (EGR) is not yet technically mature or a commercially viable technology (OECD/IEA 2003).

The size of the reservoirs available is a major determinant with regard to the relevance of CCS as a mitigation option. Various figures have been published (Grimston et al. 2001, IEA 2001). However, the most detailed and most recent data are provided by Hendriks et al. (2004), and summarized in Table 5-1 below. .

Table 5-1: Storage potential (Gt CO2)

	Remaining Oil Fields	Depleted Oil Fields	Remaining Gas Fields	Depleted Gas Fields	ECBM
			Onshore		
Total Annex-1 *)	2,6 - 186,2	8,4 – 16,8	91,2 - 382	2,5 - 156,7	0 - 401,7
Total non Annex-1 *)	6,4 - 547,8	13,6 – 27,2	127,8 - 543	1,5 - 234,3	0 - 1078,3
Total	9 - 734	22 – 44	219 - 925	4 - 391	0 - 1480
			Offshore		
Total Annex-1 *)	0,6 - 67,2	6,1 – 32,6	38,3 - 412,3	13,6 - 20,5	10,4 - 374,1
Total non Annex-1 *)	2,4 - 240,8	13,9 – 74,4	110,7 - 365,7	6,4 - 11,5	19,6 - 706,9
Total	3 - 308	20 - 107	149 - 778	20 - 32	30 - 1081

*) Own calculation based on data from: Hendriks et al. (2004, p.28) (for example, Former S.U. may include both Annex I and non Annex I countries)

As can be seen from the table, there exists great uncertainty regarding the storage capacity. Global potential in geological reservoirs is in the range of about 476 to 5880 Gt CO2, with a best estimate of 1660 Gt. The geographical distribution of the possible storage capacity differs for different types of reservoirs. Saline aquifers seem to be distributed most evenly across the world, but also the distance to large amounts of point sources of CO_2 is of relevance. The bigger part of the world-wide storage potential seems to be located in the non Annex I countries of the UNFCCC.

When analyzing the costs of CCS as a climate mitigation option, the full chain, from capture to storage and monitoring has to be taken into account. The cost of CCS therefore, consists of:

$$C_{CCS} = C_{capture} + C_{transportation} + C_{storage} + C_{monitoring}$$

The largest part of CCS costs consists of capture costs, with values ranging from about 24 to 52 €/t CO_2-avoided (Hendriks et al. 2004, VGB 2004).[112] However, the costs for CO_2 capture per ton avoided vary with the plant characteristics and capture system

[112] However, whenever talking about costs in relation to the avoided emissions, the baseline plant used to calculate the emission reduction costs is of crucial importance. For detailed discussion of this issue see Anderson et al. (2003).

applied.[113] Significantly lower costs are only achieved in capture of CO_2 from ammonia and hydrogen production.

Transportation costs by pipeline vary with the transportation distance, the amount transported, the pressure of CO_2, landscape characteristics, pipeline diameter, and country regulations. Per 100 km pipeline, the cost estimates range from 1-6 €/tCO_2, with decreasing costs for larger throughputs (Hendriks et al. 2004; Freund and Davison 2002). The transport of CO_2 by ship vessels will be cheaper over longer transportation distances (Freund and Davison 2002).

Storage costs reported in the literature are mainly based on the technical investment to be made, notably the drilling of wells and operation costs. Hendriks et al. (2004) estimates costs for storage in aquifers, natural gas and empty oil fields at 1 to 11 €/tCO_2, varying with the depth and permeability, as well as the type of the storage reservoir. For EOR, the cost range is from -10 to 30 €/tCO_2, taking into account the revenues resulting from the enhanced fossil fuel production.[114]

Theoretically, possible combinations of the different capture, transport and storage options based on the cost estimates mentioned above, may range from profitable values of minus 3 to plus 106 €/t CO_2-avoided. The vast majority of options will probably be somewhere in the middle of this range. Further cost reductions require additional R&D. Learning effects seem to be limited, as the single components are already widely developed and deployed, rendering economies of scale less important (OECD/IEA 2004, p 78). Information on and experience with monitoring costs seems to be very limited.

5.3. Permanence of storage

Apart from the technical and economic potential, the issue of the non-permanence of storage is also relevant for the implementation of CCS as a mitigation option.

The term non-permanence describes the likely releases of CO2 after capture has taken place. Figure 5-1 illustrates possible emissions along the whole chain of CCS, which will have to be accounted for when integrating CCS into the international climate regime. In the following, however, we are focusing on emissions from the reservoir.

While some experts consider seepage rates in well-selected geological reservoirs very low (DTI 2004), it is still difficult to predict these rates from long-term storage of very

[113] Costs per ton avoided include the costs of the energy penalty. They are, thus, greater than the costs per ton captured. The literature costs is extensive. see for example OECD/IEA (2004), Audus 2000, Condorelli et al. (1991), Herzog (1999), David and Herzog (2001), Freund and Davison (2002), Göttlicher and Pruschek (1999), Reimer et al. (1999), Rubin and Rao (2002), Simbeck (1999), and Smelser (1991).
[114] Further storage cost estimates can be found in e.g. Gupta et al. (2002), Hendriks et al (2001), Reeves and Schoeling (2001), Smith et al. (2001), as well as Wildenborg and Van der Meer (2002).

large volumes of CO_2 (OECD/IEA, 2004, p. 94 - 97). Storage site integrity depends on various factors, like the geological characteristics of the reservoir, the history of human usage, and the quality of well and sealing packages (e. g. Jimenez et al., 2003). The retention time of CO2 is therefore site specific.

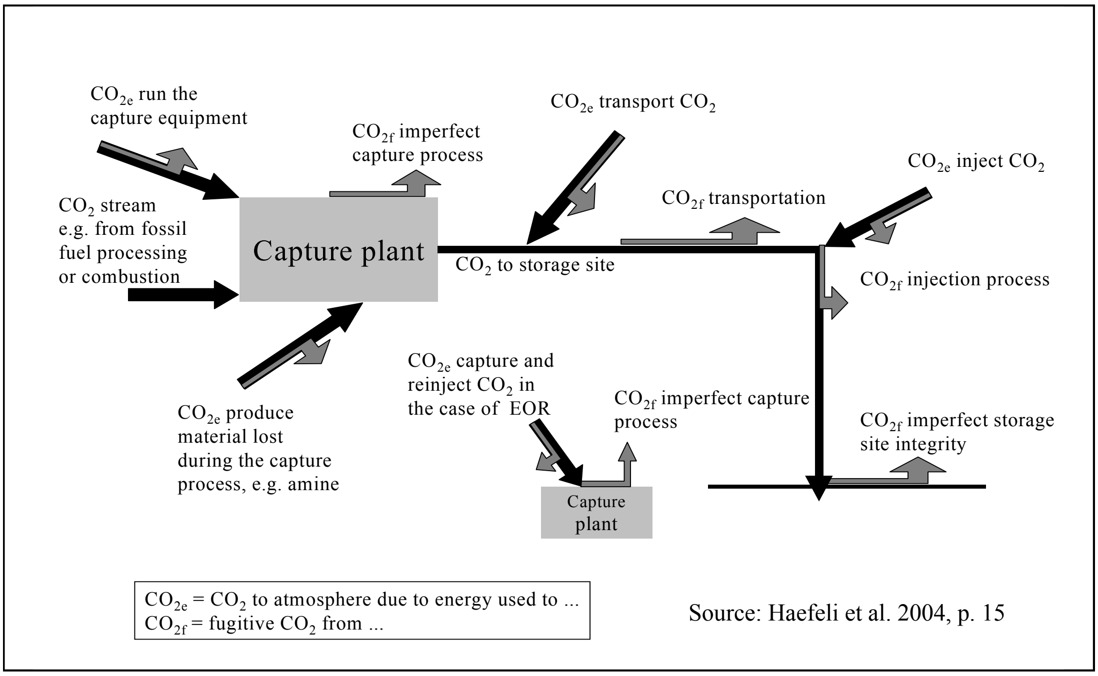

Figure 5-1: Possible emissions of the CCS chain

Furthermore, unforeseeable events like earthquakes could lead to the rapid release of larger volumes of CO2 from the reservoir. Strict criteria for site selection could be seen as one means of guaranteeing the high environmental integrity of geological storage (Haefeli et al. 2004). We consider such criteria a necessary, but not a sufficient condition for the integration of CCS into the international climate regime. They do not guarantee the complete accounting of emissions, which is one of the main principles of every greenhouse gas accounting framework (Haefeli et al. 2004). The fact that there is a possibility of non-permanence of storage makes it necessary to incorporate liability for future releases into the accounting scheme in order to guarantee that the burden relating to such potential releases cannot be shifted onto others.

5.4. Integration of CCS into the climate regime

5.4.1. CCS: removal or emission reduction

The special characteristic of CCS that results in the formation of CO_2 without its emission into the atmosphere, gives rise to the important question of whether CSS is dealt with as:

1. a removal (sink enhancement) or
2. an emission reduction (at source) activity.

The answer to this question to a great extent determines how CCS will be accounted for in the climate regime. When treating CCS as a *removal activity*, the captured CO_2 would have to be considered as emitted - even though not vented - into the atmosphere at the source, and would therefore appear as an emission in the national emission inventory. Any CO_2 stored would be accounted for as a removal of CO_2 - similar to the accounting of sequestration in the LULUCF area (Haefeli et al. 2004). Regarding the removal approach, it should to be noted that the term 'sink' is defined by the UNFCCC as "any process, activity or mechanism which removes a greenhouse gas, an aerosol or a precursor of a greenhouse gas from the atmosphere" (Article 1.8 UNFCCC). This legal definition does not apply to the process of CCS, since this option mainly refers to the capture of CO_2 from point sources and not from the atmosphere. Therefore, CCS has to be considered an emission reduction in the framework of the UNFCCC.[115] Thus, a change in the emission factor will have to account for the captured CO_2. The status of the discussion in the framework of the 2006 IPCC Guidelines for National Greenhouse Gas Inventories is that the captured CO_2 should be metered and subtracted from the source emissions. Emissions from transport and injection should be accounted for by the country where they occur by using estimates based on industrial experience. Site investigation, models and measurements are supposed to provide the estimates of releases from the storage site.[116]

5.4.2. CCS Cross-border projects

The fact that CCS is considered an emission reduction has implications regarding the characterisation of this activity under the flexible mechanisms. An overview is given in Table 5-2. All the cases where capture (the emissions reduction) takes place in a non-Annex I country (case 3, 5 and 6 in Table 5-2) fall under the CDM. In these cases, emission reduction credits would be generated.[117] Regardless of where the CO_2 is stored, projects with capture in an Annex I country (case 1, 2 and 4 in Table 5-2) can be considered Annex I mitigation, either conducted as domestic mitigation or as a JI project.[118] Those CCS activities in which CO_2 is stored in an Annex I country (cases 1-3)

[115] Biomass combustion will have to be dealt with differently.

[116] This information is based on a presentation at the Side Event "2006 IPCC Guidelines for National Greenhouse Gas Inventories, held by Simon Eggleston, 20 May at the SB Meeting in Bonn.

[117] For further detail on this, see the analysis below.

[118] Regarding of JI, a third Annex I country in which CO2 is neither captured nor stored, could be part of the project buying the emission reduction units. The country in which the emission reduction takes place is

account for the possible non-permanence of storage. Seepage from the reservoir will appear in the national emissions inventory of the storing Annex I country. A new inventory category would have to be introduced for such purposes.

Table 5-2: Possible combinations of capture and storage countries and resulting type of mechanism under the Kyoto-Protocol

Case	Capture	Storage	Type of mechanism
1	Annex I (same as storing country)	Annex I country	Annex I mitigation*
2	Annex I (other than storing country)		Annex I mitigation*
3	non- Annex I country		CDM
4	Annex I	non- Annex I country	Annex I mitigation*
5	non- Annex I ((same as storing country)		CDM
6	non- Annex I(other than storing country)		CDM

*Annex I mitigation can either be domestic mitigation or JI.

However, as non-Annex I countries do not have emission targets, possible seepages from the reservoir located in non-Annex I countries will not be subtracted from the emissions budget of whatever country.[119] Thus, the overall emissions budget of the Annex I countries might be inflated and environmental integrity of the climate regime endangered.

5.4.3. Dealing with liability for non-permanence in non-Annex I countries

In order to account for the non-permanence in the case of storage in non-Annex I countries, three different solutions are possible.

1. Ban on CCS with storage in non-Annex I countries
2. Consideration of seepages by discounting
3. Creation of rules that account for actually occurring releases

The first option of restricting CCS to projects with storage in Annex I countries[120] would, however, decrease the storage potential significantly. Furthermore, it may conflict with

always the capture country, which is likely to financially compensate the storing country for costs associated with storage (storage, monitoring, risks of later releases etc.).

[119] Similar problems occur if the country has not ratified the Kyoto Protocol or does not have sufficient inventory quality.

[120] Those Annex I countries which have ratified the Kyoto Protocol and comply with a minimum standard of inventory quality.

the objective of technology transfer to non-Annex I countries.[121] Another option is the discounting of emission reductions based on an assumed standard rate of seepage (see Haefeli et al. 2004). However, discount factors for seepages would have to be estimated ex ante for the whole time frame of storage.[122] At present, credible values for discounting are not available.[123] Another reason why discounting is problematic is that it is difficult to account for unforeseeable events or wilful releases.[124] If the discount factor acknowledges the possibility of these events or releases it is very conservative and thus provides little incentives to invest in CCS. If, on the other hand, the discount factor is low and thus provides incentives, it cannot include the possible undesirable releases.

The third option mentioned above relies on a determination of releases from the reservoir by monitoring. Thus, the ability of monitoring technologies to quantify possible seepage events is an essential condition for creating such a liability framework. In the following section we will analyze in further detail, which rules in the framework of the international climate regime might be able to guarantee liability for releases from storage reservoirs located in non-Annex I countries. In outlining how liability for these releases could be established in the Kyoto Protocol, one has to distinguish between the CCS projects falling under Annex I mitigation (case 4) and those falling under the CDM (case 5 and 6). In case 4, as mentioned above, the emission reduction due to capture of CO_2 is accounted for by subtracting the captured CO_2 from the total CO_2 emissions formed at the source. Thus, the capturing Annex I country would have to be liable for possible emissions from the storage reservoir if it is exporting CO_2 into a non-Annex I country. Creating liability for emissions in the non-Annex I country could thus be seen simply as an inventory question.[125] Similar inventory issues have been discussed regarding the treatment of harvested wood products (HWP). Emissions from the

[121] See decision 5/CP.7 of the Marrakech Accords.
[122] For an overview of methods for the estimation of default factors and an outline of accounting rules, see Yoshigahara et al. (2004).
[123] DTI (2004) comes to the conclusion that "whilst a conservative approach to discounting could be adopted, based on estimates from some type of CO2 seepage scenario modelling, current constraints in the understanding of specific CO2 fluxes from potential storage reservoirs presents a barrier to setting credible rates"
For monitoring technologies available, see for example Pearce et al. (2004)
[124] Depending on the rule for liability, there might be incentives for reservoir operators in non-Annex I countries to release CO2 after "permanent" CERs have been issued and to subsequently refill the reservoir and to receive CERs again for the same reservoir.
[125] See also Haefeli et al. (2004), pp. 21-22

reservoir in the non-Annex I country could, for example, be included in the national emissions inventory of the capturing Annex I country.[126]

In the two CDM cases with storage in a non-Annex I country (case 5 and 6), liability has to be dealt with differently.[127] The buyer of the CERs resulting from a CSS project should remain liable for possible emissions. Therefore, expiring CERs[128] similar to those issued for CDM forestry projects could be one option for guaranteeing liability for the stored CO_2 in the framework of the international climate regime.

The respective mechanisms guaranteeing liability in each of the described cases are summarized in Table 5-3.

Table 5-3: Different CCS cases and respective mechanisms to guarantee liability for non-permanence of storage

Case[*)]	Capture - Storage	Mechanism	Rule guaranteeing liability
1 & 2	Annex I – Annex I	Annex I mitigation	Possible emissions appear in inventory of country storing CO_2
4	Annex I – non-Annex I	Annex I mitigation	Possible emissions appear in inventory of country capturing CO_2
3	non-Annex I – Annex I	CDM	CER issued, possible emissions appear in inventory of country storing CO_2
5 & 6	non- Annex I – non-Annex I	CDM	Temporary credits issued (buyer liability)

[*)] see Table 5-2

The above analysis shows that the way in which CCS is accounted for in the international climate regime is likely to depend largely on where capture and storage takes place. This suggests that the elaboration of rules and modalities for integrating CCS into the international climate regime is probably a complex task.

[126] This is similar to the 'Production approach' proposed for the consideration of HWPs which includes the emissions from the HWP pool in a non-Annex I country in the national inventory of the exporting Annex I country. For an overview of the HWP discussion, see UNFCCC (2003d).

[127] Issuance of permanent CERs is unproblematic if CO_2 is stored in an Annex I country (case 3).

[128] For forestry projects, two types of expiring credits exist (temporary CERS, tCERs and long-term CERs, lCERs). For more information on temporary credits for LULUCF, see Dutschke et al. (2004).

5.5. Economic implications of non-permanence of CCS

With the exception of EOR, CCS does not produce any additional income except for that generated by the credits for the CO_2 storage. Kallbekken and Torvanger (2004) compare the net economic benefit of geological storage at different levels of permit prices. However, when comparing costs with the benefits of CCS, the cost term must also include the costs of the non-permanence of carbon dioxide storage.[129] Therefore, in the following economic analysis, we apply the approach of temporary credits in the CDM to CCS.

In case of releases of CO_2, temporary credits have to be replaced by the country which has used them for compliance. We call the cost incurred to compensate for future releases of CO_2 replacement costs (RC). The replacement costs are equal to the discounted costs incurred for buying (permanent) credits on the market to compensate for future CO_2 releases.[130] Therefore, the benefit of temporary storage in economic terms lies in the postponement of the purchase of a permanent permit. Consequently, the value of temporary storage (V^{temp}) is equal to the value of a permanent emissions reduction (V^{perm}) minus the replacement costs[131]:

$$V^{temp} = V^{perm} - RC$$

With decreasing replacement costs, the value of the temporary credit will increase. Due to these additional costs related to the future releases of CO_2, any (temporary) CCS activity must be cheaper than permanent mitigation options by an amount equivalent to the replacement costs. Based on this concept, the value of temporary storage for different release and discount rates, expressed in a percentage of the value of a permanent emission reduction, is calculated (see Table 5-4). In the calculation, we assumed a stable price for (permanent) emission reduction credits.[132] While at low release and high discount rates, the value of temporary storage is almost equal to the value of permanent emissions reductions, high release rates and low discount rates lead to substantial decreases in the value of temporary storage. With permanent storage, the value of a temporary credit would, of course, be equal to the value of a permanent one.

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[129] For a detailed analysis on the effectiveness of carbon storage with a focus on non-permanence, see Herzog et al. (2003)

[130] See also Ha-Duong and Keith (2003).

[131] The value of temporary storage consists of the price obtained for the chain of temporary credits generated during the crediting period.

[132] When assuming e.g continously increasing prices in the future, the general tendency remains the same.

In spite of the fact that the temporary credits approach has only been proposed for cases 5 and 6, the results represented in Table 5-4 are, from an economic perspective, also valid for the other CCS cases.

Table 5-4: Value of temporary storage in a percentage of the value of (permanent) emission reduction, stable carbon price path

V^{temp}		Release rate (%)			
		0	**0.01**	**0.1**	**1**
Discount Rate (%)	**1**	100	98.8	90.6	48.5
	5	100	99.6	97.7	80.8
	10	100	99.7	98.7	88.0

As long as liability for future releases is guaranteed, either the capture country (as in case 4), or the storing country (as in cases 1, 2 and 3), has to incur the cost related to future releases from the reservoir. As release rates are expected to be rather low in most cases, it can therefore be concluded that the decrease in the value of temporary storage due to non-permanence is almost negligible for CCS in general.

For those CDM cases for which the temporary credits approach was proposed (cases 5 and 6), this conclusion is not generally valid. The assumption underlying such a calculation is that a CCS CDM project can generate temporary credits over an unrestricted period of time. However, the time for receiving CERs under the CDM, the so called crediting period, is currently limited. For energy projects, the maximum crediting period is 21 years, for forestry, 60 years.[133] While permanent CERs do not have to be replaced after the end of the crediting period, all temporary credits generated by forestry projects expire after the end of the crediting period. The latter is equivalent to the assumption that after 60 years, all the sequestered carbon is released into the atmosphere, even if it remains sequestered in the biomass thereafter. The special case of temporary credits with restricted crediting periods in the CDM will make temporary carbon storage less attractive since it reduces the value of temporary storage. The reason for such a pattern originates from the fact that crediting periods considerably shorter than retention times neglect a great part of the storage taking place beyond the crediting period. Therefore, the benefit from postponing the purchase of permanent credits can only be realised in part, as illustrated by Figure 5-2.

[133] The rules and modalities offer a choice between a non-renewable crediting period of (10) 30 and a twice renewable crediting period of (7) 20 years.

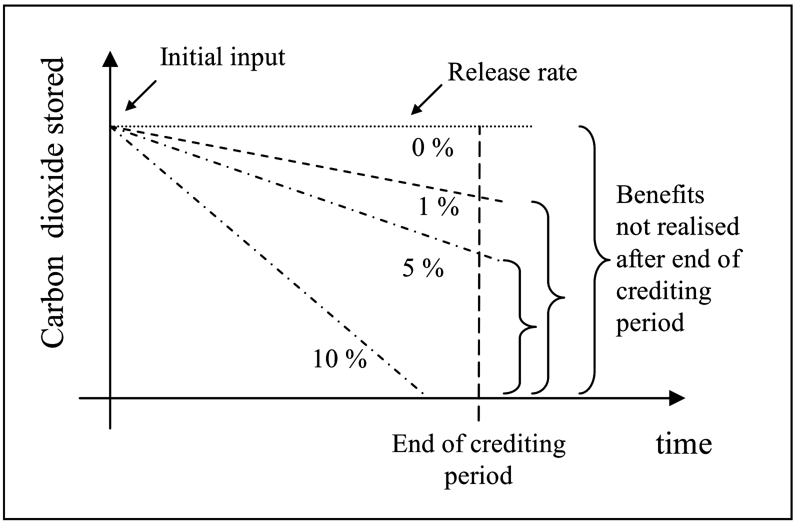

Figure 5-2: Effects of a limitation of a crediting period

In the case that also CSS CDM projects using temporary credits (case 5 and 6) should be subject to a limited crediting period, the value of temporary storage would be significantly smaller than for the other CCS cases. In the case of short crediting periods (e.g. 20-60 years), the economic viability of such CDM projects is going to decrease significantly as compared to those generating permanent credits.

5.6. Conclusion

Carbon dioxide capture and storage (CCS) does not avoid the formation, but the emission of CO_2 to the atmosphere. According to Art. 1.8 of the UNFCCC, CCS has to be considered an emission reduction. When integrating CCS into the climate regime, one has to however taken into account that there might be releases of the stored CO_2 back to the atmosphere and that CO_2 might be transported over country borders.

Based on the fact that CCS is an emission reduction, we conclude that all CCS projects with capture in a non-Annex I country fall under the CDM, while the projects capturing CO2 in an Annex I country could be considered Annex I mitigation (either domestic mitigation or JI), independently of where the CO_2 is stored.

When CO_2 is stored in an Annex I country that has ratified the Kyoto Protocol and complies with inventory quality standards, possible non-permanence of storage is accounted for as emissions from the reservoir. CO2 releases will enter the national emission inventory of the Annex I country in which the reservoir is located. As non-Annex I countries do not have emission targets, possible seepage from the reservoir located in non-Annex I countries will, however, not be subtracted from the emission budget of whatever country. Thus, it could water down the overall emission target of the climate regime. Therefore, special liability rules will have to be implemented for those cases in which CO_2 is stored in non-Annex I countries. In the case in which an Annex I country is exporting CO_2 to a non-Annex I country, a possible solution may be to have the Annex I country report emissions from the reservoir and include them in its own national emissions inventory. In the case of capture and storage taking place in a non-Annex I country, liability for the stored CO2 could be created by expiring credits, similar to those issued for forestry projects in the CDM.

If release rates from the storage reservoirs are as small as widely suggested (> 0.01), the cost incurred to compensate future releases can be expected to be negligible. It has to be noted however, that the economic viability of CDM projects that generate temporary credits and are subject to relatively short crediting periods can decrease significantly as compared to those generating permanent credits.

The present paper focused on two of the most important issues: accounting for releases from the reservoir and cross-border cases. Nevertheless, there are further issues which must be dealt with before CCS can be accounted for appropriately as a climate mitigation option. Accounting might become much more complicated than discussed, if different CO_2 exporting (capture) countries use the same storage reservoir, and if release rates are a function of the quantity stored. Transboundary reservoirs, too, may be difficult to deal with due to the territory principle underlying the Kyoto Protocol. Finally CO_2 stored in non-Annex I countries may become a contentious issue when emission targets for these Parties are negotiated in the future.

Regarding the numerous complexities of integrating CCS into the international climate regime, it has to be kept in mind that only accurate and complete accounting which guarantees the long-term liability for future releases, will allow CCS to become a credible mitigation option.

Chapter 6

Conclusion

6. Conclusion

The present thesis deals with carbon sequestration options in the international climate regime, with a focus on carbon sequestration in the terrestrial biosphere as well as carbon dioxide capture and storage.

Chapter 2 comprises a study of the negotiation process on LULUCF in the framework of the UNFCCC. This analysis combines qualitative background information with a quantitative approach to explain negotiating positions and behavior of Parties in the negotiations on LULUCF. A multinomial logit model is used to identify factors influencing the LULUCF negotiating position of countries. The results suggest that the most important reason for supporting the introduction of LULUCF in the calculation of emission targets has been the attitude towards international climate policy in general. Another, although less important, factor influencing the negotiation position regarding Article 3.3 and 3.4 is the amount by which Parties were able to reduce their already agreed emission target due to the introduction of LULUCF. The countries pushing for the inclusion of LULUCF under Article 3.3 and 3.4 were, however, not necessarily the countries with the most stringent targets. The factors influencing the positions on the inclusion of forestry projects in the CDM are more complex and less clear than the ones on LULUCF in Annex I inventories. A zero-inflated Poisson model is applied to examine which factors had an influence on the participation of countries in the submission process on LULUCF. Countries in favor of the inclusion of additional sink activities appear to have been more actively involved in the submission process on LULUCF, while the exact opposite seems to be the case for supporters of the inclusion of forestry projects in the CDM. Moreover, a positive but modest influence of the delegation size on the number of submissions can be identified. The results of this chapter can contribute to a better understanding of the role of carbon sequestration options in the negotiation of emission targets. It has to be emphasized, though, that this analysis aims solely at the identification of factors influencing negotiating positions and the participation in the submission process, but does not try to explain the outcome of the negotiations.

Chapter 3 examines the market effects of decisions taken in the negotiations dealt with in Chapter 2. It focuses on the inclusion of forestry projects in the CDM. Marginal carbon sequestration cost curves representing different LULUCF policy scenarios are developed and implemented into the partial equilibrium model of the international market for emissions offsets CERT. A sensitivity analysis is conducted in order to account for the uncertainties in the data on forestry potentials and costs. The results suggest that the reduction in the market price due to the inclusion of forestry projects in the CDM will be rather small in all the scenarios if compared to the effect of the withdrawal of the US and the hot air in the market. Furthermore, the distributional effects of making forestry an eligible CDM activity (in comparison to a purely energy-based CDM) are investigated and compared to the respective negotiating positions of Parties to the UNFCCC. While Annex B countries profit from the introduction of forestry in the CDM, non-Annex B countries lose or remain unaffected. A devaluation of the hot air held by Russia and the Eastern European countries is the reason for losses encountered by these countries due to the introduction of forestry in the CDM. Inside the non-Annex I group, income is shifted away from China and the Dynamic Asian Economies, while Brazil is the biggest winner of an introduction of forestry in the CDM. The distributional pattern is partly in line with country negotiating positions on LULUCF in the CDM. Brazil and the European Union, however, have been rejecting the integration of LULUCF in the CDM although they could benefit from it economically. This adds an additional aspect to the results obtained in Chapter 2, showing that country negotiating positions are only partly based on economic rationale, while political factors might weight more heavily for certain countries. An analysis based on sequestration cost curves as the one in Chapter 3 rests upon the underlying assumption that the amount of sequestration taking place is purely determined by the potential and its respective costs. However, other factors are likely to play a significant role for CDM investment flows as well. This aspect is taken into account in the following chapter.

In Chapter 4, a host country classification based on the attractiveness of CDM host countries is elaborated using cluster analysis. Not only the mitigation potential of a CDM host country is considered, but also the investment climate as well as the institutional CDM capacity are taken into account in the classification. Due to the lack of data on LULUCF potentials for the whole set of countries included in the study, the analysis is restricted to non-sink projects only. The resulting classification of host countries provides a first picture of what the distribution of CDM flows might look like. The results suggest that CDM investment in non-sink projects will be concentrated in rather few countries and regions. Of the countries included in the analysis, the CDM stars are China, India, Brazil, Argentina, Mexico, South Africa, Indonesia and Thailand. Some smaller countries like Costa Rica, Trinidad and Tobago, Panama and Chile are promising CDM countries as well. The smaller host countries are likely to reap a significant benefit from the CDM, especially in the early phases of the market. The big countries will probably take over at later stages if they succeed in shaping their CDM institutions well. The inequitable geographical distribution is unlikely to change considerably if forestry options in the CDM are considered as well. Climate policy has little means available to promote a more equal distribution of CDM projects, as it is asked for by the Marrakech Accords. Since the CDM is a market-based tool, however, it seems more appropriate to ask for an equal distribution of CDM opportunities rather than CDM project activities.

While the discussion on LULUCF in the context of the UNFCCC is quite advanced, the issue of whether and how to account for carbon dioxide capture and storage has entered the political debate only recently. Therefore, Chapter 5 deals with the integration of carbon dioxide capture and storage into the international climate regime. As CCS is different from LULUCF in the sense that it does not sequester carbon from the atmosphere but directly at the emission source, based on the UNFCCC sink definition, it will have to be dealt with as an emission reduction activity in the international climate regime. Inventory and accounting methods will have to consider that the captured CO_2 might be transported over country borders and be stored in a different country than the one where it has been captured. CCS projects with capture in a non-Annex I country fall under the CDM, while the projects capturing CO_2 in an Annex I country could be considered Annex I mitigation.

When CO_2 is stored in an Annex I country, possible CO_2 releases from the reservoir will enter the national emission inventory of the Annex I country in which the reservoir is located. As non-Annex I countries do not have emission targets, possible seepage from the reservoir located in non-Annex I countries will, however, not be subtracted from the emission budget of whatever country. Therefore, special liability rules will have to be implemented for those cases in which CO_2 is stored in non-Annex I countries. In the case in which an Annex I country is exporting CO_2 to a non-Annex I country, a possible solution may be to have the Annex I country report emissions from the reservoir and include them in its own national emissions inventory. In the case of capture and storage taking place in a non-Annex I country, liability for the stored CO_2 could be created by expiring credits, similar to those issued for forestry projects in the CDM.

If release rates from the storage reservoirs are as small as widely suggested (> 0.01), the cost incurred to compensate future releases can be expected to be almost negligible. It has to be noted however, that the economic viability of CDM projects that generate temporary credits and are subject to relatively short crediting periods can decrease significantly as compared to those generating permanent credits. This shows that implementation issues can determine to a great extent the costs and benefits of CCS and, therefore, exert a great influence on the role it might play as a mitigation option in the future.

The present thesis contributes to improving the understanding of carbon sequestration in the international climate regime. It goes without saying that it can only address a small selection of the issues relevant to carbon sequestration as a climate mitigation option.

One issue not dealt with explicitly is the argument that carbon sequestration options will fulfill a ‘bridging function’. This refers to the possibility to limit the increase in the greenhouse gas concentration in the atmosphere until cheap technological options for emission reductions at the source are available. An argument which can be brought up against this is that the widespread use of carbon sequestration instead of emission avoidance could lead to a delay in the development of such technologies. These are essential questions which should be addressed in more detail by future research on carbon sequestration. This is especially relevant regarding CCS because its attractiveness lies exactly in the possibility to achieve significant emission reductions without the need to restructure the world energy system significantly.

Since carbon sequestration implies the risk of a future release of the stored carbon, a detailed set of rules and modalities guaranteeing liability for such releases is essential. Throughout this thesis, it became clear that this is one of the reasons why implementation of carbon sequestration as a mitigation option in the framework of the international climate regime is a rather challenging task.

The implementation of LULUCF into the climate regime has, however, contributed to the slowly growing efforts to create markets for environmental services (internalization of positive externalities). Hence, the UNFCCC more than any other convention has its share in giving the issue of financing of environmental services (carbon sequestration in forests) an international dimension. It has to be mentioned, though, that LULUCF activities which are only focused on carbon sequestration might as well be in conflict with goals of other international conventions, e.g. the Biodiversity Convention. Since the only aim of CCS consists in carbon sequestration, ancillary (environmental) benefits as potentially occuring in the area of LULUCF cannot be expected to arise from its use as a climate mitigation option.

In spite of the growing knowledge on carbon sequestration, its share in the portfolio of mitigation options is still quite uncertain. However, the role carbon sequestration will play in the future does not only depend on its technical potentials and costs, but also on the degree by which rules and modalities elaborated for its integration into an international climate regime are able to create a credible framework for its implementation.

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Curriculum Vitae

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Education

May 2002- Sept. 2005	Ph.D. Scholarship of the International Max-Planck Research School on Earth System Modelling, Max-Planck Institute for Meteorology
October 1996-March 2002	Studies of Economics at the University of Cologne, Germany
March-August 1999	Studies of Economics at the “Universidad Nacional Mayor de San Marcos”, Lima, Peru
October 1995-April 1996	Studies of Social Science at the University of Nuremberg-Erlangen
June 1994	High School Graduation (Abitur), Erftstadt, Germany
August 1991-June 1992	Exchange year at Placer High School, Auburn, California, USA

Professional experience

May 2002-April 2005	Research fellow at the Hamburg Institute of International Economics (HWWA), Programme International Climate Policy
May 2001-April 2002	Student assistant at the Research Institute for Public Finance at the University of Cologne (FiFo)
June-December 1998	Student assistant at the Central Archive for Empirical Social Research at the University of Cologne

Other

October 2003	Resource person, FAO/IUCN/UNEP Workshop: “Forests and Climate Change – Preparing for Decisions on Land use and Forestry at COP 9” Manila, Philippines
January 2005	Expert Reviewer for the Special Report on Carbon Dioxide Capture and Storage of the Intergovernmental Panel on Climate Change (IPCC)

Internships/courses

March 2000	Intern at the Wuppertal Institute for Climate, Environment and Energy
October 1994-June 1995	Spanish course at the Independent University of Madrid
July 2004	Summer School on Integrated Asessment for Environmental Management, The Integrated Assessment Society (TIAS)

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